LogDynamics
Research Report

Research Report 2016/17

International Graduate School
for Dynamics in Logistics

Universität Bremen*

*EXCELLENT.
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Success Story

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LogDynamics Research Report

Content

Dynamics in Logistics

What is logistics? – In general, we think about logistics as transport of goods and people, as well as information and energy. We experience it in our daily lives, on our way to work by car or on public transport, during traveling by plane and with all those trucks on highways. This executive part is complemented by planning, for example, when we arrange our shopping on our way home. The planning part includes intuitive improvements, such as saving time by combining the two activities of shopping and going home. When we follow such a plan, we sometimes change it. For example, when the bus is running late, or when new tasks arise, our experience can be enhanced very easily by changing the arrangement of our other plans.

On an abstract level, planning, optimization, control and execution represent the core aspects of logistics. As a result, the question that immediately arises is 'what is Dynamics in Logistics?' Just as a bus may be running late, we may face problems on a large scale, too. For instance, a storm may block ships, or blocked airspace may delay planes. Although these aspects are basically unknown, there is still a pattern. To integrate and even utilize the latter, the goal of the Bremen Research Cluster for Dynamics in Logistics (Log*Dynamics*), for over 20 years, has been to constantly derive basic knowledge, new methods and respective tools.

As logistics connects all parts of the world, understanding cultural backgrounds is a crucial factor in problem-solving processes and the development of international networks. To strengthen the latter, LogDynamics has been putting emphasis on its doctoral training program, implemented by the International Graduate School for Dynamics in Logistics (IGS) within the past decade. We are constantly working towards improving the training program by designing, evaluating and implementing new measures in order to structure and support the academic process for doctoral students in logistics. Practicing cross-cultural cooperation across disciplines on a regular basis over a prolonged period is how the IGS deepens cultural awareness, not only for our candidates, but also within our working groups at the University of Bremen.

The IGS has, up to date, an excellent track record. The University of Bremen has awarded doctoral degrees to 31 young scientists from all over the world. Since 2015, all grants have been financed by third-party funding. Above all, the German Academic Exchange Service (DAAD), as well as the Erasmus Mundus mobility projects cLINK, FUSION and gLINK contribute to the funding of scholarships and to the international recognition of the IGS program. Moreover, cooperation with the Zhongyuan University of Technology, Zhengzhou in China, the University of Peradeniya in Sri Lanka, and the Capital University of Science and Technology (CUST) in Islamabad, Pakistan were established by contracts to sustain our network for the future.

The Research Report 2016/17 provides a kaleidoscope of research topics, results, training concepts and snapshots of the ordinary course of life at the IGS.

Prof. Dr. Jürgen Pannek
Professor for Dynamics in Logistics, University of Bremen

Logistics in Bremen

The federal state of Bremen is the second largest logistics location in Germany. This is due to its advantageous maritime position and good hinterland network. Established logistic-related companies are based in Bremen, for example aeronautics and space technology, automobile construction, food manufacturers, etc. The importance of the logistics industry for the state of Bremen implies the respective scientific focus.

The University of Bremen meets the demand for logistics research by linking competences of different scientific disciplines within an interdisciplinary high-profile area. Log*Dynamics* was founded in 1995 as a cooperating network of research groups originated from four faculties: Physics/Electrical Engineering, Mathematics/Computer Science, Production Engineering and Business Studies/Economics. Recently the logistics focus has been acknowledged by contributing to the title "University of Excellence" awarded by the German Research Foundation (DFG). Besides the four faculties, further partners within Log*Dynamics* are: BIBA – Bremer Institut für Produktion und Logistik GmbH, ISL – The Institute of Shipping Economics and Logistics (ISL), and the Jacobs University Bremen gGmbH.

The activity fields of Log*Dynamics* range from fundamental and applied research to transferring findings into practice. The research cluster collaborates closely with enterprises. The objective is to strengthen interdisciplinary research and development in the competence area of logistics for the benefit of the region Bremen as well as to foster international cooperation.

The International Graduate School for Dynamics in Logistics (IGS) is the structured doctoral training program of Log*Dynamics*. It offers outstanding researchers from all around the world the opportunity to complete a doctorate at a logistic location of long standing tradition. The objective of the IGS is to foster excellence in research and education by pursuing an interdisciplinary and cross-cultural approach.

Interdisciplinary Cooperation

The logistic challenges cannot be solved within one single scientific discipline. Therefore, research in Log*Dynamics* is based on interdisciplinary cooperation to generate synergy effects. The areas of research of the currently supervising professors will be introduced below. The research cluster conducts fundamental and applied research, offers education at the highest level and organizes scientific conferences. At the same time the reference to industrial practice is one of the most important aspects.

Log*Dynamics* makes special efforts to feature opportunities for cooperation between science and industry. Furthermore, it promotes the idea of giving small and middle-sized enterprises access to research and innovation. The resulting dialogue of industry and science contributes to a better understanding of different perspectives and possible solutions in logistics.

Faculty 1: Physics / Electrical and Information Engineering

Dynamics in Logistics is intrinsically tied to the information exchange between all the players in the logistics domain, such as suppliers, manufacturers, transport companies, customs, and authorities. This information exchange is based on an increasing number of fixed and wireless information networks. Access networks usually employ wireless or mobile network technology, which are connected to infrastructure networks either directly or indirectly. These networks range from sensor networks to satellite networks. Research topics in this area are related to the performance evaluation and optimization of communication processes. Another related aspect investigated is the use of information networks to implement dynamic routing algorithms for transport logistics. These react to the dynamic events that, sometimes drastically, influence transport processes. Head of the research group for Communication Networks is **Prof. Dr. Anna Förster.**

In the near future, it will be possible to capture not only the position of each container world-wide, but also of any pallet or even each individual piece of goods. The conditions of carriage like temperature or humidity have to be

Research Beyond Boundaries

supervised permanently and influence current decisions. Due to the high amount of resulting data, centralized control will not be possible. Especially during periods of missing radio communication, when the freight has to react on disturbances and new information correctly. With new mathematical theories and progresses in the fields of microelectronics and micro system technologies, it will be possible to integrate low-cost sensors to monitor and control the product quality as well as the environmental parameters. This contains the conception of the ad-hoc sensor network and the corresponding communication system. New sensors and wireless communication mechanisms have been investigated under the notion of "Intelligent Container". **Prof. Dr.-Ing. Walter Lang** is the director of the Institute for Microsensors, -actuators and -systems (IMSAS).

Faculty 3: Mathematics / Computer Science

In the logistics' futuristic scenarios, intelligent autonomous robots will automate warehouses and logistics centers by fetching, placing, and rearranging products. Furthermore, they will automate the supply chains for the production and transportation of goods. **Prof. Michael Beetz Ph.D.** is head of the Institute for Artificial Intelligence. His research interests include plan-based control of robotic agents, knowledge processing and representation for robots, integrated robot learning, and cognitive perception.

Circuits and systems were mainly applied in computers a few years ago. Meanwhile, they are part of everyday life and are used more and more in safety-critical areas. They are the core technology in Cyber-Physical Systems (CPS). CPS play a key role in overcoming logistical challenges, and they contribute to finding solutions for the increasing complexity in the logistic sector. **Prof. Dr. Rolf Drechsler** represents the subject of computer architecture in research and teaching. His research interests comprise of the complete design flow of circuit and system, where he focuses particularly on testing and verification using formal techniques. Since 2011, he is a director in the German Research Center for Artificial Intelligence (DFKI) in Bremen, where he also leads the research group of Cyber-Physical Systems.

In analogy to conventional logistics, autonomous logistic processes are in need of knowledge to perform their task. Data, information, and knowledge are the key resources, which ensure the quality of a logistic process. Knowledge management is required to support autonomous logistic processes by providing context-sensitive information. In addition, it has to be considered that actors in these processes act in a competitive way. Consequently, information and knowledge should be treated as tradable goods, which hold high utility potential for their consumers. Projects by **Prof. Dr.-Ing. Otthein Herzog** include, for example, knowledge management for the planning and scheduling of autonomous logistic processes.

In software engineering, as well as in other areas of computer science, diagrams and graphs are used in manifold ways for modelling logistic processes, easily describing and visualizing complex structures. Rule-based methods have proven to be extremely effective for capturing dynamic aspects like process and system flow. This inspires the attempt to employ rule-based graph transformation of modelling logistic processes and systems. Since the so-called graph transformation units, in particular, include a control component, they are an obvious choice for the description of autonomous logistic processes. **Prof. Dr.-Ing. Hans-Jörg Kreowski** is a professor for theoretical computer science and a member of the Technology Centre Computer Sciences and Computer Technology (TZI).

IT is taking over all living and work environments while it has not previously been capable of providing support to the people on the move. **Prof. Dr. Michael Lawo** is a professor for applied computer science and is also involved in numerous projects of logistics, wearable computing, artificial intelligence and IT-security. In his research, he deals mainly with human-computer-interaction for industrial as healthcare applications, or even human-robot-collaboration.

Logistic Processes are always linked to the humans who can play multiple roles. Humans are at the one end of the process: customers or consumers. At the other end, they manage and control processes, and in the middle they can work as drivers, packers or in a variety of different roles. Modelling the semantics of logistic processes and interaction in and with logistic processes is an important subject in logistics and human computer interaction. **Prof. Dr. Rainer Malaka** is a Professor for Digital Media and the director of the TZI (Centre for Computing and Communication Technologies). The focus of his work is intelligent-interactive systems and his projects include interactive

systems, contextual computing, multimodal interaction, semantics and ontologies, adaptive and cognitive systems.

Faculty 4: Production Engineering

The goal of the Production Systems and Logistic Systems group, administered by **Prof. Dr. Till Becker**, is the development of novel approaches for the design of robust and efficient manufacturing and logistic systems. Its research focuses on the understanding of the interrelations between the material flow as the dynamical component and the structure as the topological component of a complex logistic network. This includes the analysis of the impact of disturbances and fluctuations, the design of robust manufacturing systems, and the design of interfaces between local manufacturing systems and global logistic structures.

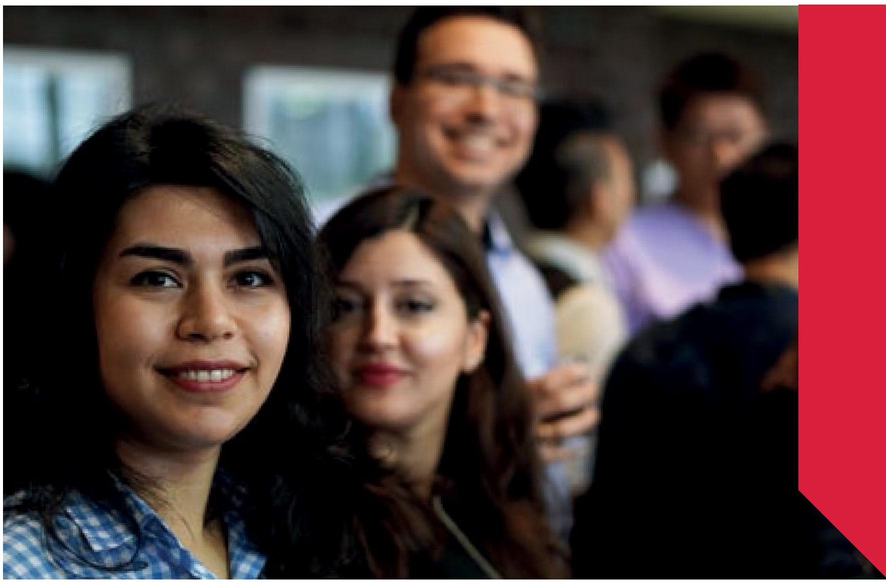
Industry 4.0 technologies, particularly cyber-physical production and logistics systems, and new opportunities for robot-supported automation of logistic processes are strong forces behind the changes in production and logistics systems. Intensive global competition, as well as changing and diverse customer requirements boost the necessity for using these technologies, while at the same time developing adaptive, flexible and dynamic production and logistics systems. However, these systems can only unfold their full capacity if their planning and control are more decentralized and dynamic. Based on this background, the research unit Intelligent Production and Logistics Systems sees its major tasks in the research, development and application of Industry 4.0 technologies for production and logistics, the automation of logistic processes with the help of these innovative technologies, and in the development of efficient and practice-suited planning and control methods for production and logistics. **Prof. Dr.-Ing. Michael Freitag** adminsters this research unit and is the director of BIBA – Bremer Institut fur Produktion und Logistik GmbH.

The dynamics of logistic networks and processes is growing in today's globalized world. This implies new technical and structural challenges to design and steer such systems. **Prof. Dr. Jürgen Pannek** is a professor for Dynamics in Logistics, a subject which combines engineering science, informatics, mathematics and the science of management. His research focus lies on the development of methods for modeling, simulation and control of logistic systems regarding dynamics and complexity on the operational, tactical and strategic levels. Instead of compensating for the dynamics, his goal is to integrate and utilize it within the control of the production and logistic system.

High performing co-operations between independent companies with the aim to develop and realize customized products are an important success factor for the competitiveness of the European industry. So-called enterprise networks can be seen as an addition to the traditional supply chains. The research unit "ICT applications for production" prepares, develops, and discovers methods and tools to support co-operative inter-organizational enterprise networks. The research concentrates on the efficient and effective collaborative design and production processes by applying innovative information and communication technologies (ICT). The focus is the collaborative acting of enterprises during distributed design and production processes, and during the late processes of the product life cycle such as the usage phase or the recycling phase. **Prof. Dr.-Ing. Klaus-Dieter Thoben** is the director of this research unit. He is also the managing director of BIBA – Bremer Institut fur Produktion und Logistik GmbH and spokesman of Log*Dynamics*.

Faculty 7: Business Studies and Economics

Business logistics research in cargo mobility and elaboration of management tools, which are elaborated for the development and techno-economic evaluation of an added value orientated system integration of multimodal transport already pick up today's major design options for the realization of sustainable logistics. **Prof. Dr. rer. pol. Hans-Dietrich Haasis** is an industrial engineer and holds the chair in maritime business and logistics. He is the spokesman of the IGS, as well as an official member of the Board of Academic Advisers to the Federal Minister of Transport and Digital Infrastructure. Applied research, education, training and knowledge transfer of the chair focus on coopetitive techno-economic solutions in logistics, on maritime transportation and on decentralized production, as well as on business logistics concepts and on process management innovations for enterprises and regions. These topics also integrate an e-business orientated management of supply chains, the design and evaluation of smart logistics processes, as well as concepts for digitalization of business logistics.



International Doctoral Training in Logistics

Since 2005, the International Graduate School for Dynamics in Logistics (IGS) at the University of Bremen has been offering excellent researchers from all around the world the opportunity to complete an efficient, structured doctoral training at a logistics location with a long-standing tradition. The IGS is embedded in the Bremen Research Cluster for Dynamics in Logistics (Log*Dynamics*) and collaborates closely with the industry. The curriculum of the IGS is designed for a three-year full time doctoral training. It bundles interdisciplinary competences and cross-cultural cooperation and fosters the link between research and industry. Besides the individual doctoral project, the curriculum covers collective thematic introductions, subject specific courses, interdisciplinary colloquia, dialogue forums, excursions, as well as individual coaching regarding complementary skills and personality development. The language of training and thesis is English. However, a basic knowledge of the German language and culture is also required. German IGS graduates have the opportunity to participate in a scientific exchange at foreign universities.

Fields of Research

The aim of the IGS is to identify, describe, model and evaluate the required and feasible intrinsic dynamics in logistics processes and networks both an operational and strategic level. It conducts research on innovative dynamic planning and control by using new decision support algorithms and methods, new communication and cooperation arrangements, as well as new technologies. Special topics are adaptive and dynamic control methods for logistics as well as the synchronization of material and information flows. Against this background, cross-disciplinary cooperation under consideration of intercultural aspects is the basis for research.

The IGS meets the challenge of globalization through practice-oriented research within the scope of fundamental and applied research. The research is centered on four topic areas:

- Business models, decision processes and economic analyses of dynamics in logistics
- Holistic interdisciplinary methods for modelling, analysis and simulation of dynamics in logistics
- Adaptive and dynamic control methods in logistics
- Synchronisation of material, information, decision and financial flows

The curriculum includes individual doctorate projects, disciplinary supervision, scientific mentoring as well as specific trainings in the field of complementary skills.

Supervision

Currently, thirteen professors from four faculties of the University of Bremen supervise the doctoral candidates of the IGS. Furthermore, all professors of Log*Dynamics* are available as supervisors or at least as mentors. Additionally, the early-stage researchers receive a structural supervision by the Managing Director of the IGS, as well as scientific support from the postdoctoral research fellows in their working groups.

Doctoral Project

Working on a unique doctoral project is the central research activity in the curriculum. In order to fulfil this task under optimal conditions, the doctoral candidates are integrated in the disciplinary research group of their supervisors. Through this assignment, they can benefit from the knowledge and the infrastructure of the respective faculty and institute. Furthermore, they learn to use the tools of scientific work required for their particular project and receive individual support in their research activities.

Courses and Coaching

The training is divided into lectures with tutorials, seminars, workshops, practical training, and integrated learning in small groups and individual coaching. The aim of the disciplinary courses is to educate on the level of international standards of the respective research area. Thematic introductions into the ‘other’ disciplines support the interdisciplinary cooperation at the IGS. Additional course-offers include project management, tools of the craft of research, academic writing for scientific purposes, presentation and communication techniques, cross-cultural awareness, language courses, and voice development. Each doctoral candidate agrees her/his own training set according to their individual strengths and weaknesses.

Interdisciplinary Research Colloquium

The interdisciplinary research colloquium of the IGS (IRC) offers an institutional and issue-related forum to present and discuss the concept and status of the doctorate projects with all involved faculties.

The young researchers have the opportunity to exchange research results, develop interdisciplinary research questions, and participate in cross-disciplinary discussion groups. Colloquia with all professors of Log*Dynamics* or visiting professors ensure targeted impulses for the individual research projects. Research speed dating sessions and poster presentations are some of the used methods.

In addition, there is an internal IRC on a weekly basis. Under the guidance of the Managing Director of the IGS, the doctoral candidates co-operate in the cross-disciplinary and multi-cultural community on a regular basis. After at least three years of training, the doctoral candidates gained an awareness of the differences and developed an individual way to benefit from the diversity, as well as to contribute to the interdisciplinary logistical challenge in an appropriate way.

All these elements involve the young researchers in a critical dialogue that – instead of presenting a single dominant perspective – encourages discussions beyond scientific boundaries and helps to create a dynamic, issue-related network. The system of concerted-individual measures ensures the well-directed and effective personnel development through the institutional combination of possibilities and obligation on the path to exchanging ideas actively. This enables the researchers of the IGS to receive excellent qualifications and helps the university to gain efficient new insights. Furthermore, Log*Dynamics* makes its contribution by helping to turn research results into practice.

Log*Dynamics* Summer School

The Log*Dynamics* Summer School (LOGISS) strives to generate an extended network of young researchers within the field of logistics. The aim of the network is to foster ideas from other disciplines and give rise to opportunities for joint research. To support this process, in addition to offering intensive tutorial lectures delivered by international lecturers from renowned universities and holding group lab sessions, LOGISS is accompanied by classical social elements such as get-togethers, dinner and guided tours.

Alumni of the IGS

By now 73 young scientists from 24 countries started their doctorate with the IGS. The University of Bremen has already awarded 31 of them with a doctoral degree:

Dr.-Ing. Larbi Abdenebaoui, Dipl. Inf.
Mathematics / Computer Science
Graph-Transformational Swarms – A Graph-Transformational Approach to Swarm Computation

Dr.-Ing. Ali Babar Mohamed Alamin Dow, M.Sc.
Physics / Electrical and Information Engineering
Design avnd Fabrication of a Micromachining Preconcentrator Focuser for Ethylene Gas Detection System

Dr.-Ing. Mehrdad Babazadeh, M.Sc.
Physics / Electrical and Information Engineering
Plausability Check and Energy Management in a Semi-autonomous Sensor Network Using a Model-based Approach

Dr.-Ing. Jan Ole Berndt, Dipl. Inf.
Mathematics / Computer Science
Self-organizing Supply Networks: Emgergent Agent Coordination in Autonomous Logistics

Dr.-Ing. Kateryna Daschkovska, Dipl.-Ing., M.Sc.
Production Engineering
Electronic Seals and their Influence on the Dynamics of Container Logistics

Dr.-Ing. Salima Delhoum, M.S.I.E.
Production Engineering
Evaluation of the Impact of Learning Labs on Inventory Control – An Experimental Approach with a Collaborative Simulation of a Production Network

Dr.-Ing. Nagham El-Berishy, M.Sc.
Production Engineering
Green Logistics Oriented Framework for Integrated Scheduling of Production and Distribution Networks – A Case of the Batch Process Industry

Dr.-Ing. Enzo Morosini Frazzon, MB
Production Engineering
Sustainability and Effectiveness in Global Logistic Systems – An Approach Based on a Long-Term Learning Process

Dr.-Ing. Fasika Bete Georgise, M.Sc.
Production Engineering
Supply Chain Modeling & Improvement of Manufacturing Industry in Developing Countries

Dr. rer. pol. Julie Gould, M.A.
Business Studies / Economics
A Decision Support System for Intermodal Logistics under Considerations for Costs of Safety and Security

Dr.-Ing. Safir Issa, M.Sc.
Physics / Electrical Engineering
Flow Sensors and their Applications to convective Transport in the Intelligent Container

Dr.-Ing. Amir Sheikh Jabbari, M.Sc.
Physics / Electrical and Information Engineering
Autonomous Fault Detection and Isolation in Measurement Systems

Dr.-Ing. Amir Jafari, M.Sc.
Physics / Electrical and Information Engineering
Development and Evaluation of an Autonomous Wireless Sensor Actuator Network in Logistic Systems

Dr. rer. pol. Fang Li, M.A.
Business Studies / Economics
Supply Chain GHGs Management under Emission Trading

Dr.-Ing. Huaxin Liu, M.Sc.
Production Engineering
A Dynamic Bottleneck-oriented Manufacturing Control System

Dr.-Ing. Melanie Luderer, Dipl. Inf.
Mathematics / Computer Science
Control Conditions for Transformation Units: Parallelism, As-long-as-possible and Stepwise Control

Dr.-Ing. Safdar Marwat, M.Sc.
Physics / Electrical and Information Engineering
Link Level Scheduling for Future Mobile Communication

Dr.-Ing. Afshin Mehrsai, M.Sc.
Production Engineering
Feasibility of Autonomous Logistic Processes by Reconfiguration of Business Processes

Dr.-Ing. Javier Palafox, M.Sc.
Physics / Electrical Engineering
Analysis and Prediction of Sensor and Quality Data in Food Transport Supervision

Dr.-Ing. Nicole Pfeffermann, Dipl.-Ök.
Production Engineering
An Integrated Management Concept of Innovation Communication and its Contribution to Company Value

Dr.-Ing. Thomas Pötsch, M.Sc.
Physics / Electrical Engineering
The Efficiency of Transport Protocols in Current and Future Mobile Networks

Dr.-Ing. Mehdi Safaei, M.Sc.
Production Engineering
Delivery Time Uncertainty in Dynamic Supply Networks

Dr.-Ing. Arne Schuldt, Dipl. Inf.
Mathematics / Computer Science
Multiagent Coordination Enabling Autonomous Logistics

Dr.-Ing. Gulshanara Singh, M.Sc.
Physics / Electrical and Information Engineering
Efficient Communication in Agent-based Autonomous Logistics Processes

Dr.-Ing. César Stoll, M.L.I.
Production Engineering
Evaluation of the Application of Automatic Conditions Monitoring of Produce in Fresh Food Warehouses

Dr.-Ing. Yi Tan, M.Sc.
Production Engineering
Extension, Configuration and the Advantages of the Shifting Bottleneck Approach for Solving Dynamic Job Shop Scheduling Problems in Production and Logistics Processes

Dr.-Ing. Vo Que Son, M.Eng.
Physics / Electrical and Information Engineering
Modeling and Implementation of Wireless Sensor Networks for Logistic Applications

Dr. rer. pol. Jiani Wu, M.A. in Management
Business Studies / Economics
Sustainable Freight Village Concepts for Agricultural Products Logistics

Dr.-Ing. David Zastrau, Dipl. Inf.
Mathematics / Computer Science
Estimation of Uncertainty of Wind Energy - Predictions with Application to Weather Routing and Wind Power Generation

Dr. rer. pol. Hongyan Zhang, M.A. in Management
Business Studies / Economics
Knowledge Integrated Business Process Management for Third Party Logistics Companies

Dr.-Ing. Raúl Zuñiga Arriaza, M.Sc.
Production Engineering
Modeling of Supply Chain Processes of the Mineral Raw Materials Industry from the Perspective of EM, SCOR and DCOR Models

Achievements and Guests

Log*Dynamics* contributes to the success story of the University of Bremen in the high-profile area of logistics. The IGS is the educational part of Log*Dynamics* and contributes particularly through its ultrahigh degree of internationality and interdisciplinary cooperation in research and education. Since 2015, 73 doctoral candidates out of 24 nations started their doctorate at the IGS. The University of Bremen has already awarded 31 of them with a doctoral degree.

The IGS is partner of three Erasmus Mundus mobility projects, funded by the European Commission:

cLINK – *Centre of Excellence for Learning, Innovation, Networking and Knowledge:* The project facilitated the academic exchange between European and Asian universities. It finished on July 14th, 2016, after 4 years of fruitful exchange of people and expertise. The IGS hosted a total number of 20 incoming researchers on all levels of qualification.

FUSION – *Featured eUrope and South asIa mObility Network:* The project aims to foster partnerships of emerging Asian with European countries to enhance the capacity for international cooperation by facilitating transfer of people, know-how, culture and best practice in training the next generation of researchers and academic staff. The IGS hosted 14 incoming researchers and sent four outgoing scholars to the partner universities in Asia.

gLINK - *Sustainable Green Economies through Learning, Innovation, Networking and Knowledge Exchange:* The project aims to promote multi-disciplinary advanced research, education and professional training on sustainable green solutions through mutual collaboration and knowledge exchange between Europe and Asia. The far-east and south Asian countries (Vietnam, Laos, Cambodia, Malaysia, Mongolia, Thailand, China, India, Indonesia, and Sri Lanka) are the targeted areas. Thus far, the IGS has hosted 12 incoming scholars and has sent 2 outgoing students and one academic staff member to Asia.

Through these projects, scholarships on all academic levels, such as students, doctoral candidates, postdoctoral researchers and academic staff, are offered a mobility from Asia to Europe or vice versa. So far, a total of 52 mobilities have started, some are ongoing until 2018. By integrating the scholars from Asia into the academic training program, the IGS extends and intensifies its international foundation through personal experiences.

The fruitful co-operation generated some sustainable bi-lateral contracts: The first Memorandum of Understanding (MoU) with the Zhongyuan University of Technology (ZUT), Zhengzhou, China, generated a vivid exchange of academic staff in both directions. In December 2016, a MoU with the University of Peradeniya, Sri Lanka, was signed to provide the opportunity for collaborative research, as well as exchange of students, researchers and staff in the areas of logistics and industrial engineering.

In 2017, the MoU with the Capital University of Science and Technology (CUST), Islamabad, Pakistan, was signed in the same areas. Several mobilities of academic staff have already taken place in both directions. CUST organized its 6th International Business Research Conference in Islamabad, in collaboration with the University of Bremen.

In the summer of 2017, the IGS hosted the Doctoral Training SummerCamp of the Texas Tech University (TTU), USA, to increase engineering programs in Ethiopia. 15 lecturers from Ethiopia stayed for 3 months at the University of Bremen. 10 American professors and a representative of the Ethopian Jimma University supervised their doctoral research. In cooperation with the TTU coordinator and INROS LACKNER SE, the IGS offered 18 excursions and presentations in the doctoral candidates' fields of interest.

On the academic level, one award should be mentioned: Morice Daudi received the best paper award for his contribution 'Effects of Decision Synchronization on Trust in Collaborative Networks' at the PRO-VE 2016 – 17th IFIP Working Conference on Virtual Enterprises.

For several years, the alumni and guest researchers of the IGS have been acting as ambassadors of Log*Dynamics*. They have always represented the high quality of education and research at the University of Bremen. Since 2016, selected doctoral candidates of the IGS have been taking part in the VIA BREMEN Logistics Ambassadors training program and will internationally expose the advantages and competences of the logistics location Bremen/Bremerhaven, as well.

Due to this international awareness, an increasing number of young researchers apply to the IGS and the community is growing constantly.

Guest Researchers

Husnul Abid
FUSION fellow of Engineering and Technology, United International University, Dhaka, Bangladesh

Prof. Dr. Mujtaba Hassan Agha
cLINK fellow, TT of Production Engineering, Capital University of Science and Technology, Islamabad, Pakistan

Abdulkalam Azad MD
FUSION fellow of Engineering and Technology, United International University, Dhaka, Bangladesh

Sangju Cha
Master student of Computer Science and Engineering, Pusan National University, Busan, South Korea

Supansa Chaising
gLINK fellow of Transport and Traffic Studies, Mae Fah Luang University, Chiang Rai, Thailand

Undram Chinges
gLINK fellow of Engineering and Technology, National University of Mongolia, Ulaanbaatar, Mongolia

Gia-Huy Dang
gLINK fellow of Engineering and Technology, Ho Chi Minh City International University, Vietnam

Arighna Deb
cLINK fellow of Department of Electricial Engineering, Jadavpur University, India

Lintao Duan, PhD
FUSION fellow, PostDoc of Engineering and Technology, Chengdu University, China

Prof. Stephen Ekwaro-Osire, PhD
Department of Mechanical Engineering, Texas Tech University, Lubbock, U.S.A.

Sundari Enkhtugs
gLINK fellow of Management and Production Engineering, National University of Mongolia, Ulaanbaatar, Mongolia

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Alena Fedotova
Bauman Moscow State Technical University, Moscow, Russia

Juliana Fisaini
gLINK fellow of Management and Production Engineering, Institut Teknologi Bandung, Indonesia

Dorjsundui Gombokhurts
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Global Logistics and Transportation Program, College of Charleston, U.S.A.

Prof. Kate Grudpan
Center of Excellence on Innovation in Analytical Science and Technology, Chiang Mai University, Thailand

Dr. Liu Guiqing
Economic Management, Zhongyuan University of Technology, Henan province, China

Prof. Hamid Reza Karimi, PhD
Mechanical Engineering, Politecnico di Milano, Italy

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Azfar Khalid, PhD
cLINK fellow of Production Engineering Capital University of Science and Technology, Islamabad, Pakistan

Dr. Sri Yogi Kottala
gLINK fellow of Business Studies with Technology, Indian Institute of Technology Roorkee, India

Dr. K.M. Asela K. Kulatunga
gLINK fellow, PostDoc of Engineering and Economics, University of Peradeniya, Sri Lanka

Matheus Leusin
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Jiaqi Li
Master student of ShanghaiTech University, Shanghai, China

Chao Liu
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Yahui Liu
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An Peng
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Matheus Pires
Federal University of Santa Catarina, Florianópolis, Brazil

Prof. Dr. Amir Qayyum
Faculty of Engineering, Capital University of Science and Technology, Islamabad, Pakistan, cLINK/FUSION partner

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Phintip Samutloiwon
FUSION fellow of Engineering and Technology, Chiang Mai University, Thailand

Himangshu Sarma
cLINK fellow of Computer Science and Production Engineering / Electrical Engineering, National Institute of Technology Sikkim, Ravangla, India

Seung-gwan Shin
Master student of Computer Science and Engineering, Pusan National University, Busan, South Korea

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cLINK fellow of Engineering and Management, Dalian Maritime University, China

Zifeng Yi
cLINK fellow of Engineering and Management, Dalian Maritime University, China

Taiyuan Yin
FUSION fellow of Engineering and Technology, Zhongyuan University of Technology, Zhengzhou, China

Yanlin Zha
Master student of ShanghaiTech University, China

Heng Zhang, PhD
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A Supplier Selection Economic Lot Sizing and Order Allocation Model

A multi-objective mixed integer nonlinear (MOMIN) model for the supplier selection, lot siz-ing, and order allocation problem under all unit quantity discount and intermodal transportation costs is developed. The multi-objective includes the minimization of cost and rejection rate, in addition to maximization of purchasing value while considering capacity of supplier and truck, lead-time, and demand as constraints. In determining the purchasing, first, AHP is used in determining the relative weight of a criterion and the weighted score of the supplier, which in turn are used as inputs for the purchasing value function. In the second stage, the MOMIN model is converted into a single-objective function using the ε-constraint method, and is then solved using AIMMS's Outer Approximation solver.

Getachew Basa Bonsa

Introduction >>> Companies have gained competitive advantage in today's global market by exploiting oppor-tunities in the entire supply chain. One function of supply chain logistics that has a potential cost-saving advantage is purchasing. Purchasing involves the selection of the right supplier able to supply the required quantity of the product at the right time with the minimum cost compared to other suppliers. In addition to the supplier selection decision, purchasing also involves decisions regarding the economic lot sizing and the type of the transportation mode to be used to acquire the demand. In the past, the three mentioned decisions of purchasing were optimized separately resulting in a suboptimal solution. Since supplier selection, lot siz-ing, and carrier selection are decisions interdependent on one another, an integrated considera-tion of the problem has attracted some research (Choudhary & Shankar, 2013; Mendoza & Ventura, 2009).

In addition to minimizing the cost objective, considerations of supplier's performance on qual-ity and delivery, geographic location, and shelf life of the product are necessary to achieve overall goal of the purchasing function. In this research, both quantitative and qualitative crite-ria are taken into consideration in developing the multi objective mixed integer nonlinear (MOMINP) for the integrated supplier selection, lot sizing, order allocation, and carrier selec-tion problem. In this paper, a single pharmaceutical product is considered for procurement from six capacity-constrained suppliers with quantity discount options. Since the suppliers are located in different parts of the world, transportation cost for two alternative carriers (sea & air) is also considered in the cost objective function. The two alternative carriers are consid-ered in the modeling in spite of the obviously lower cost of sea transportation, but because of their impact on speed of delivery in terms of lead-time. The multi objective model considers the minimization of the total cost, which includes inventory holding, ordering, item, and transportation cost as the first goal. The second goal is the minimization of the total percent-age of rejected procured items. The third goal is the maximization of the purchasing value, which is the sum product of the score of the supplier and the total quantity ordered from the supplier. <<<

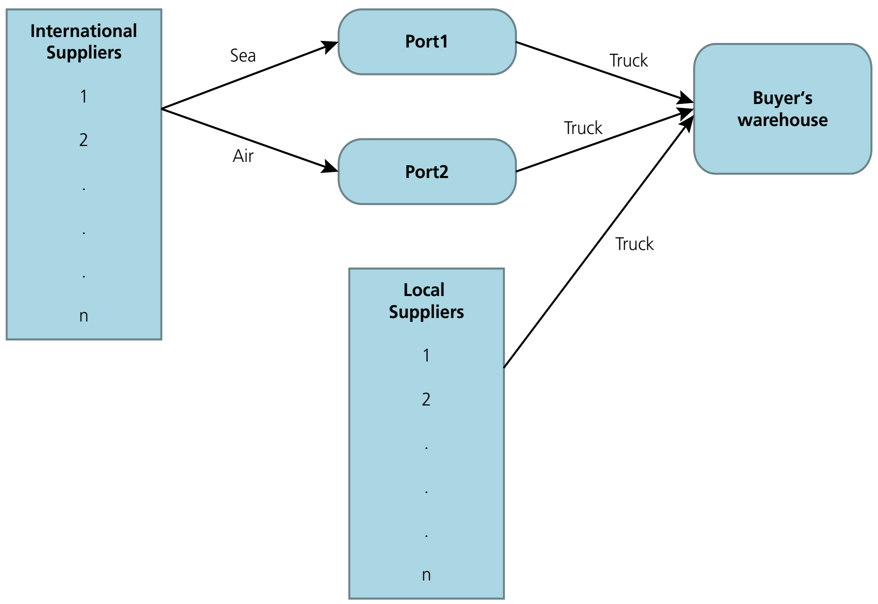
Problem Statement

Consider multiple suppliers with capacity constraints that can supply different types of prod-ucts requested by a buyer. The suppliers offer quantity discounts of different types (all unit and business volume discount schedules, for example) to encourage the buyer to order more, and since they are located in different parts of the world, the transportation cost of an item from each supplier is different. For international suppliers, two alternative modes of transpor-tation (sea and air) are available. Once the item arrives at the destination of either of these modes of transportation, the buyer transports the item using trucks. The buyer is concerned with determining the right supplier(s), the economic lot size, the amount of order, and the min-imum number of trucks that minimizes the total cost of the supply chain (procurement, inven-tory, and transportation) while meeting its demand, and lead time requirements without violat-ing the capacity of the supplier and capacity of truck constraints.

Literature Review

One of the major tasks in the pre-supplier selection process is the identification of appropriate criteria for evaluation. Identifying and ranking criteria has been a major task for researchers since the early 1960's. The most commonly used single criterion in supplier evaluation and selection process was price (Degraeve & Roodhooft, 1999). However, the use of a single crite-rion in the evaluation and

Figure 1: Supplier Selection Problem with Transport Networks



ranking of suppliers was not found to be efficient enough as it ig-nores other relevant criteria including quality, delivery performance, geographic location, and overall performance of the supplier. In order to overcome the limitation of using a single crite-rion for supplier evaluation and ranking, researchers proposed multi-criteria decision methods (Kahraman, Cebeci, & & Ulukan, 2003; Weber, Current, & Benton, 1991; Zhang & Zhang, 2011). Dickson 1966 carried out pioneering work on iden-tifying and ranking the multiple cri-teria that are used by companies. A similar task was carried out by (Weber et al., 1991) re-viewing the literature that was published between 1966 and 1991. Based on their review, they also ranked criteria according to their importance. One thing that all the supplier selection studies have in common is the objective of selecting supplier even though they differ greatly in the evaluation criteria and the method they used. Since this paper is concerned with studies that integrate the supplier selection, lot sizing, order allocation, and transportation mode selec-tion, we will concentrate the review on these specific studies, which also include quantity dis-counts.

With regard to the structure of the supplier selection problem, the problem can be classified based on the types of sour-cing used, number of products, and the planning period. In single-type sourcing, the suppliers can satisfy all the needs of the consumer whereas in multiple-sourcing the suppliers cannot satisfy all the needs of the customer due to their capacity con-straints (Ghodsypour & Brien, 1998). Hence, the customers split the demand across multiple suppliers to meet the demand (Demirtas & Üstün, 2008). If the supplier selection problem is formulated for a single product, then supplier selection is called a single-item supplier selection problem (Ghodsypour & Brien, 1998; Razmi, Rafiei, & Hashemi, 2009), otherwise it is called multiple-item problem (Benton, 1991; Kilic, 2013). Finally, the supplier selection problem is also classified as a single-period problem where the problem is formulated for a single plan-ning period (Ghodsypour & O'Brien, 2001; Narasimhan, Talluri, & Mahapatra, 2006). When the order allocation is considered for multiple planning horizons, it is called multiple-period supplier selection problem (Demirtas & Üstün, 2008; Reza, Moghadam, Afsar, & Sohrabi, 2008). The supplier selection and order allocation problems are complex when multi-sourcing and multi-item are integrated and considered simultaneously. The problem even becomes more com-plex when quantity discount is considered instead of fixed price of the item (Amid, Ghodsypour, & O'Brien, 2009; Benton, 1991; Lee, Kang, Lai, & Hong, 2013; Razmi & Maghool, 2010; Wang & Yang, 2009; Xia & Wu, 2007). There are primarily three different types of quantity discounts: all units discount, business volume discount, and incremental quantity discount. In all unit discount, if the order quantity is in a specified quantity range, the reduced price applies to all the units starting from the first unit (Lee et al., 2013). In the in-cremental quantity schedule, the reduced price applies only to quantities in the quan-tity range (Benton, 1991). For the business volume discount, the reduced price applies when the total sales volume exceeds a specified range (Dahel, 2003; Ebrahim, Razmi, & Haleh, 2009; Xia & Wu, 2007). Benton 1991 formulates the multi-sourcing and multi-item SSP with the objective of minimizing cost. Unlike Benton 1991 and Dahel 2003, Xia and Wu 2007b formulated the multi-sourcing multi-item supplier selection problem as a multi-objective mixed integer linear program (MOMILP) taking both multiple criteria and quantity discounts into consideration. An integra-ted approach of analytic network process and multi-objective mixed integer linear programming is proposed by Demirtas & Üstün (2008). In their proposed model, maximizing the total value of purchasing, minimizing the budget and defect rate are considered objectives, while capacity and demand are considered constraints. However, their proposed model con-siders no quantity discount and is formu-lated for a single item. Amid et al., (2009) proposed a fuzzy multi-objective model to determine the order quantity from a supplier. Their proposed fuzzy multi-objective model consists of minimizing the net cost, minimizing the net rejected items and minimizing the net late deliveries, while considering the capa-city of the supplier, and demand of the buyer as constraints. Then they proposed a fuzzy weighted additive and mixed integer linear programming to solve the single-item capacity-constrained multiple sourc-ing SSP with price breaks. Kokangul & Susuz (2009) introduced an integrated AHP and non-linear integer multi-objec-tive program for the capacitated multi sourcing single-item SSP under all unit discount. Their objectives are maximi-zing the total value of the purchase and minimiz-ing the total cost of purchase, while capacity, demand, and budget are formulated as con-straints. as in the model in Kokangul & Susuzs (2009), Wang & Yang (2009) also introduced an integrated AHP and fuzzy compromise programming for the SSP under all unit quantity discount. Mendoza & Ventura (2013) developed a mixed integer non-linear program to deter-mine the order quantities with the objective of minimi-zing the sum of the item, inventory, and transportation costs while satisfying the capacity and demand constraints. Trucks are used in transporting the item, and hence the transportation cost for both full- truckload and less-than-truckload (LTL) options are considered. Lee et al. (2013) proposed a mixed integer program to solve the supplier selection and order allocation problems with multiple periods and all unit quantity discount. The proposed objective is to minimize total cost, which consists of ordering cost, holding cost, purchase cost and transportation cost, while satisfying capacity and de-mand constraints. Choudhary & Shankar (2014) constructed a multi-objective integer linear program for the simultaneous decision of supplier selection, order allocation, and carrier selec-tion for a single-item, multi-period SSP. The multi-objective proposed includes: minimizing net rejected item, net costs, and net late delivered items while capacity, demand and storage space are considered as constraints. Meena & Sarmah (2016) developed a model for the single item, single period, supplier selection and demand allocation problems under supply disruption and quantity discount environment. Their pro-posed model minimizes the expected total cost, which is the sum of purchasing cost, supplier management cost, and expected loss cost to de-termine the optimal number of suppliers and the order while meeting the demand constraints, which is the only constraint included.

The case of capacity constrained multi-sourcing, supplier selection and order allocation prob-lems with quantity discount and intermodal freight cost has not been adequately addressed in the literature.

Solution Methodology

The multi-objective, capacity-constrained, and all unit quantity discount supplier selection and order allocation problems are solved using the ϵ-constraint method where two of the three objectives are transformed to a constraint by bounding their values below (in case of maximization) and above (in case of minimization). That is, when one objective is optimized the rest of the objectives are set as constraints. The transformation is done first by finding the optimal values for the quality objective and purchasing objective by solving separately one objective at a time and ignoring the other objectives. The following mathema-tical formulation is intended to present the transformation employed in this paper. That is, equation 1 is transformed to its equivalent equation 2.

$$\begin{aligned}
&Min\ (f_1(x), f_3(x)),\ Max\ f_2(x)\\
&g_i(x) \le 0 \quad \forall i = 1, 2, 3, \ldots, I\\
&x \in X
\end{aligned}$$

$$\downarrow$$

$$\begin{aligned}
&Min\ f_1(x) + \epsilon_1 + \epsilon_2\\
&g_i(x) \le 0, \quad \forall i = 1, 2, 3, \ldots, I\\
&f_2(x) \le Z_2(x) + \epsilon_1\\
&f_3(x) \le Z_3(x) + \epsilon_2\\
&x \in X
\end{aligned}$$

On both the multi objective and single objective functions, the X represents the set of decision variables, Z_2 and Z_3 are the optimal values of the purchasing value and the quality objective respectively. Finally, the transformed single objective mixed integer nonlinear program is solved with the AOA solver..

Conclusion

Few papers consider the simultaneous consideration of the supplier selection, economic lot-sizing, and order allocation problems under quantity discount and transportation cost. Taking the capacity limitation of suppliers, quantity discount offers, intermodal transportation costs, and lead time constraints make the supplier selection and order allocation pro-blem more com-plicated. In this paper, a two-stage approach is proposed in model-ling the problem. First, AHP is proposed and used considering both quantitative and qualitative criteria to compute the score of suppliers, which is then used as an input for the purchasing value func-tion. In the sec-ond stage, a multi-objec-tive mixed integer nonlinear program with three objective functions (cost, purchasing value, and percent reject) and set of cons-traints is formulated. The MONIP is trans-formed into a single-objective function using the ε-constraint method, and is then solved using AIMMS's AOA open source solver. The result showed that the propo-sed model is applicable and effective.

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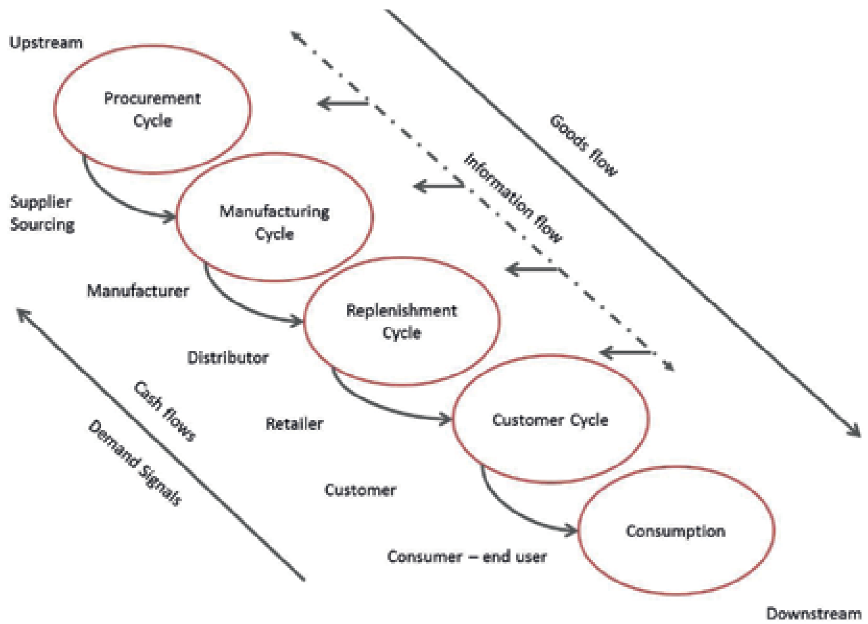
Social Media Text Data Analysis for Decision Making in Fashion Supply Chains

The fashion industry is highly consumer oriented. Hence, capturing the customers' demand is crucial for companies' success. Nowadays, these customers publish content on various social media platforms. At the same time, these consumers are members of the fashion supply chain. This paper considers a simplified fashion supply chain and focuses on the buyer. The objective is to examine if textual social media data contains color information and whether these color occurrences correspond to customer demand. Blog data is analyzed and compared to qualitative information on colors from a real-world company. The analysis shows that it is possible to discover color information from fashion blogs. Furthermore, it revealed that the information identified on the blogs correspond to real-world customer demand.

Samaneh Beheshti-Kashi*

Introduction >>> Fashion markets are characterized by highly specific peculiarities, such as a high number of product variables in terms of style, material or color. Since purchasing fashion articles is often an impulse decision by the customer, the availability of products is a crucial aspect. However, these customers are often influenced not only by various factors such as their current life circumstances and social factors, but also by current trends. Consequently, fashion is highly consumer and trend oriented. Hence, the demand is highly volatile and generates uncertainties for the companies involved. In order to achieve a precise understanding of the customer needs, some feedback from the customer to fashion companies is needed. This feedback is often available on social media platforms. Based on the results, fashion companies will be able to conduct, for instance trend analysis and understand which garments the customers prefer. This way, decisions such as selection of future fashion collections can be properly covered and improved. These decisions might probably impact processes in the whole supply chain. In this framework, the fashion buyer plays a crucial role with his different responsibilities. These responsibilities include tasks such as trend monitoring, which is often the foundation of decisions for future collections. The objective of the current research is to examine if social media text data contains color information and if these color occurrences correspondent to real-world customer demand. <<<

Figure 1: Supply Chain Processes (adapted from Hines, 2014)



Fashion Supply Chains and Decision Making Processes

Figure 1 illustrates a simplified fashion supply chain. Each stakeholder has different functions, processes and decisions, which have to be carefully taken care of in order to keep the chain running successfully. Accordingly, each of the cycles consists, in themselves, of a number of processes, stakeholder, roles and functions. For these decisions, the different stakeholders require particular information. This research takes the perspective of the retailer. The fashion buyer has a crucial function and his decisions impact the success of the company (Wong, 2013). Therefore, we will focus on this function in the following sections. A typical buyer has different responsibilities in a company. He manages the collections, is responsible for negotiating with suppliers and others about prices and deliveries. Furthermore, he identifies target groups and examines the purchasing behavior of the customers. He has to predict the sales of the products. Moreover, he has to continuously monitor upcoming trends in order to react properly to market changes (T. Jackson & Shaw, 2001). For the purpose of this paper, we will describe in more depth the task of trend monitoring. A buyer monitors and evaluates different products and fashion trends in order to decide which products to include in the assortment for a particular season and to be able to react timely to market changes. For this purpose, the buyer requires information, particularly regarding future fashion trends. Therefore, it is required to look deeper into the topic of fashion trends, which will be discussed in the following section.

Fashion Trend Analysis

Jackson (2014) defines a fashion trend as: *The term fashion trend refers to aspects of the appearances and construction of fashion products that relate to a particular season. Such trends are manifest in the appearance of fashion products, which are designed and manufactured prior to being delivered in a season.* In addition, they define long-term and short-term trends. While long-term trends usually "underpin future designs", short-term designs refer to a certain season. However, what exactly do these trends manifest? Jackson (2014) reports that the features color, fabric, print, silhouette, styling detail and trim can be manipulated to reflect changing fashion. Along the apparel supply chain, the relevance of a fashion trend will be different for different stakeholders. The information needs vary depending on their position and functions along the chain. However, a buyer requires information ideally on all the features (Jackson 2014). In order to obtain this information, traditionally, in addition to other methods, buyers visit fashion shows and fairs or analyze sales data. However, due to the increased relevance of social media applications, we are considering this a supplementary source for the buyer (Beheshti-Kashi & Thoben, 2014).

Social Media

With the advent of the Web 2.0, a huge number of different tools have emerged. These include social networks, blogs, microblogging services, wiki, video and photo sharing platforms. In literature, we can find different definitions on social media (Kaplan & Haenlein, 2010) (Boyd & Ellison, 2007). On the different platforms, a variety of topics are published and discussed. From electronics, travel, beauty, sports, celebrities and politics to fashion, pictures, videos or comments can be found on the different corresponding applications. Focusing on blogs, we can monitor a huge diversity of topics. One type of blogs, which has attracted a huge amount of attention within the recent years, is fashion blogs. The following section provides an overview of fashion blogs, their development and their relevance for the fashion industry. Fashion blogs have attracted a huge amount of attention within the recent years. They are mostly authored by young women (but not exclusively) who often write about lifestyle, fashion, beauty or travelling topics. Fashion blogs can be divided into different categories depending on their focus. This research focuses on the so-called outfit blogs, on which the bloggers usually present themselves, their daily lives and routines. Bloggers are often considered opinion leaders or influencers (Uzunoğlu & Misci Kip, 2014) since they have a large outreach to their readers and followers. Their impact on them is often explained using the idea that the influence of interpersonal communication on individual's behavior is higher than the mass medias' impact (Weimann, 1994). The fashion industry has realized this influence and have been using it for reaching their customers. In 2006, the first fashion bloggers were invited to report from the New York Fashion Week.

Often social media content is published in the form of unstructured data. This includes text as well as multimedia data such as pictures and videos. In order to extract information and gain some insight from this data, it is required to apply some pre-processing according to the type of data, which is being analyzed. In the case of textual data, which is highlighted in this research, natural language processing (NLP) methods need to be conducted in order to transform the data into structured content. With the emergence of the social media tools, researches on different aspects of social media have also increased. One research stream is the exploration of the predictive value of User-Generated-Content (UGC). Following this stream, diverse authors examine potential relationships between online discourse and real-world outcomes. However, most of this research is conducted with Twitter data. In addition, there is hardly any analysis in the application field of fashion. A short overview of the predictive value of UGC is provided by Beheshti-Kashi et al. (2015). A second famous research stream is subjectivity analysis, which includes opinion mining and sentiment analysis (Khan, Baharudin, Khan, & Ullah, 2014).

Methodology

In accordance with the research objective, the following two questions were discussed: Do fashion blogs contain information on colors? Do occurrences of the colors and the real-world customer demand correspond? In order to break down these questions, two different types of information are required. Firstly, it is required to have textual data from fashion blogs in order to examine the occurrence of potential relevant information published on them. Secondly, in order to analyze potential relationships with real-world processes, it is required to have information on sales, or in general, the customer demand information of a real-world fashion company. An Italian clothing company provided us with information for instance on different shapes, materials or colors for the period of October 2014 to January 2015. This information was available in a qualitative form. However, it was applied in order to examine the two questions mentioned.
In order to compare both data, it was crucial to collect blog data exactly from the given time period. Since the real-world information was from an Italian company with stores located in Italy, it was accordingly required to use Italian fashion blogs. However, the language of the collected text data is English. The blog posts were searched based on the color list provided by the company. The color list contained the demanded and sold colors for the given time period. In addition to the colors from the list, the color white was added. The first focus of this examination was to find out if we could extract information on colors from the blog posts.

Data and Results

Table 1 shows the blog corpus characteristics. Surprisingly, not only dark colors such as black, brown or grey predominate the

Table 1: *Corpus Statistics*

Number of blogs	5
Number of posts	232
Language	English
Time frame (period)	October 2014 - January 205
Number of colours	290

corpus, often these colors are expected since they are typically associated with autumn and winter. The colors red, white and pink seemed to have outstanding relevance during the time period. Particularly, red, which occurs 77 times in the corpus, seemed to be a leading color (see figure 2). In addition, pink, which is often associated with the seasons spring and summer, is mentioned relatively frequent compared to for instance brown, which is typically associated with autumn and winter. Comparing this result to the real-world information, we can state that in the case of red and pink, our findings correspond to the actual data. However, in the case of white, the two datasets do not correspond. We can find white within the blog posts, but not in real-world data. After discussing this issue with the clothing company, we learned that in knitting, the color white is hardly used since the yarn has to be decolored. In these cases, often the names cream, milky white or light natural are used instead of white. This case has revealed a further challenge for the work, which lays in the diverse naming of colors. Furthermore, it has shown that it is required to also include experts' feedback into the analysis. The colors burgundy, yellow or mustard belong in the demanded colors. Although, they do not appear often in the blog posts, an interesting observation is that burgundy and yellow have their highest frequency in October (see figure 3). This exactly corresponds to the provided information.

In the case of white, datasets do not correspond. White is not mentioned in the real-world data. This finding was discussed with the clothing company. In addition, the discovery was that in knitting the color, white is hardly used, since the yarn has to be decolored. Instead, often names such as cream, milky white or light natural are used. This analysis has revealed a further crucial challenge of the work, which lays in the diverse naming of colors. Furthermore, it has shown that it is required to include experts' feedback into the analysis, as well. The colors burgundy, yellow or mustard belong in the demanded colors. They do not appear often in the blog posts; however, an interesting observation is that burgundy and yellow have their highest frequency in October. This emergence exactly corresponds to the provided information. Figure 3 illustrates the occurrences of the different colors on a time axis over the selected 4 months.

Conclusion

The aim of this research was to examine whether the blogs contain color information and if the color occurrences correspond to real-world customer demand. The analysis shows that it is indeed possible to discover color information from fashion blogs. Moreover, it revealed that the information identified in the blogs correspond to real-world information. However, it is suggested that an analysis of textual color

Figure 2: Colour Distribution

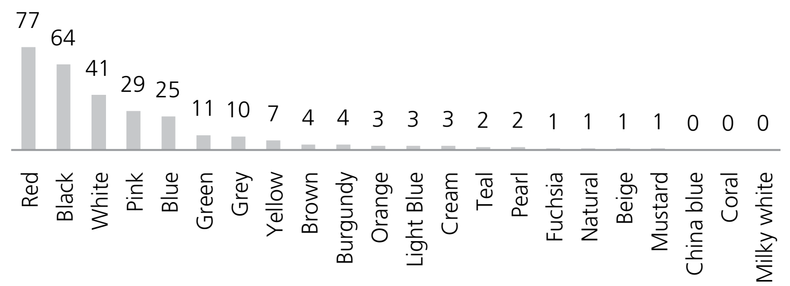
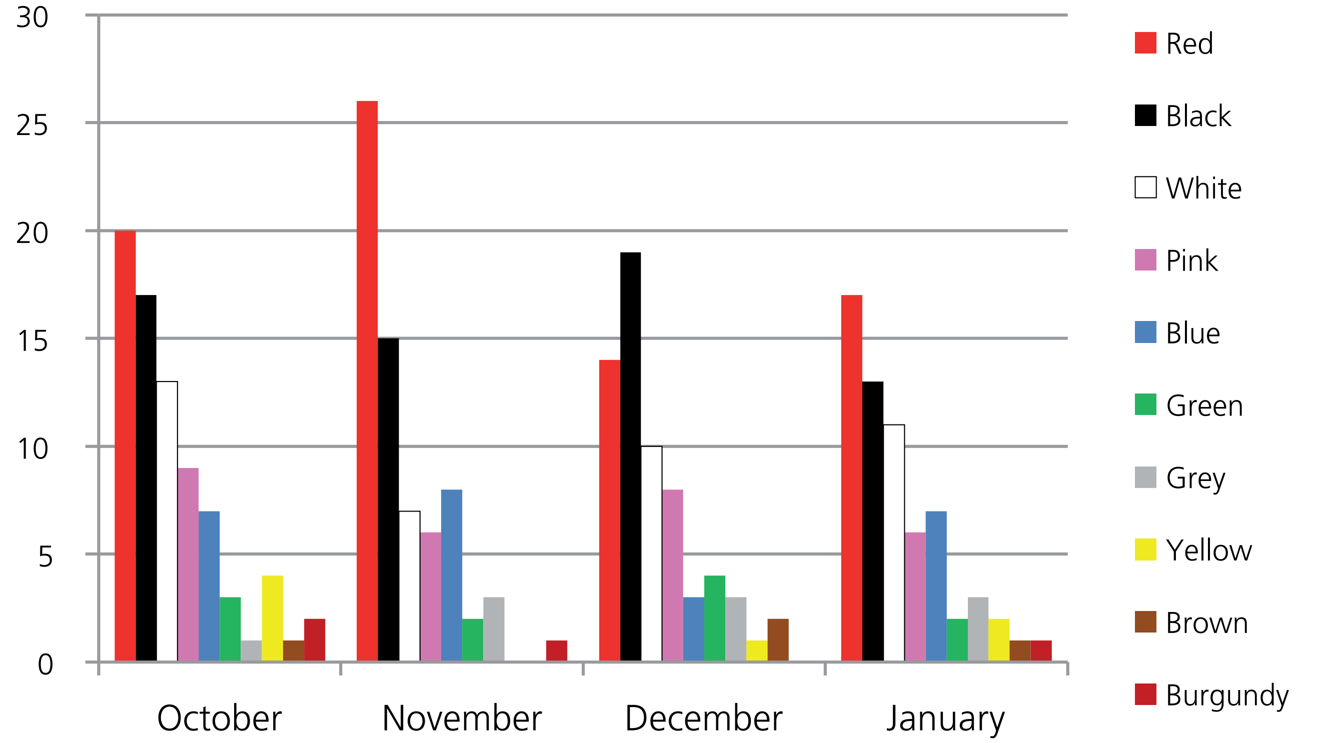


Figure 3: Monthly Colour Distribution



information by quantity can only be a guideline for the buyer or in general the stakeholders in the supply chain. More in-depth analysis is required to catch the popularity of colors in a certain time frame. Particularly, a further analysis may be added through the consideration of an additional semantic layer over the colors, which for instance can be assigned to demonstrate the relation of the colors to each other. For this purpose, co-occurrence analyses have to be conducted. Besides, for further text analysis, an additional layer of computer vision analysis should be added to match text with photo colors in order to overcome the inconsistency in naming the colors.

What implications do these results have for the supply chain? For a buyer, it means that in addition to the traditional ways of monitoring and catching fashion trends, such as visiting fashion shows or fairs, fashion blogs should also be considered in order to extract color information. Answering questions such as to what extent is it possible to discover information on other features such as prints or silhouettes remains for future work. Given the case that all the information that a buyer requires for reasonable decision-making can be extracted from fashion blogs, potential implications for the whole supply chain have to be discussed deeper. For instance, whether the buyer will be able to make decisions in a timelier manner regarding the consideration of the fashion blog analysis, or would other stakeholders such as manufacturers or suppliers be impacted by this development.

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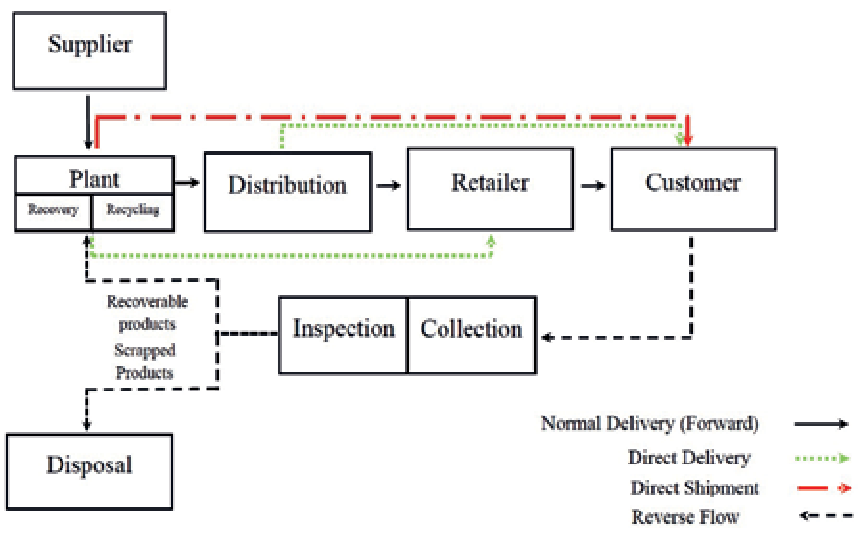
A Memetic Algorithm for a Closed-loop Supply Chain Model

The distribution-allocation problem is known as one of the most comprehensive strategic decisions. In real-world cases, it is impossible to solve a distributionallocation problem in the traditional way with acceptable time. This forces researchers to develop efficient non-traditional techniques for the long-term operation of the whole supply chain. These techniques provide near optimal solutions particularly for large scales test problems. In this paper, we present an integrated supply chain model, which is flexible in the delivery path. As for the solution methodology, we apply a memetic algorithm with a novelty in population presentation.

Elham Behmanesh*

Introduction >>> A supply chain is a network of suppliers, manufacturers, warehouses, distributions and retailers. It is organized with the aim of producing and distributing products. The respective design issue is to determine the number, location and capacity of the facilities as well as the amount of the flow between them [1]. The aim of supply chain design is minimization of total cost [1] or profit maximization [2] while satisfying customer requirements. Each supply chain network involves decisions on three different levels: operational, tactical, and strategic. As long-term strategic decisions take priority over tactical and operational ones, network configuration comes first in any supply chain network design, and needs to be optimized for the long-lasting effcient operation of the entire supply chain. In most of the past researches, the design for forward and reverse logistics networks were considered separately, which resulted in sub-optimal solutions. Consequently, both parts should be considered simultaneously [3]. This leads us to a closed-loop supply chain network, cf. Figure 1 for a sketch. In this figure, black arrows present the classical (forward) and reverse supply chains. In the returned flow, returned products are collected by collection centers, and after inspection, the recoverable products are shipped to the plant for further operations while scrapped products are transferred to disposal centers for safe disposal. Fast and on-time delivery of products with a great accuracy plays an important role in customer satisfaction. Supply chain's ability to satisfy the customer's expected delivery time is called "supply chain responsiveness" [4]. Some previous researchers have proposed models to optimize the supply chain network with regards to both cost-efficiency and responsiveness simultaneously [4,5]. However, most of these researches limited themselves to exclusively consider shipment between consecutive stages or just indirect shipment mechanisms [4–6]. Yet, efficiency can be improved when all possible delivery ways are considered, which renders the problem to be more complex, cf. Figure 1 for a sketch of the delivery graph. Based on the aforementioned descriptions, within this paper, we consider an integrated forward/reverse multi-stage, single-product, single-period logistics network, which is enriched by a full delivery graph representing an NP hard mixed integer linear programming model. To cope with the NP hard problems in supply chain networks, many heuristics [1,6] and metaheuristics have been proposed [3,4,6–10]. However, there is still a critical

Figure 1: Framework of the Proposed Closed-Loop Supply Chain Network



need in this area to increase the efficiency of solution approaches, especially when the complexity of the model increases, cf., e.g., [11]. To address the latter in this work, we propose a memetic algorithm with a novel idea to generate population. <<<

Description for Integrated Forward/Reverse Logistics Network

To support the presentation of the proposed mathematical model, we consider the general model area of our problem. To this end, we consider $G=(N, E)$ to be a digraph where N denotes the set of all nodes, and E the set of all edges in the closed-loop network. The cost for node $i \in N$ are denoted by c_i, and the unit transportation cost on edge $(i, j) \in E$ are given by c_{ij}. The respective decision variables $y_i \in \{0,1\}$ and $x_{ij} \in \mathbb{N}_0$ represent whether a stage $i \in N$ is used, and which quantity is transported between node i and j.

To determine the optimal distribution network and capacity of each node, we minimize the transportation and operation cost of the proposed network, which reveals the following mixed integer minimization problem:

$$\begin{aligned} \min_{x_{ij},y_i} \quad & \sum_{(i,j)\in E} c_{ij}x_{ij} + \sum_{i\in N} c_i y_i \\ \text{s.t.} \quad & \sum_{(i,j)\in E} a_i x_{ij} \leqslant b_i y_i \\ & x_{ij} \geq 0,\ y_i \in \{0,1\} \end{aligned} \tag{1}$$

Next, we specialize this model to reflect the network properties.

Mathematical Formulation

The previously described network setting represents an integrated supply chain with seven echelons, cf. Figure 2 for a schematic sketch. The objective of this model is to minimize the total cost of the proposed supply chain, which consists of fixed costs for facilities, and variable costs for transportation. The constraints in (1) are specialized and we have that the capacities in each node induce the inequalities

$$\sum_{(i,j)\in E} x_{ij} \leq \begin{cases} b_i & \forall i \in S \\ b_i y_i & \forall i \in N \setminus \{S \cup C\}. \end{cases} \tag{2}$$

Additionally, by assumption, only a fraction p^{return} is returned by customers, and a $p^{disposal}$ of the returned products has to be disposed off. Apart from these exceptions, the supply chain network is subject to the law of the flow conservation, i.e. in-flow and out-flow in each node must be identical for these nodes. These conditions reveal

$$\sum_{(j,k)\in E} x_{jk} = \begin{cases} \sum_{(i,j)\in E} x_{ij} & \forall j \in N \setminus \{C \cup Co\} \\ p_j^{\text{return}} \sum_{(i,j)\in E} x_{ij} & \forall j \in C \\ p_j^{\text{disposal}} \sum_{(i,j)\in Co\times Di} x_{ij} & \forall j \in Co \\ (1-p_j^{\text{disposal}}) \sum_{(i,j)\in Co\times P} x_{ij} & \forall j \in Co \end{cases} \tag{3}$$

Lastly, the demands of customers must be satisfied.

$$\sum_{(i,j)\in E} x_{ij} = b_j \quad \forall j \in C \tag{4}$$

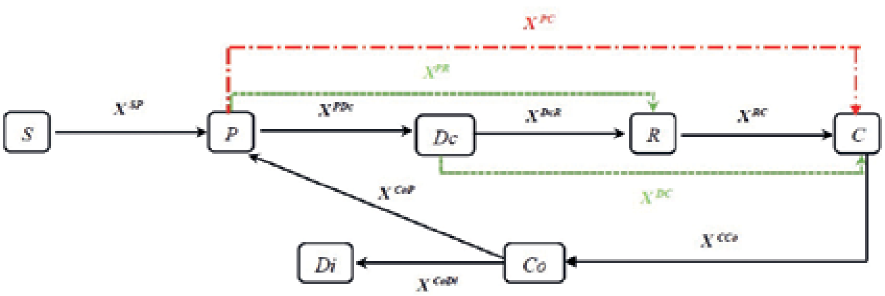
Solution Approach

Since our network model is a capacitated allocation and a multi-choice problem, it is recognized as an NP hard problem [7,12]. Hence, although the problem can be reformulated into integer linear programming, we cannot compute a suitable solution for large-scaled problems within a short time. To reduce the search space and increase the solution quality, we consider the class of metaheuristic algorithm to solve this model. According to [13], memetic algorithms are appropriate for the proposed model. According to the reviewed literature, chromosome representation has significant effect on the performance of a memetic algorithm [8].

Chromosome Representation

A chromosome must have the necessary gene information needed for solving the problem. Selecting a proper chromosome representation highly affects the performance of metaheuristic algorithm. Therefore, the first step to applying MA to a specific problem is to decide how to design a chromosome.

Figure 2: Underlying Structure of MILP



Extended Random Path-based Direct Encoding

Although applying the new delivery paths improves the flexibility and efficiency of the supply chain network, it also makes the problem more complex. In Figure 3, the representation of the extended random path-based direct encoding method in two segments is shown. The first segment is encoded by using random path-based direct encoding method, which shows the delivery path for each customer. The second segment of a chromosome contains two parts: the first part with J locus including the guide information regarding plant assignments in the network, and the second part of length K containing the information of the Distribution centers. As shown in Figure 3, the length of chromosome is $(7 * M)+J+K$ where M, J and K are the total number of customers, plants and distribution centers respectively. Each sequence of seven subsequent genes forms a group. Each group encodes four potential delivery paths through plant, distribution center and retailer to customer as well as a recovery path from customer through collection/inspection to disposal center or plant. The first three alleles of a group represent the reverse flow of the network, while the next four alleles of that group show the forward flow from supplier to customers. As an illustration, a randomly assigned ID to these facilities in the reverse and forward flow is shown in Figure 3. Each locus in the second part is assigned an integer in the set {0,2} for plants due to existence of three delivery options for each plant in the network. Regarding distribution center, an integer from {0,1} is chosen to represent the two respective delivery options. The second segment is involved by determining the sort of delivery path for the selected plant as well as distribution center in first segment.

Extended Random Path-based Direct Decoding

Decoding is the process of mapping chromosomes to candidate solution to the problem. As an example, Figure 4 represents an instance of a delivery and recovery path in our model.

In each gene unit, four delivery paths can be designed by applying normal delivery, direct shipment and direct delivery. All of them are from a neighborhood. For instance, we can obtain the neighborhood from the sample of gene unit shown in Figure 4 that shows the delivery path

Figure 3: Representation of Extended Random Path-Based Direct Encoding Method

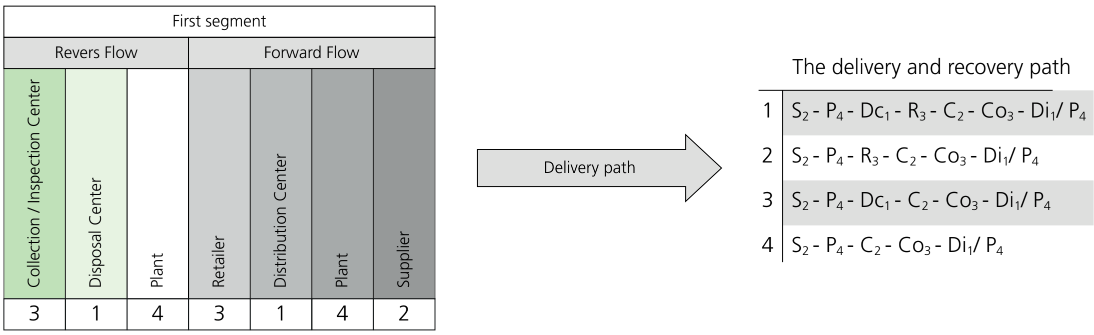
Delivery path to customer 1							Delivery path to customer 2							…	Delivery path to customer M						
Collection / Inspection Center	Disposal Center	Plant	Retailer	Distribution Center	Plant	Supplier	Collection / Inspection Center	Disposal Center	Plant	Retailer	Distribution Center	Plant	Supplier		Collection / Inspection Center	Disposal Center	Plant	Retailer	Distribution Center	Plant	Supplier
3	2	2	5	6	2	2	3	1	4	3	1	4	2	…	4	1	3	5	2	3	1

First segment: Random path-based direct encoding

Information about assigning the Plants				Information about assigning the Distribution Centers			
P_1	P_2	…	P_J	Dc_K	Dc_2	…	Dc_K
1	0	…	2	1	1	…	0

Second segment: Extended encoding for direct shipment and direct delivery

Figure 4: *Delivery path for a sample of gene unit*



to customer 2. Considering the second chromosome (customer 2) in Figure 4 as an example, we start by supplier 2 and continue via plant 4, distribution center 1 and retailer 3 in forward flow as well as collection/inspection center 3, disposal center 1 and plant 4 in the reverse flow. Due to construction, four different delivery paths are possible, cf. Figure 4. The delivery and recovery path 1 occurs if normal delivery is chosen for all stages. By skipping distribution centers, path number 2 is selected. Similarly, path number 3 is chosen if retailers are skipped. Lastly, if direct shipment is selected, the delivery path number 4 will be implemented.

An important difference between the traditional random path-based direct decoding method and the method adopted in this paper is that we include the delivery path information of the second segment.

Conclusion

In this paper, we focused on a comprehensive mixed integer linear programming formulation for a seven-stage closed-loop network design problem. We applied the extended direct delivery path representation based on a memetic algorithm, which was developed for a full delivery graph and a combined forward/reverse logistics design to decrease delivery time and avoid sub-optimal solutions respectively. The aim of this work is to minimize total cost, which we addressed as an allocation problem to find the optimal number and capacity for any facility as well as the optimal transportation flow between facilities. Since the basic problem is NP-hard, the combination with flexibility in delivery path makes the search space of the problem much larger, more complex, and NP-hard as well. Since existing methods are unable to solve this problem, we proposed an MA approach to compute a near optimal solution for largesized problems. In this study, we introduced a new chromosome representation for MA to enhance its search ability for the proposed flexible model.and more complex and NP-hard as well. Because existing methods are unable to solve this problem, we proposed a MA approach to compute a near optimal solution for large size problems. In this study, we introduced a new chromosome representation for MA to enhance its search ability for the proposed flexible model.

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Measures for the Solutions of Capacitated Dynamic and Stochastic Vehicle Routing Problem

In the Dynamic and Stochastic Vehicle Routing Problem (DSVRP), a fleet of vehicles is routed to serve a set of customers at minimum cost in the presence of dynamic events and stochastic information. First, an optimization is performed based on a priori knowledge, computing the so-called a priori route plan. Then, when an event occurs, the plan is adapted to accommodate the changes. If the rate of events is high, this approach may not be real-time capable. We propose a Robust Solution Approach to the Capacitated DSVRP, aiming to design a robust a priori route plan that allows accommodating new events without losing structural properties and optimality. The results on a benchmark dataset show that the robust route covers for unmet demand while causing only small additional costs.

Marcella Bernardo

Introduction >>> The basic task in freight transport is to ship goods from depots to geographically dispersed customers. Hence, a combinatorial optimization problem arises, which is known as Vehicle Routing Problem (VRP). The VRP aims to determine a set of vehicle routes to perform transportation requests with a given vehicle fleet at minimum cost. In this kind of problem, one typically assumes that the values of all inputs are known and do not change. However, in today's economy, one issue needs to be integrated: Customers desire more flexibility and fast fulfillment of their orders. Besides that, the recent developments in information technology permit a growing amount of available data and both control of a vehicle fleet and management of customer orders in real time. This context calls for real–time decision support in vehicle routing, motivating a version of the VRP, the so-called Dynamic and Stochastic Vehicle Routing Problem (DSVRP). The DSVRP is an enriched problem, where parts or all necessary information regarding inputs is stochastic and the true values become available at runtime only. One common way to address the problem is given by sampling algorithms. Sampling-based Algorithms or Multiple Scenario Approach (MSA) incorporate stochastic knowledge by generating scenarios with realizations of the inputs based on the probability distribution of the input. MSA is based in the concept of time steps. At each time step, each of these scenarios is optimized in order to obtain the most likely ones in the near future and anticipate the source of dynamism [6, 2]. The time steps are defined in intervals between updates of the problem data, such as the arrival of a new customer, and the response of the system, corresponding to the time before the next time step [5]. Therefore, when the rate of events is high, there may not be sufficient time to generate and solve scenarios, thus rendering this approach to be not real–time capable. In this project, we propose a solution approach that prevents the disadvantages of sampling-based algorithms, i.e. it shall be real–time capable. We aim to develop a solution approach such that the plan of routes is robust against small changes in the inputs, i.e., allowing to compensate changes in the input without losing structural properties and optimality. The idea is to address demand uncertainty using higher moments, permitting the routing plan to be able to adapt to situations when the real demand is greater than the expected demand. <<<

Problem Definition

Consider a set of vehicles V with restricted capacity $C>0$ each and a fully connected graph $G=(N,A)$, with $|N|=\bar{n}$ and $|A|=\bar{a}$ are given. N is the set of vertexes representing customer locations (0 is the depot of vehicles), and A is the set of arcs representing travel times between connected vertexes. Moreover, costs c_{ij} are fixed for all $(i, j)\in A$ and demands are random variables $d_n:\Omega n\rightarrow\mathbb{R}_0^+$ for all $n\in N$ with sampling space Ωn, then is called the Capacitated Dynamic and Stochastic Vehicle Routing Problem (CDSVRP) where x^v denotes the

Table 1: Vehicle Routing Problem Mathematical Model

$$\min_x J_V(x) := \min_x \left\{ \sum_{v\in V} \sum_{k=1}^{|x^v|-1} (c_{ij} \mid i = x^v(k),\ j = x^v(k+1)) + F(x) \right\} \qquad (1)$$

$$\text{ST. } x^v(1) = x^v(|x^v|) = 0 \qquad \forall v \in V \qquad (2)$$

$$x^v(k) \neq x^v(k') \qquad \forall v \in V,\ \forall k, k' \in \{2, \dots, |x^v|-1\} \text{ with } k \neq k' \qquad (3)$$

$$x^v(k) \neq x^{v'}(k') \qquad \forall v, v' \in V \text{ with } v \neq v' \text{ and } \forall k \in \{2, \dots, |x^v|-1\},\ k' \in \{2, \dots, |x^{v'}|-1\} \qquad (4)$$

$$x^v(k) \in V \setminus \{0\} \qquad \forall v \in V,\ \forall k \in \{2, \dots, |x^v|-1\} \qquad (5)$$

$$\sum_{k\in\{2,\dots,|x^v|-1\}} d_{x^v(k)} \leq C \qquad \forall v \in V \qquad (6)$$

Table 2: Robust Cost Function and Anticipated Demand

$$\min_x \overline{J}_V(x) := \min_x \left\{ \sum_{v \in V} \sum_{k=1}^{|x^v|-1} (c_{ij} \mid i = x^v(k),\, j = x^v(k+1)) + \omega \sum_{s \in S} \frac{F(x,s) - F(x,s_0)}{\overline{s}-1} \right\} \quad (7)$$

$$\overline{d}_i = d_{is_0} + \omega \sum_{s \in S} \frac{d_{is} - d_{is_0}}{|S|-1} \qquad \forall i \in N \quad (8)$$

route of vehicle $v \in V$ in x, $|x^v|$ the length of the respective route and $x^v(k)$ the k-th vertex visited by vehicle v. The cost function contains two parts (stages): the planned costs c_{ij} (first stage) and F (second stage) which resembles the additional costs for vehicles to cover costumers, which were not serviced by the first stage. Equation (2) presents the initial and terminal conditions, i.e. the route has to start and end at the depot. The deadlock free condition in which a vehicle is always moving is represented in (3). The tour arc conditions are expressed by (4) to avoid overlaps and (5) to ensure return to the depot only once. Last, condition (6) states that the total capacity C of vehicle $v \in V$ must not be exceeded.

To calculate a robust capacitated DSVRP and therefore a robust a priori plan of routes, which allows small changes in the demands, we change the objective function (1). Given a set of $\overline{s}$ scenarios $S := \{s_j = (d_1(j), \ldots, d_{\overline{n}}(j), c_1, \ldots, c_{\overline{a}} \mid j = 0, \ldots, \overline{s}\}$ where s_0 is the nominal scenario, and a measure $F : G \times S \rightarrow \mathbb{R}_0^+$ of the second stage costs, we want to compute a set of closed subgraphs $x = \{x^v\}_{v \in V} \subset G$ minimizing

In comparison to (1), the additional term in (7) accounts for the spread of the solutions. Hence, certain disturbances in demand can be compensated. The weight ! represents the parameter of choice for managers to modify the importance of the two aspects in the cost functional (7): optimality and robustness. Note that we do not characterize a certain tolerable bound on the disturbances, which would lead to a worst -case estimate. Instead, we let the optimization mechanism decide, which (modified) minimum is robust in a structural sense. For this reason, we will not state expliciteexplicit bounds on tolerable disturbances, and if disturbances are too large, they will be handled by re-planning or extra tours.

Robust Solution Approach

For the problem described before we develop ana robust solution approach. The proposed approach includes four stages: distribution -fitting, generation of scenarios, definition of a static and deterministic CVRP and optimization. In the first stage, we fit a probability distribution to customer demand data. For each customer demand, we fit one probability distribution function (PDF). Thereafter, we use these PDFs to generate S scenarios. For scenario 0, we assume that the demands are equal to the mean of their PDFs ($d_{iS0} = E\,[d_i]$). The other scenarios are constructed by sampling the probability distribution of demands using Monte Carlo Simulation, i.e. for every scenario a specific value is generated for each of the N customer demands (d_i). Hence, every scenario has a different set of values for customer demand. The outcome of the latter stage allows us to define a static and deterministic instance of the capacitated DSVRP using equation (8) representing the third stage. The latter equation is formulated using the robust cost function (7). Every (d_i) is calculated by a linear combination of the scenarios with the weight ω, which increased the deviation from the nominal value (d_{iS0}), allowing to create worse case instances. Hence, it is possible to decide how conservative a solution can be. These assumed values are used in the optimization stage. Since a capacitated SDVRP is assumed, in stage four we can make use of the efficient heuristics in the literature to approximate the solution of the robust problem. For that, we use the following heuristics: Clark Wright savings, 2-opt Local Search and Simulated Annealing. Using Clark Wright [4] savings parallel version, we generate aan initial plan of routes. Then, we apply a 2-opt Local Search [1] to remove crossing of links in a route, while preserving the orientation of the routes, which reduces the travel times. Given the result of the improvement heuristic, we utilize Simulated Annealing (SA) [7] to further improve the result. The result obtained after this optimization stage is a plan of routes. This plan of routes is robust concerning certain deviations in demands.

Computational Results

Benchmark Dataset

Since no dynamic benchmark dataset for stochastic and dynamic CVRP with stochastic demands was available in the literature, we developed a set of test problems to evaluate the proposed solution approach. The code details as well as the datasets are available via http://www.researchgate.org.

We generated three benchmark test problems. They consist of fully connected graphs with of 20 (TP1), 50 (TP2) and 100 (TP3) nodes. A number of arcs was generated so that $A=N{\cdot}(N-1)/2$. The instances exhibit only capacity restrictions. We considered the customer demand $d_{TP_qi}{\sim}U(a,\, b)$ to be uniformly distributed, and because our problem is stochastic we generated 100 values for each customer demand, adopting that there are 100 days of available data. For all test problem $(q \in \{1;\, 2;\, 3\})$ we changed the parameter a and b for every customer demand, in this way each customer demand has a specific uniform PDF.

Performance Measures

After developing the dynamic benchmark dataset, we applied the proposed solution approach to the dataset using a total of $S=10$ scenarios. We applied the robust solution approach for $\boldsymbol{\omega} \in \{0,\, 1,\, 2,\, 3,\, 8,\, 10\}$ to every test problem. Note that the first stage of the proposed solution approach is to fit a probability distribution in the customer demand data. To render the approach realistic, we included the fitting for the dynamic benchmark dataset. For that, we assumed that we do not know the PDF used to generated the instances (d_{TP_qi}). After the fitting, we obtained a PDF for each customer demand $d_{TP_qi}{\sim}U(a^*,\, b^*)$, which is similar to d_{TP_qi}.

For each value of $\boldsymbol{\omega}$, we computed a plan of routes minimizing (7) and therefore obtained six plans of routes, which represent different degrees of robustness. To compare these solutions, we introduced five performance measures:

- Reliability of a plan of routes P_{plan}(failure). It is defined as the probability that the plan of routes suffered a failure. In the context of our problem a failure occurred when the capacity of a vehicle is exceeded.
- Probability of route failure P_{route}(failure). It is the number of routes in the plan of routes, which suffered a failure.
- Extra cost of the robust plan. It is also called the price of robustness [3], and corresponds to the cost payed to allow for certain deviations within the stochastic variables.
- Expected real cost of a plan of routes. It represents the final cost after all demands are revealed.

- Difference ΔD between planned cost and expected real cost.

The first four performance measures are estimated using Monte Carlo simulation and the probability distributions that model the demands of the customers $(d_{TP_{qi}})$. The last one is the difference between the cost obtained with (1) and the fourth performance measure.

Results and Analysis

From our results given in Table 3 we observed that for TP1 and TP2 the probability of failure P(failure) is lower using a higher ω. For TP3, however, the probability of failure remained almost unchanged for all ω. One knows that a routing plan which contains a higher number of routes also has a higher probability of failure. Then, we evaluate the routing plans regarding performance measure *Probability of Route Failure*. Thus, the routing plans with different amount of routes can also be compared. For instance, in TP2 the plan of route obtained using ω=3 has a 86,55% of chance to failure, and theses failures occur on 0,09% of the routes. When we change to ω=8 the results are different. In this case, the plan of routes obtained has a higher chance to failure: 99,62%, however the occurrence reduces to 0,07% of the routes. A lower probability of failure or higher reliability of a routing plan comes associated with a price, as mentioned before, the *Extra Cost* (price of robustness). For all test problems a grow in the ω causes an increase in the *Extra Cost*. Even so, this increase is no higher than 23%.

For all test problems the *Expected Real Cost* was higher than the planned cost. This indicates that detours to depot were applied in all routing plans to meet the real demands. For instance, for TP2 and ω=2, the plan of routes is composed of 10 routes, see Fig. 1. However, when we use this plan to attend the same customers, but now assuming the real values for the demands, we have 15 routes, see Fig. 2. Hence, some routes have failed, and therefore more routes are required to attend the same clients. For example, the customer 35 was included in the route {0-47-3-26-39-5-35-0} (Fig. 1), however, when the real demands are revealed the total demand of

Figure 1: Plan of Routes for Test Problem 2 (ω = 2)

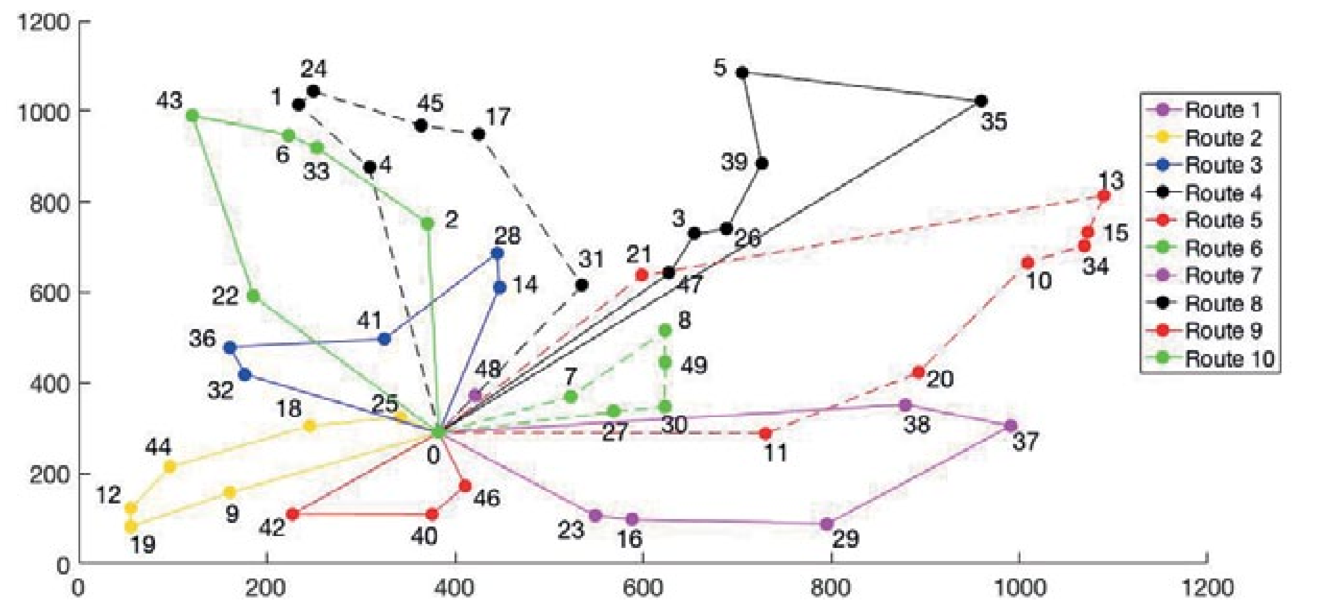

Figure 2: Plan of routes for Test Problem 2 after reavaling the real test values for the demands (ω =2)

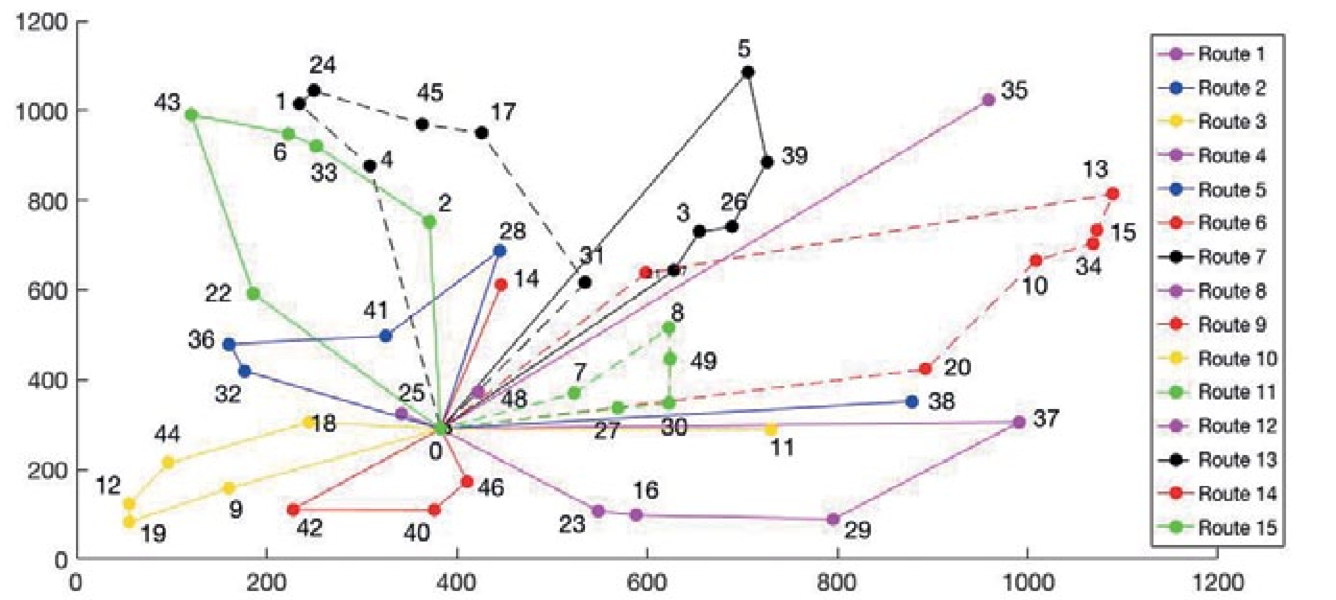

Table 3: Results for the test problems considering the weight ω									
Test Problem	ω	P_{plan} (failure)	Number of routes	P_{routes} (failure)	Planned Cost	Extra Cost	Expected Real Cost	ΔD	I
TP1	0 (mean)	0,716	4	0.2810	6476	-	9523	3047	1,48
	1	0,7521	4	0,2772	6471		8988	2517	1,39
	2	0,6852	4	0,2185	6576	1,54	8862	2486	1,37
	3	0,8232	4	0,2860	6484	0,12	9465	2981	1,45
	8	0,4388	5	0,1005	6610	2,06	7929	1319	1,19
	10	0,4388	5	0,1005	6610	2,06	7929	1319	1,19
TP2	0 (mean)	0,9849	9	0,3491	12026	-	20984	8959	1,74
	1	0,9425	10	0, 2286	19730	1,45	19730	7529	1,62
	2	0,9148	10	0, 1802	19599	3,53	19599	7148	1,56
	3	0,8655	10	0, 0827	18917	3,79	18917	6433	1,51
	8	0,9962	11	0, 0734	17081	5,77	17081	4360	1,33
	10	0,9989	11	0, 0654	16360	7,29	16360	3457	1, 27
TP2	0 (mean)	0,9993	21	0, 2865	23867	-	46956	23089	1, 95
	1	0, 9987	21	0, 2564	23845		45218	21373	1, 87
	2	0, 9990	21	0, 2528	24077	0,08	43777	21141	1, 86
	3	1	22	0, 2274	24046	0,07	42782	18736	1, 77
	8	1	22	0, 2628	24352	2,03	42770	18418	1, 74
	10	1	23	0, 2449	24184	1,32	42683	18499	1, 75

this route is higher than expected. Thus, the vehicle needs to attend the customer 35 in only one route Fig. 2). It can be observed that in all test problems the real cost and ΔD are lower if ω is higher. Since the latter means the routing plan needs less detours to depot to deal with the real values of the demands, this indicates that the solution can handle changes in inputs better for higher ω.

Conclusion

The proposed solution approach permits deciding between optimality and robustness and then computes an a priori robust plan of the routes, which allows for small changes in demands without changing solution structure and losingor any loss of optimality. Using thethis robust approach, the capacitated dynamic and stochastic VRP is reduced to capacitated capacitate static and deterministic VRP, which allows to useusing simple algorithms. The results show that the proposed approach provides significant improvements over the deterministic approach and a robust plan of routes. It is also worth mentioning that the real cost – i.e. the real cost we must pay after a working day – is theat its lowest forin the most robust solution. We would also like to note that forin some situations, it is better to choose robustness over optimality, i.e. to be safe against an worse case realization of the uncertainty. In the future, we will extend our approach to other types of uncertainties, such as stochastic and dynamic travel times. Moreover, we plan to identify different set screws such as the robustness parameter ω, which allows for a simplified decision support. approach.

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Comparing Trust Behavior of Shippers and Receivers in Collaboration

Collaborations are influenced by partner behaviors and collaborative processes. Such influence can be understood better, for example, by exploring how shippers and receivers as partners might behave when brought into collaboration. Building on information sharing, this paper compares trust behaviors of shippers and receivers. The comparison is based on multi-agent systems simulation of collaborative logistics scenario. Results indicate that shippers appear to exhibit more uncertain trust behaviors as compared to receivers.

Morice Daudi*

Introduction >>> One of the goals of integrating logistics and supply chain is to provide a close synchronization of trading partners. This integration relies on close coordination of business processes and information sharing. From this perspective, business processes and information of the suppliers, manufacturers, and customers are synchronized to ensure proper flow of materials, goods, and information. Integration can appear in variant forms such as the extended enterprises, virtual enterprises, and collaborative alliances. Relationships in collaborative alliances (horizontal and vertical collaboration) are built on commitment and trust. In a viewpoint of the latter, collaborative alliances stand on mutual existence of trust. Trust maintains such relationships and fosters partners to get committed. It can be recalled that trust originates from forthcoming expectations and previous experience; while it is manifested in partner behaviors and/or attitudes. Trust as manifested in behavior can further be influenced by processes underlying collaborative contexts. In view of this, the inconsistent and discontent behaviors, and improperly coordinated processes can lead into trust uncertainties.<<<

Trust and Information Behavior

Low level of trust accrues from uncertain and complex collaborative behaviors undertaken by partners involved. Sources of uncertainty can be originated from characteristics of task, information withholding, information unavailability, low probability, and market turbulence [1]. These sources impose difficulties on partner trust and hinder partner's ability to make effective actions and decisions. Accordingly, authors in [2] propose a concept to influence decision-making process and enhance coordination among supply chain partners. To them, an effective decision-making process consist of [2]: selection –helping partners to focus on relevant data; enrichment –complementing the data formally exchanged with other relevant information, and; modify –changing terms of the potential transactions to make them more efficient and beneficial. Firstly, these stages on decision-making process correlate with stages of collaborative functions in logistics.

In addition, they correlate to human trusting process that propagates in three stages: selection, forecast, and execution. Logistics collaborative process requires that partners propagate: (1) front-end agreement (alike to selection); (2) forecast and engagement (alike to enrichment), and; (3) execution of collaborative functions (alike to modification) [3]. Alongside this consideration, an implication is that data and information become more focused, enriched, but also modified to match (an assumed) or factual reality (beliefs) of the world as one progresses towards the execution stage. Correspondingly, a trusting process proposed in [4] mimics a notion of human representation, by which a trustor-partner: (1) develops an intention to trusting; (2) upon satisfaction, it engages in an action to trusting thereby developing expectation, and; (3) delegates its task to a trustee-partner who executes that task. In the end, the trustor-partner compares resulting outcome with expectation it had developed previously.

Trust nourishes when a partner can make effective decisions that are guided by richness of information. However, as each partner adjusts information depending on a situation that prevails its environment (stress), information may remain rich but inaccurate. To this effect, this paper investigates information behavior of shippers and receivers that can be featured during collaboration. It specifically compares trust behaviors of shippers and receivers on an aspect of information accuracy. The overall goal is to unveil a degree of variability regarding information distortions between shippers and receivers.

The rest of the paper is organized as follows. Section 2 presents related literature while section 3 presents formulation of a problem. Results and discussions are presented in section 4, while section 5 provides concluding remarks.

Literature Review

Collaborations are largely guided by theoretical foundations in social exchange, transaction cost economics, and social dilemma. Principles of social exchange and dilemma account for interactions undertaken by collaborating partners. The transaction cost economics account for organizational structure of alliances because such alliances take a form of firms, and it helps to define governance structure, for example. Nevertheless, it can be recalled that trust in collaborative relationships manifests in attitudes and behaviors. Attitudes and behaviors are determined by rewards of interaction minus the penalty/cost of that interaction [5]. In spite of this dual manifestation, the present paper draws on trust as manifested in partner behaviors. Partner behaviors consist of actions and decisions undertaken by partners in a particular context. The actions and decisions are undertaken as an outcome of both, the endogenous and extraneous influential factors. Behaviors manifest also in relational norms. Relational norms are prescribed as behaviors directed towards maintaining the relationship as a whole, and constitute a core safeguard against exploitative use of decision rights [6].

Information exchange as a dimension of relational norms defines a bilateral expectation that parties will proactively provide information useful to partner [7]. However, there emerges uncertainty regarding the ineffectiveness to: estimate future system states due to lack of information; possess enough information processing capacities, and; estimate impact of alternative actions [6]. These limitations impose stresses to partners, who therefore, must struggle to manage them. A result of this struggle may succeed or fail. Such struggle can further be influenced by previous trust experience. For example, low trust experience may lead into further uncertainty, such as information distortion. In support of this, it is stressed in [8] that level of pre-existing trust between shippers and receivers has a positive impact on relational outcomes.

Literature identifies sources of uncertainty underlying the supply chain and logistics collaboration. According to [1], levels of uncertainty in supply chain include:

- *Micro-level uncertainty* that deals with information that is predictable within a distribution, such as variability of customer demands;
- *Meso-level uncertainty* that focuses on the need for information that is unavailable, and;
- *Macro-level uncertainty* that exists in ambiguous, ill-structured contexts, where decision makers cannot even formulate appropriate questions to ask.

This paper focuses more on uncertainties, which are featured in the operational but also the tactical level of collaborative relationships in logistics. It deals with uncertainties related to behaviors, process, and capacities at forecast and execution levels of collaboration. It also build on collaborating partners whose actions and decisions are autonomously controlled.

Collaborating partners portray a range of information behaviors that can be useful or harmful. Useful information behaviors comprises of partners' actions and decisions, which conform to a purpose of collaboration, while harmful one lacks this conformity. Both information behaviors (useful and harmful) can be characterized (described and represented) using dimensions of information quality. While there exists many dimensions of information quality, in this paper, a dimension on data use in a process is considered. In logistics collaboration, data use in the process is characterized by various attributes (see in [9], [10]), including the information accuracy. The information accuracy attribute, depicts that every set of data is assumed to represent a real world situation [10]. This depiction implies two things: actual and distorted information. Exchanging actual information may promote trust in partners, while; exchanging distorted information may decrease such trust. Distorted information may be understood as the information that do not represent a factual belief of the world.

Problem Formulation

This paper builds on information accuracy to investigate trust and information behavior of shippers and receivers. Respective modeling rests on the quantitative than qualitative stream. The qualitative stream modeling advances on collaboration that employs constructs such as the "no information sharing", "limited information sharing", and "full information sharing". Unlike this qualitative stream, the quantitative stream requires that information accuracy is conceptualized on a continuum of information certainty and uncertainty. In view of this establishment and concordant to [11], the quantitative stream guide that logistics elements such as the production capacity, market demand, and forecasts are modeled to be affected by a specific factor. Such factor may increase, decrease or retain factual beliefs of the world.

Assumptions underlying factor of information accuracy affection are explained as follows. Primarily, the factor of affection is defined in a continuum, which ranges exclusively between negative one and positive one {-1, +1}. The factor is composed of many elements in an interval of 0.05 units. The negative and positive elements affect (distort) the actual belief of the world by decreasing and increasing it, respectively. If the factor is negative (say, -0.35) or positive (say, 0.20), the actual belief will decrease by 35% or increase by 20%, respectively.

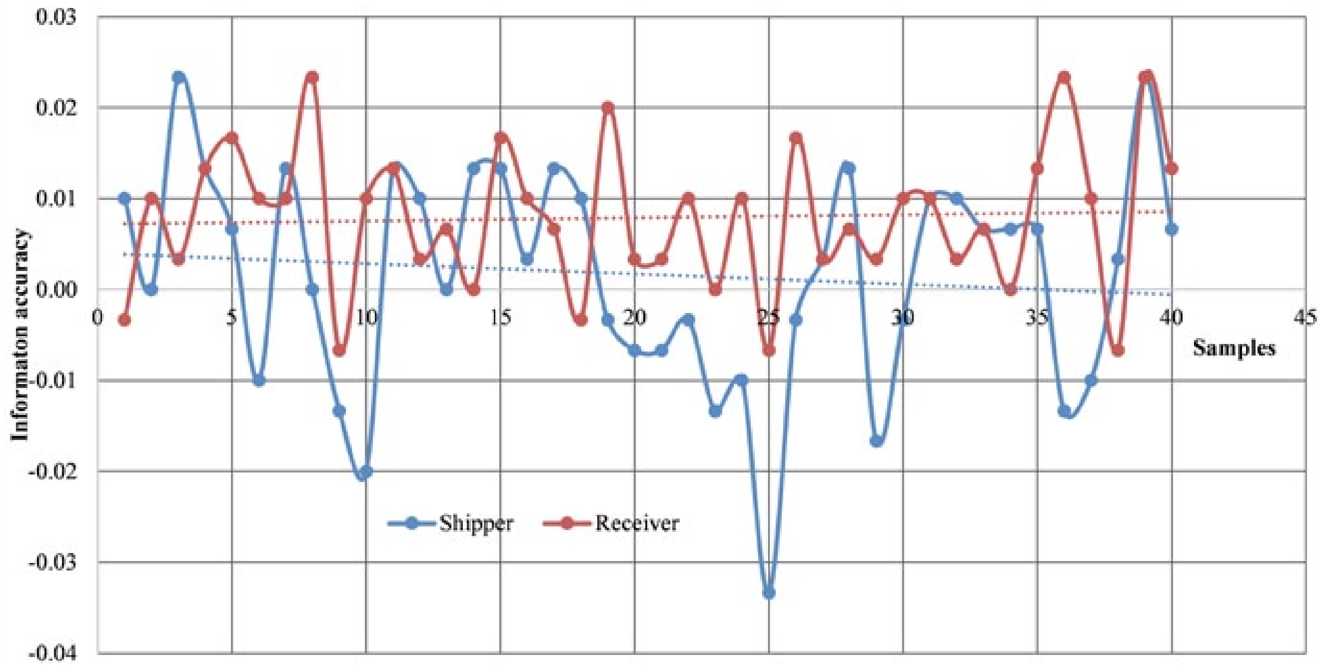
Exchanged belief = actual world belief + factor * actual world belief

If the world belief is undistorted it is then affected by neutral element (say, 0.00), and in this respect it remains certain.

While three forms of affection to information accuracy are presented, this paper concentrate on collaboration that advances on information certainty (in which actual belief is retained). By information certainty it means that collaborating partners are set not to manipulate (modify/distort) factual beliefs (true/actual information) while exchanging it. In a viewpoint of this assumption, it has to be understood further that the world is not rationally predictable. To accommodate this reality, an allowance of ±0.05 is introduced to enrich information certainty (neutral information accuracy). Neutral information accuracy means that partners choose to exchange information that is equal to the exact information without or with least distortion.

The paper operationalizes neutral information accuracy as follows. A set of information accuracy (α) for neutral affection is defined as: $\alpha \rightarrow \{-0.05, 0, 0.05\}$. A partner who chooses zero (0.00) as a factor of affection is absolutely considered an honest and reports true information. If it otherwise chooses -0.05 or +0.05, then such partner is considered the normal honest partner. Furthermore, it is conceived that if a partner had previously experienced the best (or better) trustworthy it becomes realistic by reporting almost undistorted information, on the one hand. On the other hand, if it

Figure 1: Shipper's and Receiver's Trustworthiness on Aspect Information Accuracy



had previously experienced the worst (or worse) trustworthy it struggles to recover by reporting distorted information. To finalize this formulation, it is set that the simulation scenario uses 15 shippers and 15 receivers and employs 5 seeds with each seed being replicated 8 times to yield 40 samples of observations.

Results and Discussion

For both shippers and receivers, a total of 40 samples were recorded. Results analyzed were twofold: graphical displays and statistical tests. Unlike graphical displays that guide subjective decision, the statistical results guide objective decision. Given these points, under graphical displays, output behaviors in information accuracy are compared (Figure 1) to provide subjective decision. This comparison involves variation of trusting behaviors (trustworthiness) between shippers and receivers. The subjective decision indicates that receiver's variations appear to be consistent as compared to that of the shippers. Moreover, shippers' information accuracy appear to more deviated, and occurs in a fashion that is inconsistent.

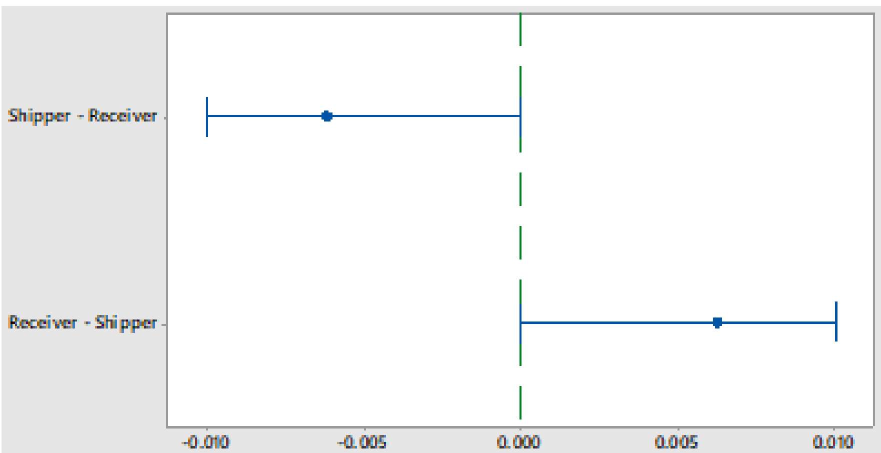
Succeeding graphical displays were results on statistical tests. With regard to mean information accuracy, shippers employed (used) information accuracy whose mean was lower (0.00167) as compared to that of receivers (0.00792). Concerning the standard deviation, shippers' information accuracy was highly deviated from central mean by 0.01212 as compared to that of receivers that was deviated by 0.00798.

To further enrich the objective decisions, additional statistical tests were carried out between shippers and receivers' trust behavior on information accuracy using Hsu's MCB comparisons. Under the Hsu's MCB tests, the following results were obtained. A difference of means for difference of levels: (1) Receiver–Shipper, and; (2) Shipper–Receiver were 0.00625 and -0.00625, respectively (Figure 2). In both cases, the adjusted p-value was the same (0.004).

Analyzed results (as also per Figure 2) indicate that trustworthiness of shippers and receivers differed significantly. This was evidenced by Confidence Interval (CIs) which had zero as an endpoint (for both difference of levels). Equally, the p-value (0.004) was less than significance value (α=0.05). As a result of this meaningful difference, the trustworthiness of receivers was relatively higher than that of shippers. This difference is evidenced by means in information accuracy where mean information accuracy of receivers was higher than that of shippers.

Although there are many implications to draw from these results, the following implications can currently be reported. It seems that trust behaviors of shippers are less consistent as compared to those of receivers. Nevertheless, shippers prefer to distort information in a wide range, and appear to largely avoid reporting exact information as compared to receivers. Inconsistencies in trust behaviors of shippers, among other sources, stem from information stresses encountered by shippers. In most cases, shippers produce according to demand orders from receivers. Normally, demand orders are

Figure 2: Hsu Simultaneous 95% CIs -Largest of Other Means for Shipper and Receiver



collected from consumers whose consumptions rates are varied. Therefore, due to uncertainty in orders, shippers seem to exhibit inconsistent behaviors as attempts to cope (manage) information stresses. To clarify further, shippers are stressed with a problem of reducing backorders and excess inventories. This situation appears different from receivers whose stresses seem to be comparatively lower. Overall, graphical displays and statistical tests unveil that shippers and receivers exhibit dissimilar information behaviors.

Conclusion and Outlook

Collaborating partners in logistics such as the shippers, carriers, and receivers exhibit multiple trust behaviors in relation to information sharing. This paper has focused on the attribute of information accuracy to study how trustworthiness of shippers and receivers differ and/or correlate. Results analyzed unveil that trustworthiness of such partners seem to differ. Furthermore, it was found that receivers seem to maintain a more outstanding level of consistence than their counterparts, shippers. One implication to draw is that shipper and receiver appear to be stressed differently and bear differences in ways they (cope) manage such stresses.

Further works may entail, among others, comparing trust behaviors under information accuracy, namely: positive information accuracy, and negative information accuracy. Since the dimension of data use in a process consists of other attributes, such as the timeliness, completeness, and relevance, further works may investigate trusting behaviors in the context of such attributes.

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A Systematic Literature Review of Challenges in Urban Logistics

The purpose of this study is to provide a systematic literature review of the challenges in urban logistics with a focus on the aspects of private and public stakeholders. It also presents the results of systematic literature reviews. The first search term identified 1,400 papers related to the topics. However, based on additional criteria, 50 papers are considered as relevant publications. The result consists of a research paper that reviews the challenges related to the issues in managerial, engineering techniques, technology and stakeholders engagement in urban logistics. It is definitely a challenge to develop tools for supporting the collaboration between multi-stakeholders, such as serious game, in order to train employee and other stakeholders in urban logistics.

Supara Grudpan

Introduction >>> The urban population is expected to continuously grow by 1.84% annually (World Health., 2016). Consequently, logistics providers will have to provide quality and reliability for the services in areas with high congestion. It is evident from the previous researches that the increment of efficiency within complex systems is mainly dependent on the interactions between the stakeholders (Rose et al., 2016; Stathopoulos et al., 2012; Österle et al., 2015). Therefore, this article presents the analysis of a systematic literature review focusing on challenges related to the collaboration among the stakeholders in urban logistics. <<<

Research Methodology

We used the online databases available at the University of Bremen, comprising of Scopus, Web of Science and IEEE, and searched for papers from 2007-2017 (present). The main keywords in the first search were ‘urban logistics’ and ‘city logistics’ leading to over 1400 hits. Therefore, additional keywords were iteratively added (1. “challenge”, 2.“management” and “technical involvement”, 3. “management” and “business” and “economic” “engineering” and “computer” and “environment”, and 4. “stakeholder”) until we had three major terms used as filtered criteria, namely “urban logistics with challenges”, ”management and technical challenges in urban logistics” and “stakeholders in urban logistics”.

Result

From the total 53 identified papers, three of them were replicates, so 50 papers were considered and reviewed (see Table1). These papers are mostly related to planning and policies of the collaboration between public and private stakeholders, or on models and algorithms related to design and support of stakeholders, which are to pursue the collaborative actions. Most of the papers discussing mathematical models and algorithms were excluded as they were irrelevant.

Management Challenges Related to Urban Logistics Stakeholders

While investigating in the field of Management and exploring the challenges related to urban logistics stakeholders, it became evident that different aspects of management, urban studies, and interaction between stakeholders, affect the process of logistics planning. The interaction between different stakeholders in urban distribution has two reflections on the activities within

Table 1: The Number of Papers Obtained in Correspondence to Challenges in Urban Logistics

Database	Main keywords	with “challenge“	with ‘management challenges‘ and ‘technical challenges‘	with “stakeholder“
Scopus	587 2007(16)/2016(107)/2017(8)	174	116	25 2011(1)/2016(8)
Web of Science	526 2007(6)/2016(140)/2017(0)	188	132	12 2009(1)/2016(3)
IEE	312 2007(3)/2016(51)/2017(3)	120	25	16 2011(3)/2016(2)

urban systems. The success of the logistics system corresponds to structure and policy sensitiveness (Stathopoulos et al., 2012). It also relates to the response of operators for policy innovations. An early involvement in the planning of an urban space system is essential for success where the identified studies had a bigger window to look into social, environmental and economic impacts regarding freights and logistic topics. Insufficient interaction between stakeholders may lead to misunderstanding of the planning processes (Eidhammer et al., 2016; Graham et al., 2015).

Technical Challenges Related to Urban Logistics Stakeholders

The research of Technical challenges related to urban logistics stakeholders has a huge shift towards the development of IT systems. The recent works in this field show that the results or outcomes of most of the researches are mainly beneficial to the public stakeholders, rather than the private ones. The use of IT systems, technologies, algorithms and mathematical models are helping to evolve Internet of Things (IoT), simulation models, decision-making processes of different stakeholders for different layers of tasks. The solution algorithms for Vehicle Routing Problem (VRP) show the influence of total distribution cost and process reliability against the safety stock and the variance of demand. Another application of this algorithm is the possibility for optimization setting for urban logistics service in a number of scenarios. Finally, agent-based-simulation models have contributed to the study of of evaluation of stakeholder behavior and the interaction between private and public actors concerning different urban logistics and transport measures (van Heeswijk et al., 2016).

Discussion

The carried out literature review indicates that the investigation of public stakeholders' interest is different from that of private stakeholders. This leads to a mismatch between the policy-making process and the operational processes. For public stakeholders, the identified topics concern management tools increasing the sustainability, which also corresponds to what we have identified in the technical papers, describing the algorithms and models used behind policy planning and assessment. For private stakeholders, the papers are mainly dealing with involvement in the planning process (i.e. interaction with public stakeholders), but from a micro economic perspective. The technical papers where mostly related to simulation of this interaction or for evaluation of different possible logistics solutions. This review indicates that a holistic approach involving all the stakeholders in a system through all phases of a systems life cycle is required, but still difficult to achieve and that there is a need for tools that support the effective collaboration between public and private stakeholders. However, to in order to improve the involvement of all stakeholders in policy development and strategic planning processes, tools and approaches are available, but they are often not implemented due to a lack of understanding regarding the necessity of stakeholder-involvement in all phases.

Conclusion

The literature review demonstrates that there are some works related to managerial issues of public-private interactions for planning urban systems. For the challenges related to technical systems used, however, there is a lack of research on the interaction between private and public systems, which is required in order to improve urban logistics solutions in the long run. In addition, the focus for private stakeholders is on time and cost, whereas for public, they are on sustainability and quality of life for citizens. Moreover, there have been attempts to investigate how private and public stakeholders should collaborate with each other effectively. Here, we saw several works on simulation, gamification and participatory design approaches. However, even in our studies cases, the deployment rate appears to be low.

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Technological Innovations and Their Effects on Urban Freight Transport

The operation mode and system structure of urban freight transport have been changed by technological innovations, which include new technological tools and new planning concepts. The growth of Internet shopping Business-to-Consumer (B2C) also affects the urban delivery system. In response to these situations, the private and public entities adjust passively to the urban freight construction. This paper describes some applications of various new technological tools and their effects on the urban freight transport. In addition, the influence of new planning concepts on the future city logistics is discussed.

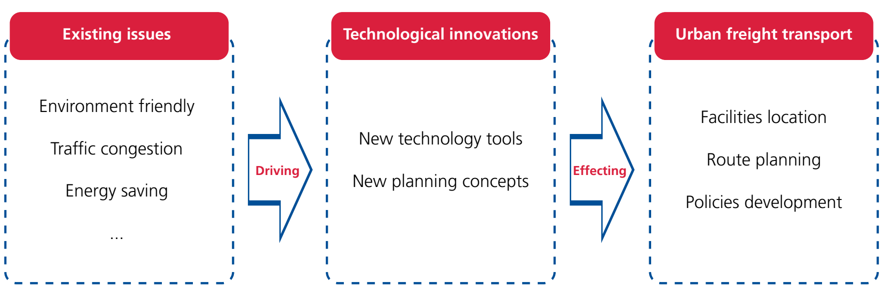
Zhangyuan He

Introduction >>> Urban freight is the system and process for transporting, collecting and delivering goods within an urban area. Information revolution and advances in technology tools provide opportunities for improving the performance of urban freight systems. In addition, the breakthrough of technology drives the emergence of new planning concepts for the sustainability of the future city. For instance, Smart City and Industry 4.0, etc. However, applications of new technology tools are based on the previous planning scheme of urban freight transport, and the carriers also rarely consider the interaction between the different technology implementations. Meanwhile, existing some drawbacks of new technologies is necessary to improve and optimize. The independent operation scheme for implementing various new technology tools has altered traditional service mode of urban freight. Hence, the need to develop a comprehensive approach to integrating all new technology tools application for achieving a deeper integration and sustainability in the future development. <<<

Problem Definition

The information revolution and technological innovations are creating both opportunities and challenges for improving the sustainability of urban freight system. Technological innovations for urban freight system is associated with two aspects: new planning concepts and technical tools (Fig.1). There are existing issues in cities, which include environment problem, traffic congestion and energy saving, etc. Since the goals of city logistics are mainly mobility, sustainability and livability, these problems significantly effect the urban freight system. Hence, the public and private stakeholders attempt to develop new technologies for response these issues, which are around the cities. However, interaction among the various new technologies implementation has changed the constructor of original urban freight system in the aspects of facilities location, route planning and policy development (Fig. 1.) The impacts of technological innovations on urban freight transport Additionally, Information and communication technology (ICT) increasingly drives the technological innovations and economic growth. E-commerce has become a mainstream way in business using the Internet. The growth of Internet shopping Business to Consumers (B2C) change urban freight system as well. It is creating a surge in home deliveries that is increasing the social and environmental costs of goods distribution systems and changing the freight requirements of inhabitants. The freight characteristics of consumer groups increasingly becoming stochastic and unpredictable.

Figure 1: The Impacts of Technological Innovations on Urban Freight Transport



New Technology Tools

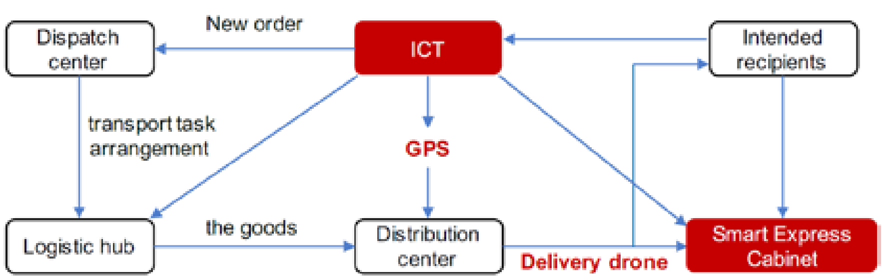
Alternative Fuel

Vehicles Internal combustion engine vehicles (ICEVs) have widely been utilized on urban freight system, for instance, truck and vans. Due to ICEVs consuming the majority of oil based energy and creating emissions, developing alternative fuel vehicles (AFVs) is used to reduce the dependence on oil for last-mile deliveries. Recently, there have been rapid advances in alternative fuel vehicles, containing electric vehicles (EVs), hybrid vehicles (HVs), natural gas vehicles (NGVs), and fuel cell vehicles (FCVs). EVs are powered by electrical energy only (Döppers F et al., 2012). The power also could be a collector system by electricity from off-vehicle sources, or self-contained with a battery, solar panels or a generator to convert fuel to electricity (Asif Faiz, 1995). HVs have two or more distinct power sources, and small electric batteries are typically used to enhance the efficiency of the combustion engine which by provide the electricity, and the oil-based energy is the current primary fuel of it. The power source of NGVs includes compressed natural gas (CNG) or liquefied natural gas (LNG). There are considerable LNG trucks transporting goods within an urban area. FCVs is also a type of EVs, but it powered by fuel cell stack to generates electricity. Using low-energy and low-emission vehicles can be achieved the energy saving. Reducing the air pollution and applying clean energy are advantages and meeting requirements of sustainable development. Nevertheless, the costs, carrying capacity and recharge mileage restrict the implementing AFVs on the urban freight transport. Additionally, building alternative fuel stations in cities is changing current planning of facilities' location, which provides new fuel for the AFVs, such as EVs charging stations, NGVs gas stations, etc. Furthermore, integrating distinct fuel stations are being strongly demanded to optimize the facilities location scheme service for various AFVs to achieve energy saving.

Delivery Drone

Unmanned Aerial Vehicle (UAV) or drone is an aircraft without the human pilot aboard that are controlled by a ground-based controller through a system of communications (ICAO, 2016). Delivery Drone is a type of UAV that has the potential to significantly reduce the costs and time required to deliver packages (Dorling K, 2017). Recently there have been rapid advances in delivery drone system, such as the project of Amazon Prime Air, DHL of Germany, etc. The operational framework of the delivery drone is based on the GPS and ICT for achieving accurate distribution in last delivery process (Fig. 2). Meanwhile, The Smart Express Cabinet have extensively been used in the city logistics system for reducing

Figure 2: The Operational Framework of the Delivery Drone



delivery time and costs within living area of cities. Using delivery drone system can be predicted to reduce the traffic congestion caused by vehicles run for home delivery. However, it still exists two elements to restrict the delivery drone implementation in practice: operation scheme and technical issues. The current operation scheme is that delivery drone flies from the delivery trucks or stations to drop off the packages to the smart express cabinet or intended recipients. Integrating both of alternative fuel vehicles and delivery drone offer a high potential for energy savings and reducing traffic congestion in the future. However, the existing technical issues are involved high costs of UAV easily influenced by the weather and artificial vandalism in the delivery process.

Autonomous Car

Autonomous Car (AC) is a vehicle that is capable of sensing its environment and navigating without human input (Gehrig et al., 1999). For urban freight system, the control systems of AC could analyses sensory data to distinguish between different cars on the road, which is very useful in planning a path to the desired destination (Wentao Z et al., 2014). Reducing the urban congestion and saving the costs of human resource are major factors to developing this technology in recent years.

3D Printing

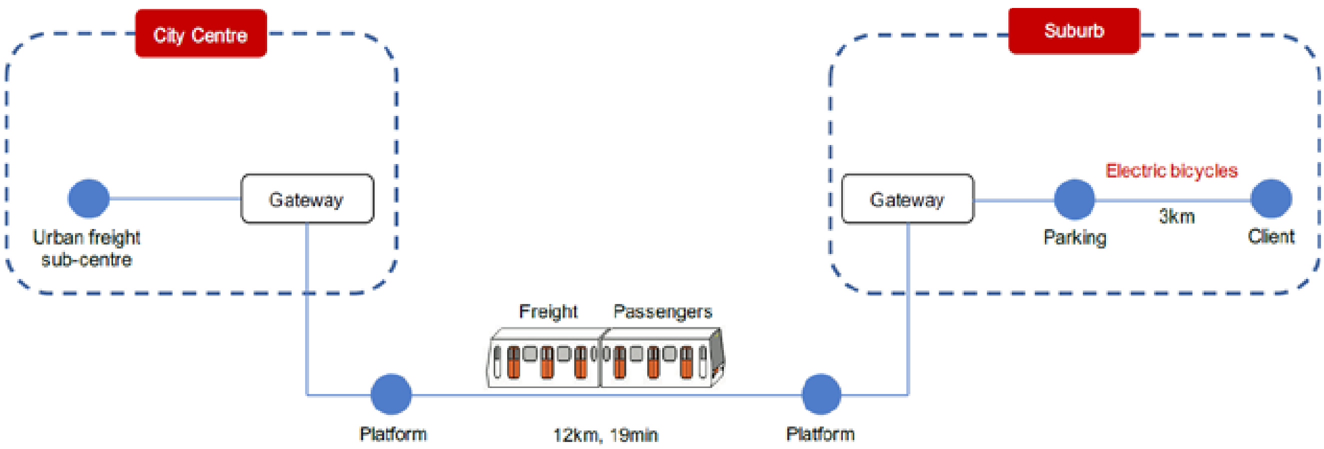
3D printing is an emerging manufacturing technology developed within the recent years. It has been utilized to produce specialized commodities at retail outlets or households. 3D printing has a potential to change the structure of supply chain and transportation system, since commodities can be produced which by 3D printers on-site and on-demand. It will be extensively used in the retailing and for personal. For the urban freight system, 3D printers can reduce the transport process particularly the distribution goods, but maybe increase the material transportation for creating goods. Implementation of 3D printers can reduce the storage at warehouse and waste of packaging for achieving costs saving. Currently, it is hard to estimate the environment influence of 3D printers on urban freight system, but applying it will reduce the demands for delivery to shops and individuals. In addition, increased demands of material transportation affect the current route planning and policy development on urban freight.

Co-modality

Co-modality is a type of transport mode, which is combining the public transport vehicles for achieving transport goods and passengers (Thompson and Taniguchi, 2014). For instance, trains, trams, buses and taxis. Public transport system can gain profit from the process of transport goods through using space on less crowded vehicles. The Yamato Transport Company has been developing a tram system for delivering goods to Arashiyama in Kyoto, Japan since May 2011 (JFS, 2011). This system has two carriage trams, which are used for passengers and freight respectively. Using electric bicycles is mainly for delivering goods to the client (Fig. 3).

The new subway-integrated logistics system of Yamato Transport Company has reduced the CO2 emissions and the number of vans used for delivering packages. However, three critical aspects hinder using traditional public transport vehicles for transporting goods: (1) extra transshipment costs, (2) needing additional handling equipment, (3) labor for loading/unloading vehicles and security. Implementing this system is needed to reorganize the previous route planning and policy development on urban freight. Furthermore, the system's interaction and coordination with other new technologies in urban freight transport should also be considered.

Figure 3: Conceptual Image of the New Subway-Integrated Logistics System



New Planning Concepts

Industry 4.0

Industry 4.0 is establishing the smart factory standards to provide smart products and services by means of smart logistics (T. Stock. et al., 2016). It is the future system for Industrial Chain and Supply Chain, and its main characteristic is 'Smart' objects (Lasi H et al., 2014). It is now becoming more and more popular in manufacturing and logistics systems. Recently, a considerable number of enterprises have designed the planning scheme and developed related technologies for Industry 4.0. The ICT and logistics are the basis of achieving it. Hülsmann T (2015) presents the significant future areas for the implementation of industry 4.0 explaining that it includes Logistics, IoT and E-commerce, etc. (Fig. 4).

The concept of Industry 4.0 has emphasized the significance of deep integration, particularly in the urban freight transport. The global environment of supply chain and the current structure of urban freight will be altered as Industry 4.0 implementation advances.

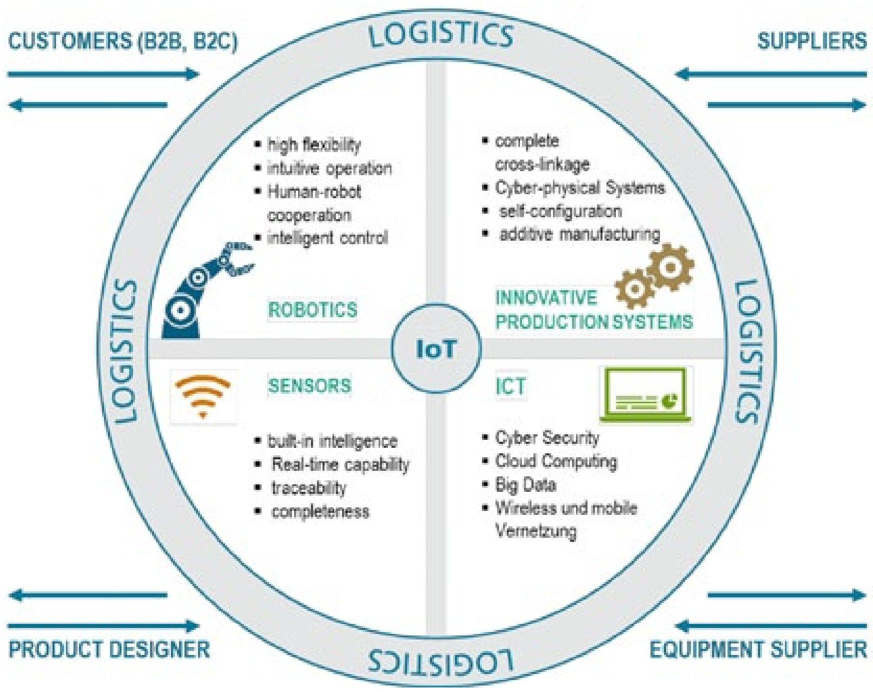
Connectography

It is proposed by Parag K (2016) that competition of supply chain is quickly becoming the theme of globalization as Geopolitics will be gradually disappearing. Moreover, he presents that integrating and connecting resources, production, services and consumption could achieve Economy of Globalization, which establishes the global supply chain. This concept indicates that the future trend of international logistics is integrating various technologies in order to achieve a deep integration and resource-sharing between different countries involved in the global supply chain. Therefore, the policies of urban freight will be affected since it is a terminal of the global supply chain.

Internet of Things

It is the inter-networking of connecting physical devices, smart devices, vehicles, buildings, and other items through the internet technology, and collecting and exchange of data (Brown et al., 2016). It is the main feature of the Big Data era. For urban freight system, IoT has changed function structure of facilities and vehicles as it improves related technologies for enhancing the service experience for residents.

Figure 4: Significant Future Areas for the Implementation of Industry 4.0



Logistics 4.0

Logistics 4.0 is utilizing smart devices, smart tools and humanizes services to establish the smart logistics systems while collecting and exchanging data to attain the purpose of 'self-evolution' (Thomas B, 2016). The Logistic 4.0 is the basis of Industry 4.0, and it is a crucial factor to enhance the competitiveness of enterprises in the background of Globalization. From viewpoints of planning the Logistics 4.0, the appropriate adjusting of current freight policies and developing related technologies are very important.

Conclusion

Continuing rapid population and economic growth lead to significant increase in freight activities in transport networks, causing traffic congestion and environmental damage. Moreover, the energy problem increasingly becomes highlighted and exacerbates the situation within an urban area. In order to find a solution to these issues, use of technological innovations is an effective approach to reduce the pressure for public departments and provide a better experience for inhabitants while enhancing the livability and sustainability of the urban environment. Optimizing the location of logistics facilities is important in megacities since it always influences land use and traffic environment. Furthermore, designing the operational scheme of route planning is a critical component of achieving sustainable development for the range of urban area. In addition to developing the policies of urban freight, the local authorities are also required to comprehensively consider the space competition among the passengers and freight as well as the interaction between the various emerging technologies. In conclusion, under the new planning concepts, which are to be implemented in the future, the public and private entities will focus on integrating distinct new technological tools and reorganizing the structure of urban freight for achieving deeper integration and sustainable development within the urban area.

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Truck Dispatching Systems for Open-pit Mines: A Systematic Literature Review

Material handling is a major logistic process for open-pit mines. To improve this logistic process, several solutions have been proposed, which use different methods and pieces of information. The purpose of this study is to identify gaps in the existing systems, and propose research to be carried out in the future. To achieve this goal, a literature review of the articles published from 2002 onwards has been carried through. The main results indicate that the use of specific information from equipment items and the use of methods able to deal with the dynamics of the environment are still a requirement for these systems, which are yet to be met.

Gabriel Icarte*

Introduction >>> An open-pit mine is a mine where soil and rock cover an ore deposit. In these kinds of mines, a major process is the material handling [1], which consists of the extraction and transportation of soil, rocks, and ore to different points in the mine. This process is carried out in a dynamic environment that may affect the performance or availability of the equipment items involved.

The equipment involved in this process must be organized efficiently to achieve the goals pointed out in the production plan with minimum cost. In order to achieve this, several solutions have been developed, which indicate the destination where the trucks must go, taking into account the objective of maximizing the production, minimizing the cost, or even both. These systems are called Truck Dispatching Systems (TDS). Depending on how they try to achieve these objectives, they use different methods and pieces of information from trucks, shovels, crushers, production plans, and the mine layout. <<<

Research Method

In this review, several elements were established following the procedure proposed by Kitchenham [2]: the objective of the review, the aim and the research questions, the search strategy, the selection criteria and the data extraction.

A review of solutions for the TDS was published in 2002 by Alarie and Gamache [1] where the main findings are related to the approaches and strategies utilized in the solutions. Another review on TDS was presented in the early 2017 by Moradi and Askari-Nasab [3]. In this review, they discuss industrial fleet management systems and the main algorithms behind such systems. Unlike the previous reviews, this work considers other aspects of TDS such as the identification of the main methods used, the objectives pursued, the information used, and the main challenges proposed. Thus, the value of this study is to provide information to researchers on how solutions have been developed and what aspects of the TDS have been taken into account. Based on these two notions, this review addresses the following research questions:

- RQ1. What are the objectives pursued by the solutions?
- RQ2. What are the methods used by the solutions?
- RQ3. Which information is used by the solutions?
- RQ4. What are the main challenges?

Results and Discussion

In this review, 42 articles have been evaluated. From those, 24 articles are from journals and 18 from conference proceedings, which correspond to 57% and 43%, respectively.

Objectives Pursued (RQ1)

Most commonly, the maximization of productivity is the main objective. Secondarily, objectives related to the simulation modeling are used. The minimization of the cost is the third objective, and the consideration of the joint maximization of productivity and cost minimization is the fourth most commonly occurring objective.

To maximize the production, researchers apply different strategies, which are more related to trucks, such as maximizing the truck production, minimizing the truck waiting time, minimizing the distance to be covered by trucks and minimizing the number of trucks in queues. To minimize the cost, the main strategy is to reduce the use of the resources, which is frequently implemented by minimizing the quantity of trucks. Other objectives found are mainly pursued by simulation modeling techniques: to test methods and/or approaches and to support decision-making.

Methods in Truck Dispatching Systems (RQ2)

The method most commonly used is simulation modeling. The majority of the articles that used simulation modeling do it for various purposes such as to support decision making, test methods, or to evaluate the behavior of the TDS in different scenarios. This is a major difference compared to operations research (OR) methods and heuristic procedures, which are focused on achieving the maximization of production, the minimization of cost, or both. Not many criticisms were found for the use of simulation modeling. Only Krause and Musingwini [4] indicated that it is possible to get different results from different models with the same input parameters.

Operations research methods are the next set of methods used by authors. The researchers often used methods based on linear programming and queueing theory. In addition, some articles show the use of OR methods with others techniques, such as simulation modeling and heuristic procedures. One of the main disadvantages of the OR methods is that they use estimated pieces of information; therefore they cannot guarantee precise solutions. Another disadvantage mentioned is that these methods do not consider the dynamics of the environment.

The techniques less commonly utilized are heuristic procedures. Three kinds of such procedures were found: those based on evolution, those based on rules, and those based on Particle Swarm Optimization (PSO). The methods based on heuristic procedures show good results, however, some researchers mentioned the same disadvantages as the ones for OR methods. In addition, other disadvantages have been mentioned: the use of mutation and crossover operators to define the population could be affected by the fact that a part of the population may affect the optimization procedure.

Information Used (RQ3)

The methods used mainly employ variables regarding trucks and shovels. Most commonly used variables related to trucks are the truck cycle time, truck waiting time, loading/unloading times, capacity and truck type. For the shovels, the variables mostly used are the shovel waiting time, saturation and coverage, capacity, loading rate and material extracted.

Other information is also considered, but to a lesser extent: the information related to the destinations of the trucks (crushers, stockpiles, and waste dumps), the mine layout and the production plans. In the case of the crushers, the capacity, blending requirements, and the crushing rate are often used. For the case of mine layout, the location of loading/unloading points and the road network were mostly used. The kind of information less commonly used is the operational cost of equipment.

Main Challenges (RQ4)

Less than 30% of the reviewed articles propose future work. Adding more operative conditions to proposed solutions is the most common future work mentioned. Another type of future work mentioned is related to adding and combining components to improve their solutions. The last kind of future work mentioned is related to doing more tests.

Gaps and Proposed Research

From the results and their discussion presented above, the following gaps are identified:

Lack of the use of specific information: The use of the average information is a disadvantage since it cannot guarantee precise solutions. Therefore, further research is proposed on the use of methods able to deal with specific information from each entity involved in the TDS.

Consider the dynamics of the environment: Some methods do not guarantee an efficient reaction when there are some changes in the environment because the methods do not consider the dynamics of the environment. Therefore, further research is suggested that includes the uncertainties of the processes.

Lack of tools to compare the methods: The methods are often used with specific scenarios. Therefore, their results might not apply to other scenarios. It is suggested that a dataset is created to help researchers in this way sound comparisons between the different methods.

Conclusions and Outlook

It was found that simulation modeling is the mostly used technique by researchers aiming to support decision-making. On the other hand, use of estimated information and the delayed reaction to the changes in the environment are the main disadvantages to the use of current methods. Future work involves the use of specific operation data from the equipment items and considering the dynamics of the environment. A multi-agent approach could be used with real-life data wherever each equipment item involved can be represented by an intelligent agent ("digital twin").

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Process Mining Overview in Manufacturing and Logistics

As a result of the characteristics of manufacturing and logistics, such as uncertainty, complexity, and dynamics, enterprises have strived to improve their business processes to compete in the market. Enterprises need to perform analytical revisions to identify and evaluate possible specific improving actions. Process mining has been proved feasible and effective in the area of business process improvement. It analyzes event logs and provides knowledge and information to discover, monitor and improve real processes. However, traditional process mining has limitations with respect to insufficient data. Furthermore, there is a limited amount of studies in the area of process mining application in the field of manufacturing and logistics. Therefore, this paper introduces an overview to process mining approaches while pointing out the issues and challenges in process mining within the context of manufacturing and logistics.

Wacharawan Intayoad

Introduction >>> Complexity, rapid changes, globalization, and uncertainty in manufacturing and logistics systems lead to high competition in the industry. Various factors cause these circumstances. For example, some products require many steps and many days to be finished. The manufacturing and logistics process might be operated across functions in company's different sites and organizations. Moreover, other factors such as the product variety, shorter product lifecycles and rapidly-changing customer needs cause business processes to become more complex. Apart from that, the uncertainty also influences the regular business processes such as job delay, broken tools, unavailable resources, or changing customer demands. Consequently, the process plans, which are generated in advanced often become infeasible or unusable [1]. However, organizations have attended to achieve process optimizations, such as high-quality products at low costs and fast delivery [1]. Therefore, business process improvement and optimization are required for companies to stay competitive in the market [2].

Under these circumstances, enterprises require intensive knowledge to optimize business processes. Knowledge provides organizations with new ways of learning, problem solving, and creation of core competencies [3]. In the modern manufacturing and logistics companies, the volume of data has been growing at an exponential rate, which can be used to extract valuable knowledge [4]. The collection of data contains useful information that could be applied to improve decision-making and productivity [5].

Process mining aims to extracts knowledge from event logs to discover, monitor and improve real processes [6]. Process improvement and compliance benefit from process mining. Over the last decade, process mining has been successfully implemented in many domains such as healthcare, education, software development, as well as manufacturing and logistics. Process mining is an approach for process discovery and analysis from the event logs. Event logs are generated from software or systems in companies. Since most of the today businesses support by information technology, a large amount of data can be collected during the normal operation of manufacturing processes [6]. However, process mining relies on the assumption that event logs provide sufficient data. In manufacturing and logistics, event logs are from different sources. Such data often is not from workflow management systems. As a result, it is insufficient, contains missing items, and is noisy.

This paper provides an overview of mining business process, process mining and also discusses the related challenges and new opportunities particularly in manufacturing and logistics. The discussion includes a review of the cutting-edge business process mining and example of the related works. Then I synthesize the general challenges and opportunities of the process mining in manufacturing and logistics setting. <<<

Process Mining

Process mining aims to analyze the data from event logs to discover, monitor and improve real processes [6]. It is based upon data mining. While classical data mining is data-centric, process mining is process-centric [7]. Process mining has proven fea-

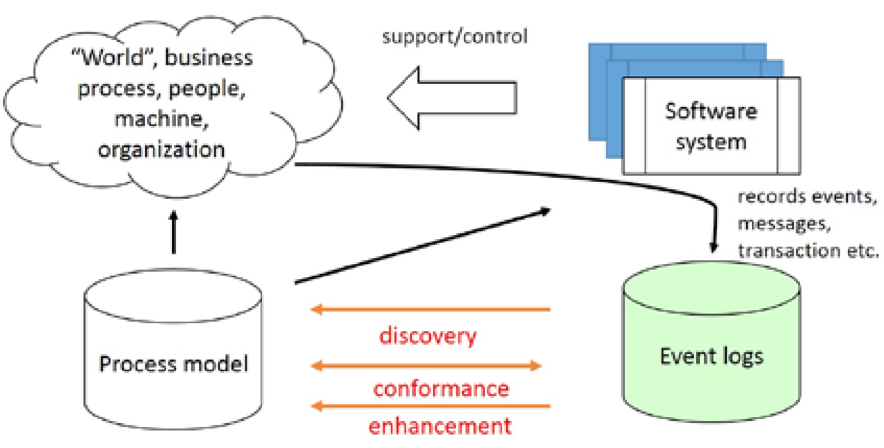

Figure 1: Three Main Types Process Mining Edited from van der Aalst, Wil, et al. (2008) [10]

sibility and effective in the area of business process improvement [8], [9]. Fig. 1 depicts the three main types of process mining: discovery, conformance, and enhancement. Process discovery is the main objective of process mining based on event logs in order to find the actual processes and process variants. The most challenging task in process discovery is coping with flexible business processes. It is difficult to find the accurate process models and interpret process models. Process conformance intends to conform the designed process model to the actual process. It can be extended to utilized in the cases of fraud detection or deviations [10]. The process enhancement aims to extend or improve the existing business process models using information recorded in event logs. For example, process enhancement aims to modify the process model to better reflect the real process [10].

The process model is the essential tool for business process management as well as process mining. That is due to the fact that the process models provide a visualized understanding of the business processes, such as transition systems, Petri nets, Business Process Model and Notation (BPMN), Event-driven process chain (EPCs), and Unified Modeling Language (UML). These models allow enterprises to analyze the processes for process re-engineering or process improvement [11]. The techniques that have been widely adopted are modeling and graphical documentation. In the process mining approach, the process model quality can be determined by four characteristics: simplicity, fitness, precision, and generalization.

The information systems in the modern manufacturing and logistics companies produce an enormous amount of event logs. The event logs generally describe process executions and activities in the real world. These event logs can be used to provide a better understanding of the actual processes [12]. However, process mining relies on sufficient event logs for analysis. Often these events logs are unstructured, unreliable, missing and noisy. Moreover, complex business processes are difficult to model. They cause spaghetti-like process models that are hard to comprehend [6]. Fig 2 shows the example of a result from traditional process mining experiment with the real-world event data from manufacturing companies. Furthermore, the huge amounts of data require automatic and intelligent data analysis methodologies for discovering the valuable knowledge. Therefore, process mining needs additional steps to prepare data for analysis.

Process mining has been deployed in various areas of manufacturing and logistics. It has been proven in various studies that it is able to detect deviation [13]. However, it cannot handle large amounts of data [14]–[16] and heterogeneous data sources [13] efficiently. Event logs are the input for process mining in order to extract actual business process models and valuable information. Process mining relies on the quality of the event logs. It requires sufficient data in order to analyze and interpret accurately. There are some studies devoted to enhancing process mining in manufacturing and logistics by adopting other techniques and methods, such as process clustering using contextual information [17]. The study applies frequency of occurrence of a process and the stability

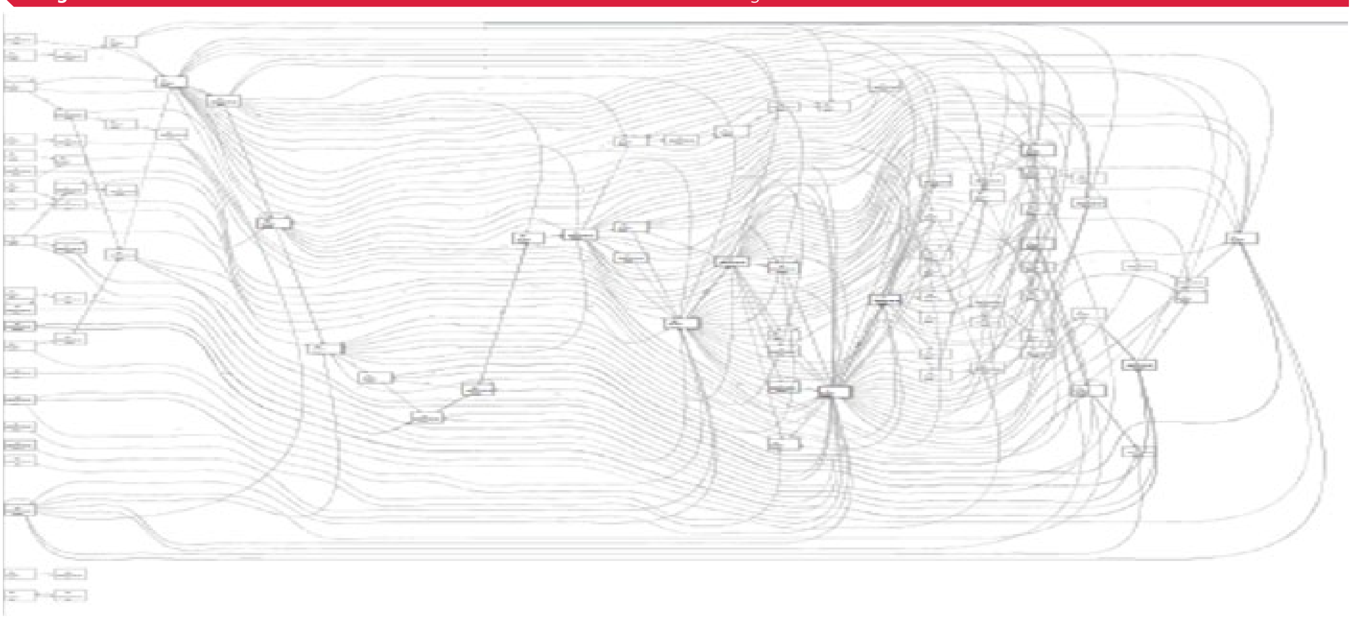

Figure 2: Derived Process Model of Real-World Data from Traditional Process Mining

of the cycle time of repeating processes for clustering purpose by applying k-mediods algorithm. The six cases of the real event logs from manufacturing were deployed to evaluate the clustering quality. The method works well in different number of cluster k, which means that the datasets are diverse. The number of clusters is also a challenge to figure out in advance. Therefore, it is necessary to check the result with different numbers of cluster. On the other hand, the circle time works can be considered as relevant context information for clustering the result. They suggested that to cope with the complex and heterogeneous data, the investigation can consider additional context information, which can be retrieved from event logs. Nevertheless, studies on the application of process mining in manufacturing and logistics are still rare, particularly in the field of improving, discovery and process analysis methods.

Issues and Challenges

The discussion in this section focuses on mining business process data based on manufacturing and logistics systems. These issues and challenges are based on the effectiveness and efficiency of automatic process analysis.

Variety and Heterogeneity

Data may be distributed a variety of sources. Process mining relies on sufficient data for analysis. In real life, event logs are derived from different data sources. In manufacturing and logistics, the event logs do not offer sufficient quality in terms of completeness and reliability. Because these data are not generated by workflow management systems, but other types of systems, which has been designed for completely differently purposes (e.g., billing or warehouse management). As well as, they are messy and correlated data [16]. Moreover, they contain outliers and have different types of granularity [7].

Generally, the manufacturing and logistics processes are separated among several sites of a single enterprise or cross-organizations (e.g. supply chain partner). This division has caused a further growth in process complexity [1], [18]. However, the traditional process mining considers single event log in one organization [7], the cross organizational process mining should be considered. Moreover, heterogeneous data sources have different data format, unstandardized, and have different granularity. As a result, to handle numerous heterogeneous data sources effectively requires an additional step before analysis and interpretation.

Scalability

A huge amount of data is generated during manufacturing and logistics processes. A large volume of data can be explored to create knowledge and valuable information. However, most data are archived because these data are difficult to handle [19]. Business process analysis encounters the large amounts of data, which make data analysis more difficult and less efficient. Therefore, business process analysis is in need for new methodologies and innovative concepts to manage these circumstances efficiently.

Accuracy

The result of process mining has to be evaluated to ensure the analysis accuracy. There are four competing quality dimensions: (a) fitness, (b) simplicity, (c) precision, and (d) generalization. The challenge is to find the models that trade-off among all four dimensions. Fitness refers to the accuracy of discovered model that it can accurately reproduce the case recorded in the log and display the behavior in the event logs. Simplicity means the simple of the models, which the discovered model should be present as simple as possible from the complex process. Precision is related to underfitting in the context of data mining. So the unrelated behaviors should not be seen in the discovered model. Generalization refers to the discovered model should be the generalized example behavior.

Complexity

Some manufacturing processes are very complex. They might span over many steps and many days. Particular in logistics processes, the business processes are rather human-centered operations. They are very flexible and complex. Such operational processes are less structured, overly confusing, and spaghetti-like processes. As a consequence, it is difficult to extract the process model accurately and explicitly[15]. Moreover, the complexity of the system makes it difficult to analyze [20].

Flexibility

Dynamic and rapid changes in business environments demand logistics and manufacturing processes to be flexible and responsive to compete in the market. The traditional process mining can be enhanced by combining with other techniques and methods to supporting online operation, which can be in the form of detection, prediction, and recommendation.

Conclusion

This paper presents the process mining approach, issues, and challenges when being applied in the manufacturing and logistics domain. Even though process mining is a promising tool for supporting business process improvement and it has been deployed successfully in various domains, the characteristics related to the focus domains generate new challenges for traditional process mining and also create opportunities to make use of the variety. Manufacturing and logistics process mining requires the solution to cope with these challenges. The result of this paper generates general issues that have to be taken into account when integrating process mining for process discovery and analysis.

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The Belt and Road Initiative and Global Logistics Networks Redesign

The Belt and Road Forum for International Cooperation, held in Beijing on 14th and 15th of May 2017, raised extensive concern worldwide. It is the highest-profile international meeting on the Belt and Road Initiative (BRI) since proposed. There are comments that regarding the implementation of this initiative, the impacts of BRI on global logistics networks will be significant, due to the consequently changing economic environment. This report focuses on the state of the research on the BRI and global logistics networks redesign, to prepare for the further analysis of the causal relationships between policies and global logistics, and reconfiguring global logistics networks in the context of BRI.

Ye Jing

Introduction >>> The Belt and Road Initiative (BRI) was unveiled by Chinese president Xi Jinping in 2013, referring to the proposal to build "the Silk Road Economic Belt (SREB)" and "the 21st Century Maritime Silk Road (MSR)" (Wei, 2015). It is a long-term strategy aims at improving traffic connectivity and cooperation among countries primarily between China and the rest of Eurasia. The "Belt" and the "Road" represent the above-mentioned two physical transport corridors, running through the continents of Asia, Europe, and Africa (see Figure 1) (NDRC, 2015). The land-based SREB plans to establish roads, railways, and gas pipelines across central Asia to Europe; the ocean-going MSR goes through the South China Sea, the South Pacific Ocean, and the Indian Ocean area (Lo, 2015). Facilities' connectivity, along with policy coordination, unimpeded trade, financial integration and people-to-people bonds, together form the five major goals of BRI. <<<

Figure 1: The BRI Routes ((PwC, 2016), Sourced by Xinhua)

The State of the Research

The initiative was proposed in 2013. However, since the year 2015 researchers have started to show their curiosities and interests in analyzing the implications of BRI in various aspects: politics, foreign policies, world economy, regional development, logistics, etc. Although the amount of literature concentrating on the impacts of BRI on logistics networks is still few, the existing research organizations and upcoming events around BRI have already highlighted the research focus. On the other hand, as the strategic content of supply chain management, redesigning global logistics networks have been widely studied in recent years, motivated by the tendency of world economy.

The state of the research can be divided into two parts: research on BRI, and research on global logistics networks redesign.

Research on BRI

As mentioned above, many perspectives about BRI have been studied, some researchers make efforts to analyze the conception or the objective of this initiative from a political view; that is to say they study it as a foreign policy. Many researchers concentrate on the impacts of BRI on the local economic development. The studied subjects include economic blocks such as ASEAN; geography districts such as Eurasia, Europe; countries such as Pakistan; districts such as Shaanxi Province. There are also articles considering the implications of the BRI for the entire world's economy, financial investment and environment.

It can be concluded that although there are waves of studying BRI worldwide, the literature researching on impacts of BRI on logistics networks are still rarely. Nevertheless, a few researchers noticed that and started to make efforts. "One Belt and One Road (OBOR) international conference on the Silk Road Economic Belt and the 21st Century Maritime Silk Road for Transportation and Global Supply Chain"-the OBOR Conference 2016 was held at RMIT University, and about 40 articles on this initiative published. In addition, it was the topic of 2017 JRI International Conference "Made in China 2025, One Belt One Road Initiative and Its Implication on the East Asian Economy and Logistics" held in June of 2017.

Global Logistics Networks Redesign

As crucial components of supply chain management, logistics networks have been designed or redesigned for two main groups: the global carriers (logistics service providers), and the manufacturing corporations (Creazza and Melacini, 2010). A majority of the existing literature concentrates on designing new networks instead of redesigning the existing ones (Hammamiet al. 2009). In order to respond to varying customer demands and product service requirements, research on redesigning logistics networks on a global scale has become more frequent in recent years. Redesign primarily aims at improving the performance of existing structures, and is often motivated by expansion to new markets, mergers, acquisitions or strategic alliances (Melo et al., 2009). However, most of the research on redesigning logistics networks apply operations research as methodology, and choose mathematical formulation or computer simulation to solve the models (Melo et al., 2014; Melo et al., 2009). Therefore, some key location-specific factors, which cannot be directly calculated or quantified, are not fully considered. Factors such as the impacts of different trading policies between countries on the logistics activities.

Conclusion and Outlook

In this report, the state of the research is presented in two categories respectively: BRI and the redesign of global logistics networks. This is partially because the consistency between global logistics networks and policy decisions is normally ignored by researchers. Few researchers studied the effects of BRI on global logistics networks. Besides, global logistics networks redesign modeling concentrates more on considering the customer demand and cost competitiveness, rather than the policy-induced changes in the globalization context. This necessitates the analysis of the relationships between these two parts, which also defines directions for future research, as well as the comprehensive modeling of redesign.

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Role of VANET in Logistics and Transportation

In Intelligent Transport Systems (ITS), Vehicular Ad-hoc Network (VANET) is one of the key wireless technologies, which helps in managing road safety, traffic efficiency, fleet, logistics and transportation. The objective of this paper is to give an overview of the implication and placement of VANET in transportation and specifically in logistics. It also summarizes the current projects regarding VANET for safety and non-safety applications. We additionally discuss current and potential domains in logistics in which new applications can improve efficiency by using VANET.

Kishwer A. Khaliq*

Introduction >>> Vehicular Ad-hoc Network (VANET) is the one of the challenging domains in wireless networks and has unique features. It does not only offer efficient traffic management, logistics and transportation, navigation, and road safety applications, but also regards for online gaming and infotainment applications [1].

Logistics includes a number of activities that ensure the timely availability of the right product to the customer and these activities create a bridge between production and consumption [2]. Two parameters can have great impact on the distance between production plant to the location market or supplier unit, i.e. availability of the product to deliver, and time efficiency in delivery of it. To get market benefits, delivery of the right product to the right consumer on right time is equally important for all companies. To cope with this challenge, the sub-system of logistic requires efficiency and automation. In the logistics process, where each stage has specific requirements with respect to the next level. At each level, different technologies can be helpful to get the required benefits. Regarding raw material, the efficient collection of it, can boost the production of the desired product. At the production units, synchronization of production steps autonomously and information management about the product specification according to demand are the important factors. Market share increases with the best distribution of product in the market and simple accessibility for the customer.

To meet the challenge of product-delivery from the production-unit to the market, efficiency in transportation is required. Efficiency in terms of time may vary because it depends on the type of product, mode of transport and location of the need [3]–[5]. The development of technology like automobiles, electronic devices, and home appliances requires different place and time-values than the production of food items. The food-item exhibits a short life span and requires delivery to market when it is fresh. In a competitive market, the latest technologies are used to shorten the process of production, and enhance storage and inventory for the quick distribution, monitoring and possible re-routing.

Sourcing from the raw material to the finished products and the respective distribution involves many tiers in the supply chain flow. In practice, supply chain integration is the setscrew and active research area to improve the supply chain performance. This integration involves two kind of flows. The first flow involves the physical steps that need to be carried out, while the second flow complements the first flow (logistics) with respective information. Previous studies [6], [7] addressed these two flows by merging information and logistics. The research studies also showed that with the help of technology transference [8], [9], the process of logistics and transportation has become more flexible. The objective of this paper is to pinpoint the advantages and importance of VANET technology in logistics and transportation with respect to the previously mentioned issues, and to discuss use of VANET to simplify this process by reducing time of product life cycle with value added services and reducing delay in delivery.

The rest of the paper is organized as follows. Section II gives the state of the art. It reviews the technology role in logistics and transportation, and discusses VANET current projects in the research area. Section III discusses different scenarios where one or more technologies can add benefits to companies. It gives overview of VANET projects for transportation. Section IV concludes and explains possible future work. <<<

Vanet in Logistics

The efficient production of customized products and their supply are the key to success for many companies. Failure leads to loss of revenue, decline in level of services, reputation and market share. Recent developments in the market e.g. increase in market competition along number of products with short life cycle and product proliferation, have created a scenario where the customer's demands are unpredictable. Thus, the ability to appropriately respond to the market has become a major asset for many companies, and a motivation for them to improve their logistics systems [10]. In port scenarios, complexity is increasing with the expansion of supply chains. Modern ports require advanced track and trace, security, information sharing and monitoring and VANET has the potential to fulfill these needs of port facilities [11] [12]. In [13], authors discussed the adoption of communication technologies to experience high levels of visibility, control and connectivity across the entire supply chain and examined the feasibility of VANET in a multimodal logistics environment. They recommended architecture to provide mentioned goals, which also assure security while accessing. Another article [14] explained its potential to manage the flow of goods and resources efficiently, particularly within international ports. In [15] authors discussed the key role of Information and Communication Technology (ICT in managing logistics operations and supply chains. Table I summarizes this discussion along target sub-tasks and solutions provided by the mentioned technology.

Vanet Projects, Applications and Discussion

Any projects are also running to develop prototypes of VANET for industry. Car-to-car cooperation [20] is a VANET project running in the Aqua-lab of Northwestern University. This project aims to provide information and entertainment to the passengers and automotive safety, and to reduce the impact of traffic on environment and smooth traffic flow. The project "Innovative Wireless Technologies for Industrial Automation (HiFlecs)" [21] in the University of Bremen, develops innovative wireless technologies for industrial real-time closed-loop applications. In the future industry, the wireless technologies allows to connect machinery and control units wirelessly. There are different challenges for future Industry 4.0 applications like low latency, highly reliability, deterministic, and secure communications. To meet these challenges, HiFlecs develop key technologies for an industrial wireless communication system with new functionality and features for real-time control applications. Intelligent System and Sensors [22] is the project of Auto21 for the development of control and monitoring of vehicle behavior, guidance, navigation, telematics, driving assistance and automation. Another funded project [23] of Auto 21 named "Vehicle Communications and Applications" at the Interlab of University of Sherbrook focuses on the development and testing of cost effective communication infrastructure, design of cooperative control strategies and their integration for vehicular communication applications. "Canadian Association of Road Safety and Professional (CARSP)" [24] is dedicated to enhance road safety by developing safety applications. Last, U.S. department of transportation is dealing with safety application where focused applications are emergency electronic brake lights, blind spot brakes, forward collision warnings, etc. It outlines new ITS Strategic Plan 2015-2019 [25] and provides a framework around with ITS Joint Program Office for research, development, and adoption activities to achieve goals. This plan is built around two key points i.e. priorities-realizing connected vehicle implementation and advancing automation. Furthermore, this plan includes program categories regarding connected vehicles, automation, emerging capabilities, enterprise data, interoperability and accelerating deployment.

Table II gives the summary of the all presented projects where road safety or automotive safety are key targets. However, some projects are focusing on the monitoring and some projects are working to improve the traffic efficiency with minimal impact on the environment and cost effective communication infrastructure. From the current projects objectives, we conclude that companies are looking for low cost, automotive safety and monitoring solutions to support logistics and general transport applications with high reliability.

In logistics and transportation, many applications can be used like automatic vehicle detection or vehicle parking system for the logistic hot-spots (e.g. seaport, warehouses etc.). It can also be used for the efficient traffic management for online delivery of logistics goods from production units to the distributed points or warehouses. Additionally, it allows automatic traffic control, re-routing the traffic in case of the traffic congestion [26] for improving just in time delivery and speed limit enforcement. Figure 1 shows the major four hot-spots of the logistics process where VANET technology can be used to maintain the information and logistics flow with the coordination of other technologies where transportation is the key factor that links industries to customers and consumers. We already know that for automation in manufacturing, we use robotics and to maintain database of products and information online technologies and sensors are already deployed on different production units. By integrating these deployed technologies with VANET, we can improve efficiency in automation in terms of information flow and control [27].

Table 1: Current Role of VANET in Logistics

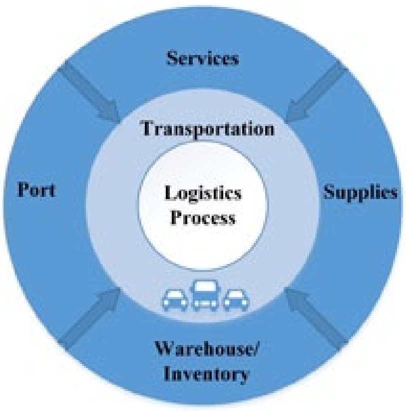
Article	Targeted Sub-task	Solution
[11] [12]	Enhancing port facilities	provide clustering solution to fulfill needs of port facilities like track and trace, security information sharing and visibility
[13]	Visibility, control and connectivity acress entire supply chain	Provide enhances visbility and connectivity
[14]	Monitoring and coordination of portside vehicular traffic	Reliable applications for monitoring and coordination, Efficient solution for information sharing
[15]	Logistic operations at intra and interorganizational level	Build communication links between enter-prises and for many organizations around the world

Table 2: Active Projects for Transportation

Project	Purpose	Organization
ITS [16]	Road safety,traffic management, secure vehicular communication	European Comission
TRIP [17]	Research activities for transportation	European Comission
Horizon 2020 [18]	Ideas generation and growth sustainability of transport	European Comission
C2C [19]	Fatalities reduction during road accidents,Improve efficiency, reduce impact on environment	C2C-CC
Car-to-Car cooperation [20]	Automotive safety, infotainment and entertainment for passengers, reduce traffic impact on environment, smooth traffic flow	Aqua-lab, Northwestern University
HiFlecs [21]	To develop innovative wireless technologies for industry	University of Bremen
Intelligent system and sensors [22]	Control and monitoring of vehicle behavior,vehicle guidance navigation and telematics,driving assistance and automation	Auto21
Vehicular communication and applications [23]	Development and testing of cost-effective communication infrastructure, design of cooperative-control strategies	Interlab, University of Sherbrook funded by Auto21
CARSP [24]	Road safety	CARSP
ITS 2015-2019 Strategic Plan [25]	Connected Vehicles, automation, emerging capabilities, enterprise data, inter-operability, accelerating deployment	U.S. Department of Transportation

Considering Figure 1, within logistic processes the key goals are automation, monitoring, process control, chain optimization and information base, and currently multiple technologies are being used in each hotpots to achieve goals. We observed in this case study that VANET has the potential to not only inter-link these hotspots, but also improve each unit. Hence, efficiency in delivery can improve economic factors for industries, and improve service level for customers and consumers while managing the freight transportation by providing best routing information, alerts for traffic jam or rerouting for congestion.

Figure 1: VANET Integration in Logistics



Conclusions and Future Work

VANET is being used for road safety, traffic management and logistics applications. With the objective of the technologies and VANET integration in logistics and transportation, it is concluded that these technologies add ease into the logistics functions. VANET as key technology in logistics and transportation, has potential to provide flexible and cost-effective solutions for logistics and transportation. It also has capability to make bridge to interlink hotspots of logistics process and other technologies. For the deployment of this technology along attractive applications, a number of projects are running under different research organizations, where each project aims to fulfill specific objective.

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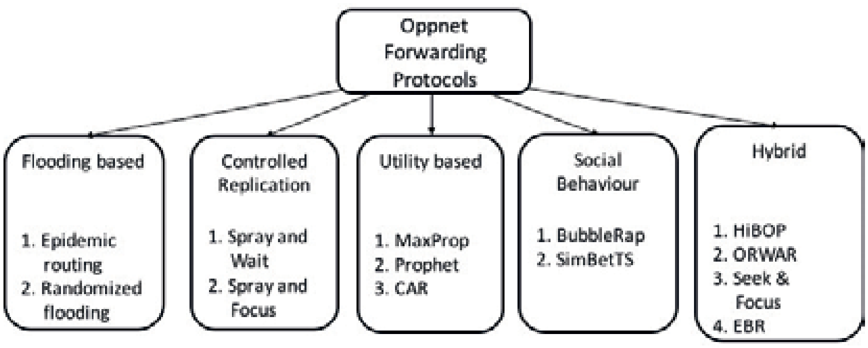
Study of Forwarding Protocols in Opportunistic Networks

Opportunistic networks forward data whenever they have the opportunity to connect to the neighboring nodes. The forwarding protocols in these networks are responsible for the procedure of data dissemination between nodes. Although the literature contains several forwarding protocols, their performance depends on the configuration and application scenarios. Our main focus is to study the forwarding protocols for destination-less scenarios. Hence, it is essential to identify the applicability of protocols as per the requirements. This report consists of the study and classification of widely-used forwarding protocols in opportunistic networks based on their operation and a brief performance analysis of epidemic routing protocol.

VishnuPriya K.M.

Introduction >>> Opportunistic networks (Oppnets) comprises of wirelessly connected nodes, which exchange data when they meet. Disaster applications and emergency scenarios have been the major applications of opportunistic networks. However, the use of opportunistic networks is also an efficient approach to disseminate data in mass events. The protocols are designed in such a way that the data is reached at the destination in an ad-hoc manner. A brief survey of these protocols has been discussed in [1]. Furthermore, we attempt to classify these protocols based on their data dissemination process. The classification is shown in Figure 1. Flooding based protocols disseminate data whenever they come in contact with a node. They work for both destination-oriented and destination-less scenarios. Protocols from other categories use a priori information about the destination and hence, can cater to only destination-oriented data delivery. In this report, the performance of one of the flooding based protocols is studied. <<<

Figure 1: Classfication of Oppnet Forwarding Protocols



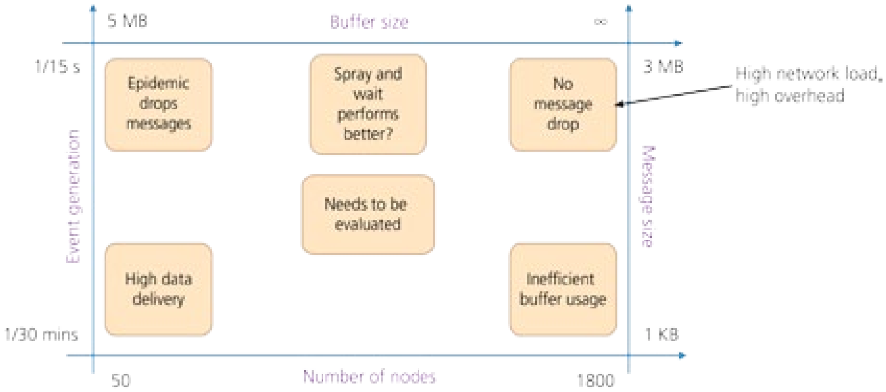
Forwarding Protocols in Oppnets

In our work, we study the Epidemic routing [2] and Spray-and-Wait [3] protocols. We are interested in evaluating Oppnets for destination-less scenarios and hence, these two protocols from the literature fit our requirements. This report only focuses on the performance analysis trends of Epidemic Routing (ER). The nodes in ER flood the network with the information they have. In ER between two nodes, the node with the lesser node ID (Node A) exchanges its summary vector with the node with the larger node ID (Node B). The summary vector contains the packet identifiers of the packet in Node A's buffer. After receiving the summary vectors, Node B checks its own buffer and identifies the missing packets in comparison with Node A's summary vector. Consequently, Node B sends a data request to Node A for only those missing packets. Then, Node B sends its summary vector to Node A and Node A requests only the missing packets from Node B's buffer. Spray-and-Wait is a variant of ER as it limits the number of copies of every packet in the network to a fixed value 'L' at any point in time.

Performance Trends of Epidemic Routing

The main advantage of ER is its high data delivery. As ER is designed to disseminate every message to all the nodes in the network, the overhead is also quite high. However, in a destination-less environment, the overhead cannot be decided based on the number of messages in the network. A destination-less forwarding protocol named Keetchi [4] calculates the overhead based on the likes and dislikes of the nodes. This is not network overhead but only receiver overhead. Hence, we find that the metrics from destination-oriented scenarios cannot be carried out to destination-less scenarios.

Figure 2: Analysis of Epidemic Routing



The main factors that affect epidemic routing's performance are message size, buffer size, number of nodes and traffic. Figure 2 shows the performance trends of ER with respect to these four parameters. As the message size increases, the buffer size needs to be increased, as well. In a dense Oppnet scenario, if the traffic generated by the nodes is high, the message size has a huge impact on the selection of buffer size.

The evaluation of epidemic routing in state-of-art assumes buffer size to infinite, which is far from being realistic. As oppnet devices can be as simple as a smartphone, which may have limited storage. Therefore, use of infinite buffers is not a practical assumption.

The authors in [5] have analyzed the performance of epidemic routing for mass events in realistic traces. Although it is based on the destination-oriented approach, they have identified that dense oppnet cases are ideal for the operation of epidemic routing as a forwarding protocol. This is due to the messages being delivered to the destination way before the expiration of packet lifetime. On the other hand, performance of epidemic routing in sparse networks needs to be studied in detail. In such cases, the lifetime of the packet will play a major role in the efficiency of ER.

Conclusion

From our study, we found that performance of ER for destination-less scenarios has to be thoroughly explored. The suitable configuration and scenario settings for ER will be carried out in our future work.

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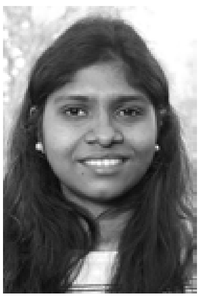

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Capacity Control of Multi-workstation Job Shop Systems with RMT

Manufacturers are confronted with the challenge to satisfy customer demands quickly and flexibly. Moreover, it renders the production systems complex and dynamical.Capacity adjustment is one approach to deal with the fluctuation in demand and improve competitiveness of manufacturer. In this work, we derive an extended mathematical model of a typical job shop system by introducing Reconfigurable Machine Tools (RMTs) to analyse the impact of this new class of machine tools on the dynamic behaviour of the system. To improve the ability of capacity adjustment, we include the operations of RMTs into the PID controller. Simulation results of a four-workstation job shop system demonstrate the efficiency of the proposed method.

Ping Liu*

Introduction >>> Nowadays, customers demands are changing rapidly and products are becoming gradually customized. At the same time, short delivery times and high adherence to delivery dates are also required [1]. In order to keep a competitive advantage and to maintain or enlarge their market share, manufacturers have to satisfy the customers requirements by producing highly customized products at reasonable costs. Moreover, they should improve their ability to respond quickly on fluctuations in demand. One method to achieve the outlined goals is machinery-oriented capacity adjustment [2], which reveals new flexibility regarding the machines. Reconfigurable Machine Tool (RMT) is one choice,which is permanently, quickly adaptable to new manufacturing processes, and designed for a specific, customized range of operation requirements and may be cost-effectively converted when the demands change [3]. To render capacity adjustment effectively, we adopt the classical Proportional Integrate Derivative (PID) method to control the process by adjusting the number of RMTs in all workstations. In order to utilize the method, we propose an extended mathematical model of a job shop system including the flexibility of RMTs and high productivity of Dedicated Machine Tools (DMTs) in this paper. <<<

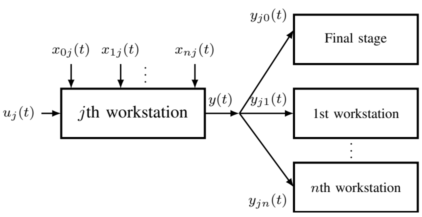
Problem Definition

Capacity adjustment is one way to deal with demand fluctuations considering product types, quantities and delivery dates. Some approaches of capacity adjustment focus on labor-oriented activities. These approaches adjust capacity through arranging the working time, such as plan-oriented capacity control, due-date oriented capacity control and performance-maximizing capacity control [4]. The key shortcoming of this approach is high overtime cost. With the development of automation and intelligence technology, machinery-oriented method reveals new flexibility regarding the machines to compensate for this issue. Generally, machine tools are divided into three types: DMTs, Flexible Machine Tools (FMTs) and RMTs. DMTs as the traditional machine tools are custom-designed for specific operation requirements with high productivity and low cost. However, these machines are not cost-effectively converted to adjust manufacturing capacity. FMTs exhibit flexible functionality for producing a high number of variants with low volume and high cost. RMTs are permanently, quickly adaptable to new manufacturing processes, and designed for a specific, customized range of operation requirements and may be cost-effectively converted when the demands change [3]. Thus, considering the above factors, RMT is a better choice to adjust the capacity.

Another factor is to decide the types of the production system. There are different ways to classify production systems. One way is to distinguish the systems mainly into flow shop systems as well as job shop systems according to production process paths. A flow shop system exhibits a dedicated routing for the manufacturing process, and the machines and other equipments are ordered according to the process sequences of the products or parts of the products [5].In general, this system is used to manufacture large volumes with high productivity and low cost. Thus, the machines of the system are usually DMTs. A job shop system is an effective organization, which consists of a set of versatile machine centers or workstations and provides an extremely high manufacturing flexibility for a variety of products [6]. This allows to manufacture small or medium volumes of many different products.

Considering these challenge, job shop system is a good choice for the production mode due to its high flexibility. However, this system also has some disadvantages, such as long lead time and high level of work-in-process (WIP). To solve these problems, we adopt RMTs to adjust the capacity of each workstation by defining

Figure 1: *Model of jth workstation with RMTs*



the number of RMTs in each station. Due to DMTs high productivity and cost-effectiveness, this system will also include some DMTs to improve the production speed and decrease the cost. Hence, in the job shop system, DMTs will be adopted to ensure the productivity and cost-effectiveness, and RMTs will be utilized to adjust the capacity.

Yet, RMTs are only one enabler for the capacity adjustment of job shop manufacturing systems. To render capacity adjustment effectively, it is necessary to complement these tools with respective control strategies, which will induce an effective adjustment of capacity according to the status of the system. In this paper, we adopt the classical PID control method for the capacity adjustment of job shop manufacturing systems. This method minimizes the error between the orders input rate and output rate by adjusting the number of RMTs in all workstations. In order to utilize the method, we propose an extended mathematical model of a job shop system with RMTs.

Mathematical Model

Mathematical model is highly important in the capacity adjustment based on control theory. In the literature, there are mainly two typical scenarios for the modeling of manufacturing systems, one focusing on the product, one on the machinery. The first considers, amongst other parameters, the cost, types, delivery date [7]–[9], and another emphasizes productivity, complexity and scalability [10]–[12]. Here, we combine these two scenarios to develop the mathematical model of the job shop manufacturing systems based on the literature. One mathematical model was introduced in [13], which can describe the production process and cover the production mode of flow shop and job shop. However, it ignored the function of machine tools. Therefore, based on [13], we propose an extended model of the job shop manufacturing system with RMTs using the definitions of variables given in Table I.

For a job shop system with n workstations, the simplified model of the jth (j=1,2,...,n) workstation is illustrated in Figure 1. The input rate of the workstation is the sum of output rate from all workstations, including the workstation itself and a possible initial stage. The output rate of the workstation is the current capacity. The workstation receives orders from the initial stage (k=0) and workstations $k \in \{1,2...,n\}$, and delivers its products to a final stage (l=0) and workstation $l \in \{1,2,...,n\}$. As the output is the current capacity, which is also the orders output rate, we have

$$y_j(t) = \sum_{l=0}^{n} y_{jl}(t) = \sum_{l=0}^{n} p_{jl} \cdot y_j(t)$$

where $\sum_{l=0}^{n} p_{jl}=1$ for all $j \in \{1,...,n\}$. The orders input rate of jth workstation is

$$x_j(t) = \sum_{k=0}^{n} x_{kj}(t) = x_{0j}(t) + \sum_{k=1}^{n} y_{kj}(t)$$

The current WIP of jth workstation is the integral difference between the orders input and output rate plus disturbances over time

$$wip_j(t) = wip_j(0) + \int_0^t (x_j(\tau) - y_j(\tau))d\tau + d_j(t)$$

When the WIP is on high level, the orders output rate is the capacity of the workstation, i.e.

$$y_j(t) = c_j(t) = \sum_{l=0}^{n} p_{jl} c_j(t)$$

The orders input and output rate of the system are the sums of all workstations input rate received from initial stage and of the output rate delivered to the final stage, respectively

$$x(t) = \sum_{j=1}^{n} x_{0j}(t) \quad \text{and} \quad y(t) = \sum_{j=1}^{n} y_{j0}(t)$$

The presented basic model does not reflect the functionality of RMTs for capacity adjustment. Thus, we propose an extended model of a job shop system with DMTs and RMTs, cf. Figure 1 for a sketch of workstation j with an assigned number of RMTs. Due to the high productivity of DMTs, this kind of machines will also be adopted in the system. The overall system includes n^{RMT} RMTs and n^{DMT} DMTs, where the RMTs can be used within all workstations, but only perform one operation at the specific period. Each DMT can only process one operation and is assigned to a specific workstation. Hence, each workstation consists of a fixed number of DMTs and a variable number of RMTs. Therefore, the maximal capacity of a workstation is given by

$$\bar{c}_j(t) = n_j^{DMT} \cdot r_j^{DMT} + n_j^{RMT} \cdot r_j^{RMT}$$

Now, we consider the number of RMTs in each workstation to be our new degree of freedom. If we change the association of RMT and workstation over time via $u_j(t)$,

Table 1: The Variables Definition in the Model

Variable	Description
$x_{kj}(t)$	Orders input rate from workstation k to workstation j for $k, j \in \{0, 1, \ldots, n\}$
$x_j(t)$	Orders input rate of workstation $j \in \{1, \ldots, n\}$
$x(t)$	Orders input rate of the system
$y_{jk}(t)$	Orders output rate of workstation j to workstation k for $j \in \{1, \ldots, n\}, k \in \{0, \ldots, n\}$
$y_j(t)$	Output signal of workstation $j \in \{1, \ldots, n\}$, which is equal to the orders output rate of workstation
$y(t)$	Orders output rate of the system
$u_j(t)$	Input signal of workstation $j \in \{1, \ldots, n\}$, which is equal to the number of RMTs
$d_j(t)$	Disturbance of workstation $j \in \{1, \ldots, n\}$
$wip_j(t)$	WIP of workstation $j \in \{1, \ldots, n\}$
$c_j(t)$	Current capacity of workstation $j \in \{1, \ldots, n\}$
$\bar{c}_j(t)$	Maximum capacity of workstation $j \in \{1, \ldots, n\}$
p_{jk}	Flow probability that the output orders from workstation j to workstation k for $j, k \in \{0, \ldots, n\}$
n^{RMT}	Number of RMTs in the system
n_j^{DMT}	Number of DMTs in jth workstation
r_j^{DMT}	DMT production rate in workstation $j \in \{1, \ldots, n\}$
r_j^{RMT}	RMT production rate in workstation $j \in \{1, \ldots, n\}$

this renders the maximal capacity to be time variant. Assuming high WIP, each workstation is operating at its maximal capacity and its output rate is given by

$$y_j(t) = n_j^{DMT} \cdot r_j^{DMT} + u_j(t) \cdot r_j^{RMT}$$

This allows us to control the output rate via the function $u_j(\cdot)$ for all workstations. Additionally, we assume the number of RMTs in the system to be limited by n^{RMT}, and each workstation contains at least 0 RMTs. This reveals the control constraints

$$0 \leqslant u_j(t) \quad \text{and} \quad \sum_{j=1}^{n} u_j(t) \leqslant n^{RMT}$$

Note that similar to n_j^{DMT} but in contrast to the input and output values $x_j(\cdot)$ and $y_j(\cdot)$, our control $u_j(\cdot)$ is integer instead of continuous. When the current WIP of the workstation is lower than its full capacity, the logistic operating function is included in the model [13].

Capacity Control

Based on the mathematical model developed in the previous section, we now consider a PID control approach to adjust the capacity to achieve the orders output rate tracking the input rate. We apply the controller to a four-workstation job shop system with fixed numbers of RMTs.

Figure 2 depicts the capacity control loop for workstation j using a PID controller. We design the controller to minimize the error between the orders input and output rate of the workstation, where the number of RMTs used in workstation j is the control variable. Note that PID is designed for continuous control variables, whereas our control $u_j(\cdot)$ is an integer valued function. Additionally, PID does not account for our constraints.

To compensate this issue, we calculate the percentage of each controller output in the sum of all controllers outputs, and assign the variable to be a new integer value via

$$u_j(t) = \begin{cases} \lfloor u_j(t) \rfloor, & \text{if } \sum_{j=1}^{n} u_j(t) \leq n^{RMT} \\ \left\lfloor \dfrac{n^{RMT}}{\sum_{j=1}^{n} u_j(t)} u_j(t) \right\rfloor, & \text{else.} \end{cases}$$

Here, $u_j(t)$ is the fractional discrete value of RMTs in the j^{th} workstation in sum of the all controls.

In the control system, the error $e_j(t)$ is given by

$$e_j(t) = x_j(t) - y_j(t)$$

For the controller, the output $u_j(t)$ is

$$u_j(t) = P_j \cdot e_j(t) + I_j \cdot \left(\int e_j(t) dt - wip_j^* \right) + D_j \cdot \frac{de_j(t)}{dt}$$

where P_j, I_j, D_j are the control parameters of PID controller, and the constant wip_j^* is the planned WIP of jth workstation. Therefore, the number of RMTs, the capacity of each workstation and the capacity of the system can be controlled through adjusting the control parameters. The input is the number of RMTs, which is constrained by 0 and n^{RMT}. When the orders output rates track the input rate, the WIP of each workstation is also stable.

Figure 2: Capacity control of jth workstation

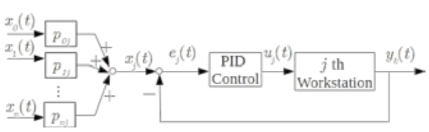


Figure 3: *Four-workstation job shop system*

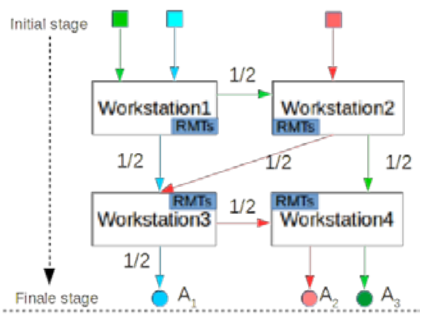


Figure 4: *Dynamic performance of the system without capacity adjustment*

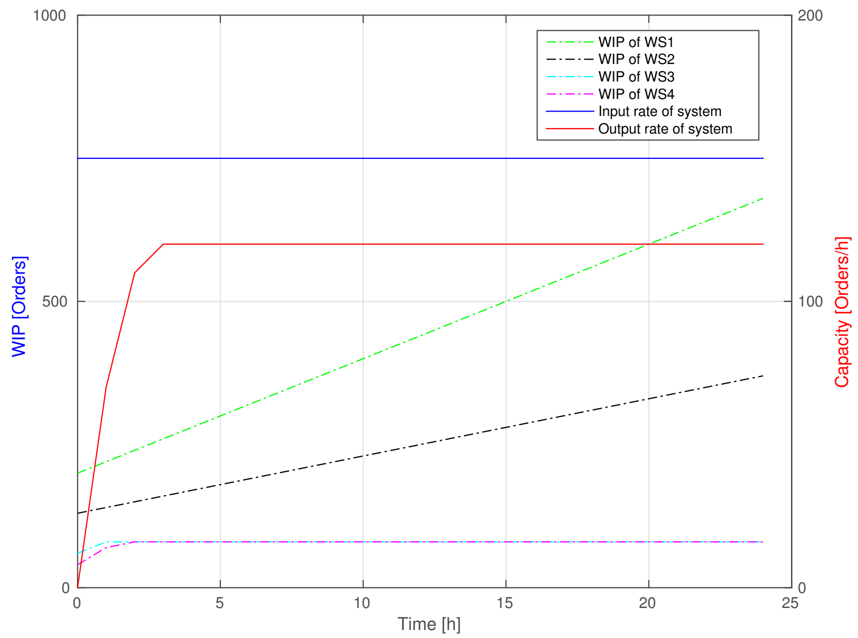
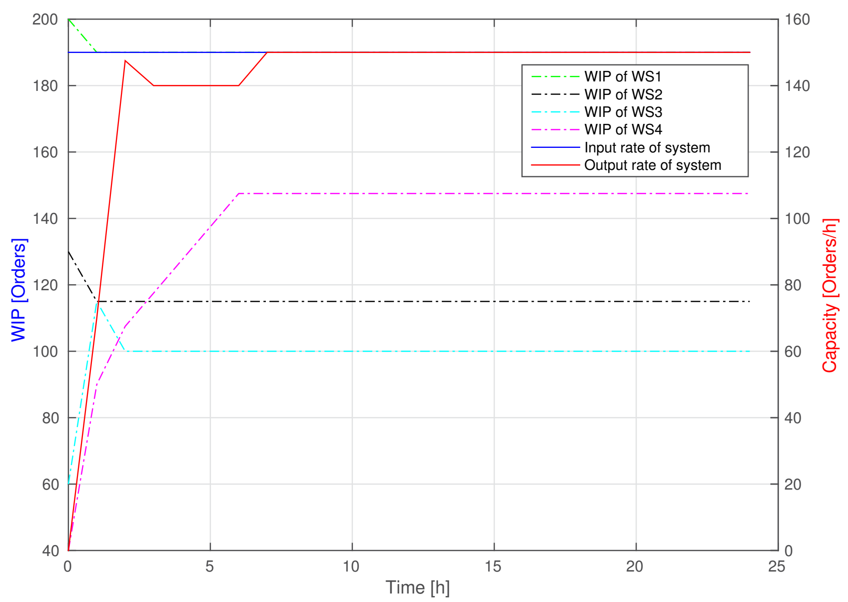


Figure 5: *Dynamic performance of the system with capacity adjustment*



Case Study

As shown in Figure 3, a four-workstation job shop manufacturing system with 6 RMTs will be used to illustrate the capacity adjustment based on PID control approach. We simulate the system in MATLAB. The operation of the four workstations are turning, milling, chamfering and drilling, respectively. The manufacturing system can produce three kinds of products A_1, A_2, A_3. The flow probability p_{jk} of the orders output from workstation j to workstation k and final stage has been added on the Figure 3. First, we analyze the performance of the system without capacity adjustment in one day (24 hours). Figure 4 describes the dynamic performance of the system,where the continuous lines are the orders input and output rate of the system.The dashed lines represent the WIP of the workstations (WS). The orders input rate is 150/h, so desired output is 150/h. However, the real output is about 120/h and hence the demand is not satisfied. The starting WIP of each WS is 200, 130, 60 and 40, respectively. The WIP of WS1 and WS2 is high, but WS3 and WS4 are relatively low. This indicates-without capacity adjustment, there is great imbalance between the workstations.

With capacity adjustment, the respective simulation results are shown in Figure 5. Here, the output rate can track the input rate after eight hours and the WIP of each workstation remains bounded between 100 and 190. We observe that after several adjustments, a stable configuration is reached. Hence, we conclude that the system is stable with PID control. The simulation results also illustrate that the capacity of the system can be adjusted through controlling the number of RMTs, and indicate that the improved model is applicable for the capacity adjustment of the job shop manufacturing system.

Conclusion and Outlook

In this paper, RMTs as well as control strategy are utilized to adjust the capacity in the job shop manufacturing system. An extended mathematical model including the flexibility of RMTs is proposed to represent the system dynamics. This model not only contributes on analyzing the relationship between products, machine tools and dynamics of the system, but also will demonstrate the influence of disturbances and delays on the system. The capacity adjustment of the system is implemented via a PID control approach. The simulation results of the four-workstation job shop manufacturing system are given to support the efficiency of the proposed capacity adjustment method. This first step for a combination of RMTs and effective control strategies will improve the abilities of manufacturers to cope with customers volatile demands and decrease the cost for flexibility.

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Supply Chain Flexibility as Strategy for SMEs Internationalization

The research of small and medium-sized enterprises (SMEs) internationalization requires an integrative outlook to include SMEs capabilities and the international environment from a network perspective, in order to develop a sustainable competitive advantage. To address this gap, this paper presents the theoretical framework for a conceptual model to integrate logistics capabilities and supply chain flexibility as enablers of SMEs internationalization. This framework is the basis to develop a conceptual model to integrate the areas of interest and to test further hypothesis.

Sylvia Novillo

Introduction >>> SMEs play a significant role on the economy health and employment growth of every country[1]–[3]. Therefore, the internationalization of SMEs has received large attention by policymakers, researchers and practitioner due to the positives effects of internationalization over firms' capabilities and performance [4]–[8]. Although internationalization is a high-risk strategy to embrace by any enterprise due to the dynamic and uncertainty of international scenarios, not adopting this strategy may constitute a strong disadvantage for the focal firm compared to its competitors that are operating in international markets [9]–[11]. On the other hand, the new competitive scenario to consider when designing strategies has to regard a supply chain context [12]. Thus, it is necessary to develop a sustainable competitive advantage in order to compete in complex, dynamic and uncertain environments [13].

In the case of SMEs internationalization in order to develop a sustainable competitive advantage, the firm needs to assess their resources, capabilities, procedures and performance compared with the industry referents [14]. SMEs lack of resources and have limited capacities still, they are recognized by their flexibility [15]. This capability contributes to provide a quicker response to any change in the business environment and to properly manage the relationships with suppliers and customers [16]. Moreover, firms have to align their strategies, capabilities, resources, and procedures, with suppliers to effectively respond to customers' requirements and reach higher levels of flexibility [13]. All this will constitute a competitive advantage not only to the focal firm but also to the whole supply chain partners. Further, there is a positive relationship between logistics capabilities, supply chain flexibility and supply chain performance [17], [18]. Based on these facts, the internationalization of SMEs requires also a supply chain approach to analyze the role of logistics capabilities in the implementation of supply chain flexibility as part of their internationalization strategy. This will lead SMEs to achieve a sustainable competitive advantage. This paper presents the theoretical framework to develop a conceptual model from an integrative literature review. <<<

SMEs Internationalization

Internationalization is defined as "firms' ability to initiate, to develop, or to sustain business operations in overseas markets" [19].Three approaches were analyzed in order to understand the phenomenon of SMEs internationalization.

First, the stage theory of internationalization considers internationalization as an evolutionary process which depends on the knowledge of the firm acquired through experiences and information from overseas [20]. This body of knowledge provides the notions needed to overcome the "psychic distance" i.e. the elements that inhibit the correct perception of foreign environments [21].

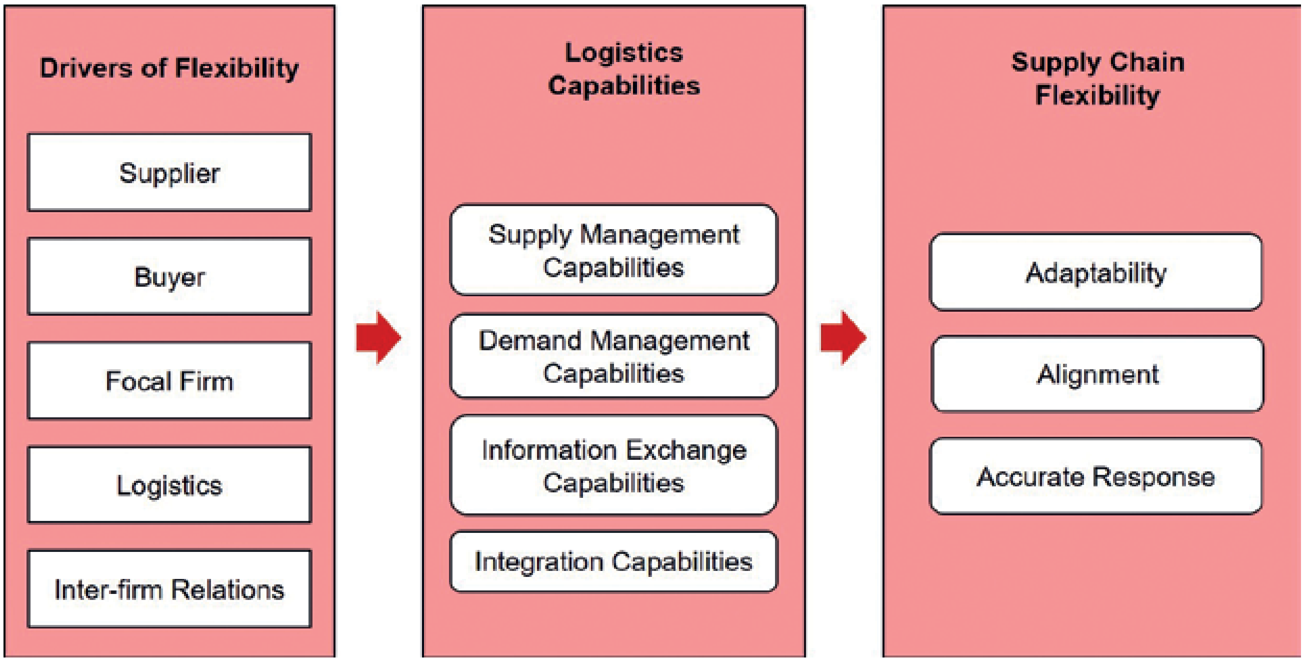
Second, the network approach states that firm' existing network relationships and networking capabilities influence the decisions and efforts to access to a specific international market [22]. Johanson and Vahlne [22] incorporated trust and commitment building as elements that allow the networking process and as a result the internationalization of the firm.

Third, the international entrepreneurship approach emerged from the entrepreneur orientation, which involves innovativeness (i.e. an experimental behavior oriented to promote and create new products or services), proactiveness (i.e. the behavior that leads to move first, faster or new directions in relation to competitors), and risk-taking (i.e. a behavior based on information exchange and co-learning process in order to undertake risky commitments abroad) to create value in the firm to launch business operations in overseas markets [23], [24].

Supply Chain Flexibility

According to the literature, supply chain flexibility is defined as the ability of the

Figure 1: Logistics Capabilities and Supply Chain Flexibility Relationship



supply chain to respond quickly to any change in the customer demand, interruptions in the supply or any other event that occurs in a dynamic environment with a minimal penalty in terms of cost, time and effort [16]. This capability as strategy, allows the adaptability of the supply chain to different stages and changes in the supply and demand scenarios, while it allows to remain the customer service level established and compete in a dynamic environment. In addition, supply chain flexibility is a multi-dimensional capability, is always present and is difficult to measure; therefore it is difficult to imitate [16], [25]. Nevertheless, supply chain flexibility involves three main aspects, i.e. adaptability (capacity to adjust the strategy and network design to meet structural changes in the supply, distribution or demand), alignment (capacity to engender initiatives within the network partners in order to achieve a better supply chain performance), and agility (capacity for a quick response to short-term variations along the supply chain) [26].

When regarding flexibility in the supply chain, two aspects have to be considered: drivers and enablers. Drivers are elements that raise the need for flexibility e.g. sourcing capability and customer demand. On the other hand, enablers are activities that engender flexibility e.g. systems integration, supplier management and information sharing [25].

Logistics Capabilities

Capabilities are a complex set of skills and information organized in a way that allow firms to manage their activities and use their resources [17]. Thus, logistics capabilities generate alignment, integration, adaptability and allow the reorganization of functional competences, assets and structural skills in order to increase the overall performance [13]. Moreover, logistics capabilities create advantages as enhancing the customer value, assessing productivity, and functional effectiveness.

Logistics has the unique attribute of coordinating with inside- and outside-functions of the firm [13]. Therefore, logistics capabilities have two dimensions, i.e. internal dimension which impacts directly on other functions and competences inside the firm [27]; and external dimension that enlarges the logistics functions outside the firm to integrate suppliers and customers [13]. This contributes to increase the firm' supply chain capabilities by coordinating resources, processes and operational systems with the rest of the supply chain partners. Logistics capabilities were classified by [28] into four broad groups, i.e. demand management capabilities; supply management capabilities; information exchange capabilities; and integration capabilities.

It is necessary the understanding of the role of logistics capabilities as a source of supply chain flexibility for developing this conceptual model. A synthesis of the literature regarding the relationship between the two areas is presented in figure 1.

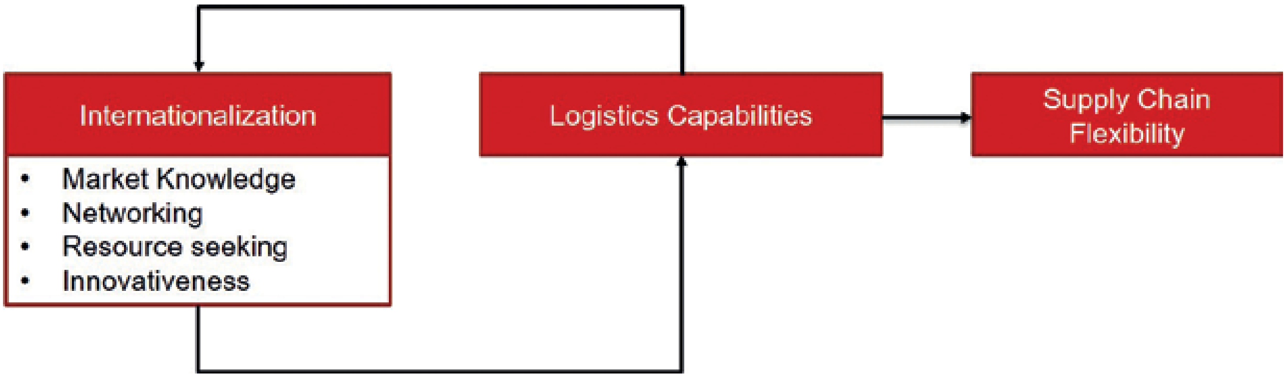
Literature [13], [18], [29], [30] provides evidence that logistics capabilities have a positive impact on supply chain flexibility and the overall performance of the supply chain. Therefore, logistics capabilities enable the firm to generate flexibility in the supply chain to cope up with the sources of uncertainty of nowadays dynamic business environment.

Developing a Conceptual Model

From the integrative literature review, five relational functions for SME internationalization management (figure 2). For the purpose of this research, a relational function for internationalization is defined as the management of the activities required to set firms' internationalization strategies and synchronize its internal functions, capabilities and the relations and efforts within its network partners in order to incorporate SCF as a way to achieve a sustainable competitive advantage.

The functions of market management and knowledge management set the main internationalization strategy that the firm will adopt from the analysis of the body of knowledge gained through information capabilities in order to establish the degree of flexibility required within the supply chain. This will create value for their products, services and processes [11]. The network management function sets the strategies regarding its relations within its supply chain partners through the development of integration capabilities in order to

Figure 2: Developing a Conceptual Model



achieve the degree of flexibility required. Moreover, the flexibility in the supply chain needs alignment and it is accomplished through information sharing [6]. Innovation management refers to firm's use of resources, knowledge and competences through a proactive and risk-taking behavior to create value and differentiation across the business network. Increasing the flexibility degree within the supply chain partners through the logistics capabilities might lead to develop new products, services and processes to reach competitive differentiation [6]. Finally, resource management allows the firm to set strategies to acquire, develop, adjust and coordinate the sourcing. Through the development of logistics capabilities, implementing SCF strategies will mean a competitive advantage to face supply or demand fluctuations [5].

Conclusions

Through the identified relational aspects as the starting point to establish a relationship between SMEs internationalization, logistics capabilities and supply chain flexibility in order to generate a sustainable competitive advantage. The development of logistics capabilities will enable the alignment of the firm with the customer demand as well as the supply side. The result of this iteration (see figure 2) will contribute to the achievement of supply chain flexibility strategies. This process may lead to the achievement of a sustainable competitive advantage. Further conceptual and relational analysis, hypothesis and empirical research are needed.

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ActivityDescriptor: Human Activity Understanding for Manipulation Robots

This is an investigation of the problem of interpreting instruction videos for robotics agents. The results are action representations including the manipulation action, the objects acted on, the action execution tools, the grasp types, and the motions that cause the effects. Addressing these multi-challenging problems we propose a CPU parallelization object localizer and optimize pose estimator to understand the human activity state using sequential learning model. Finally, we build a probabilistic knowledge representation to precept the action. Our approach reaches state-of-the-art technique while evaluating a large number of video clips with impressive interpretation abilities.

Feroz Ahmed Siddiky*

Introduction >>> The recent success of deep learning on computer vision [1, 9] inspires us to propose a hybrid deep learning framework name as ActivityDescriptor for human activity understanding. It process data in two stages. In low-level data processing (figure. 1 L blocks) it finds out activity area by locating a human. A proposal based deep learning approach used to localize activity related objects. Manipulation poses are estimated using unsupervised and regression network. Finally, a sequential learning algorithm identifies different action states. On the contrary, the high-level data processing (figure. 1 H blocks) receives raw data from lower-level and builds a joint distribution from complex interaction between objects, tools, action poses and actions. We propose a probabilistic model that learns from this joint distribution to perform the inference for input queries and percept the coherent relational information. Furthermore, our system generates the action instructions for robotics agents. <<<

Related Work

Understanding human activity has rich literature. Some of the earlier works [6, 7] based on tracking and explicit body-part modeling. Few works [7, 8] consider the static image for human pose and appearance-based descriptors. Some research work considered lower-level spatio-temporal appearance and motion features to learn the activity classes [2, 3]. Though the research reviews suggest that human activity understanding from global image representations have good results however, their applicability is limited to describe the relational semantic information. Local representations address these issues. Our ActivityDescriptor has the general strategy of localizing objects, tools, hand tracking and pose estimation that offers robustness and leverage strong semantic information abstraction.

Semantic Information Extraction

Low-Level Data Processing

ActivityDescriptor takes high resolution images from videos as input. The next section describes the approach of getting region of interest from the input images.

Region of Interest (ROI) Selection

To get the ROI we use the Gaussian Mixture Model (GMM) algorithm [4] for background-foreground segmentation. The

Figure 1: *Proposed Activity Descriptor Framework*

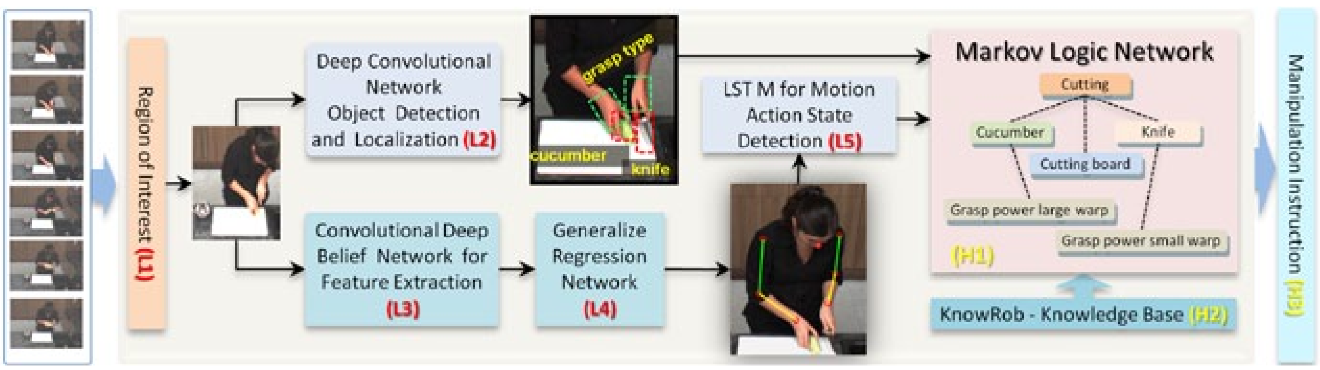
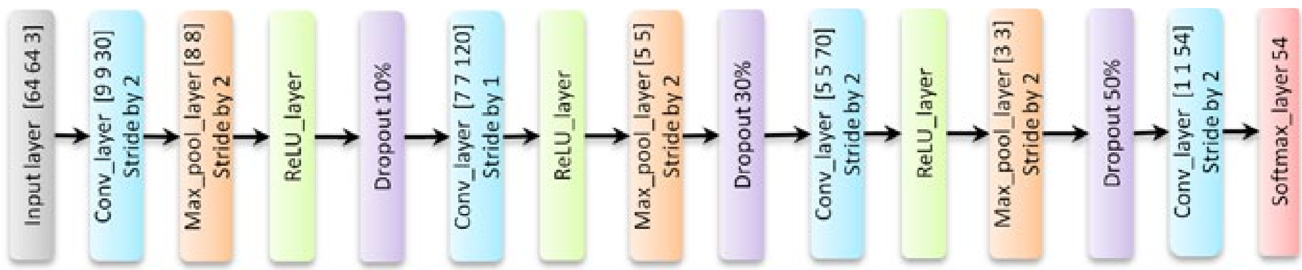


Figure 2: *Our Proposed Compact CNN Architecture.*



algorithm is adaptive and flexible to handle variations in lighting and moving scene. Let's, assume a uniform distribution for the foreground objects $p(\vec{x}^t|FG)$. The decision that a pixel belongs to the background is made if

$$p(\vec{x}^t|BG) > c_{thr}(= p(\vec{x}^t|FG)p(FG)|p(BG))$$

where c_{thr} is a threshold value and $p(\vec{x}^t|BG)$ refer as the background model. The background model build from T beginning frames until the human appear in the videos. The foreground I^t_{FG} is detected by $p(\vec{x}^t|BG)$. Then upper body detection (UBD) [16] implemented on . In case of instability of UBD, we use Kalman-Filter to predict and adjust the activity region using the formula

$$I^t_{ROI} = I^t_{FG} + (|I^t_{FG} - I^{t-1}_{FG}| \times \varepsilon)$$

where ε update ratio. Thus we get more precise I^t_{ROI} region to train for unsupervised network describes in section 3.1.3 and I^t_{ROI} wider region for object localization.

Object Localization

Object localization from images is a challenging problem for real-time analysis. Recent year R. Girshick et al. [9] propose R-CNN an excellent proposal based object localization method. However the computation cost of R-CNN is high enough for real-time data processing. We investigate two main reasons that cause R-CNN computationally expensive. First, too many region proposals are generated while very few are positive. Second, too deep pre-trained CNN increase the convolutional computation cost. Addressing these two problems we proposed compact 14 layers CNN architecture (figure 2) to reduce the computation cost.

For region proposal we chose cost effective Geodesic Object Proposal (GOP) [14] method. To skip the overlapping among proposals we cluster the proposals as I^k_{PC} according to their location, k is the number of cluster. Our approach do CPU parallelization on each cluster such that, if CNN generate strong negative probability from central proposal of kth cluster, then we skip the cluster otherwise we compute the whole cluster to find the best location. Additionally, we created features vector from the first and last three classes' probability of CNN and object's size ratio and RGB color. These features are trained with the k Nearest Neighbor (kNN). The object is finally detected if CNN and kNN have same maximum class probability. This procedure enhances the localization performance (figure 3).

Human Pose Estimation and Action State Identification

In this section we will describe a powerful but simple architecture for human pose estimation. The key part of our method is the unsupervised feature extraction using hierarchical generative model known as Convolutional Deep Belief Network (CDBN) [1]. CDBN is stack of convolutional restricted Boltzmann machines (CRBMs) [1] as building blocks. The CRBM consists of two layers: an input (visible) layer V and a hidden layer H. We use four CRBMs with probabilistic max-pooling as building blocks for modeling CDBN shown in table 1.

To overcome form over fitting problem we add a small amount of randomly offset I^t_{ROI} with the annotated boundary to create more features f^t_{CDBN}. These features are trained with mini-regression network known as Generalize Regression Neural Network (GRNN) [15]. In our approach we used two independent GRNNs to train X and Y coordinate. This separate training improves the mapping between pose coordinate and features. To understate the different action state like action starting, processing and ending we evaluate pose coordinates using sequential learning algorithm known as Long Short-Term Memory (LSTM) [11]. Our simplified LSTM model consist input i_t, output o_t and forget gate f_t. From different manipulation task we created action poses' features f_{pose} using the formula

$$f_{pose} = {}^1/_C(p_{(1,1)} - p_{(1+i,1+i)})$$

where i=2 to 7 and C is constant for normalization. The pose feature obtains by subtracting other poses (shoulder, elbow and wrist) from the head pose. We created training samples by stacking three frames' poses f_{pose} in a single vector then trained with LSTM.

High-Level Data Processing

For high-level data processing we proposed a probabilistic model using the low-level information to percept the probable action. An action can be inferred probabilistically using the perception system from the evidence collected from low-level data processing. We used Markov Logic

Figure 3: Evaluating Using a) CNN and b) CNN+kNN

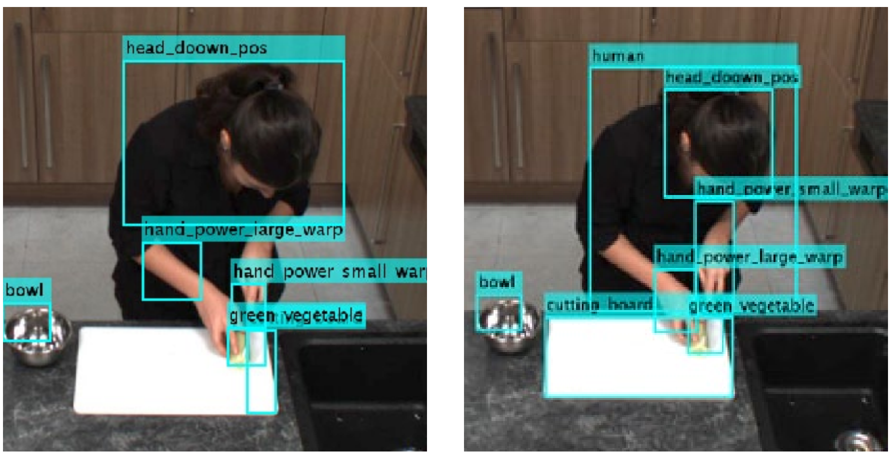


Table 1: *Different Layers of CDBN*

Input Image	1st Layer	2nd Layer	3rd Layer	4th Layer
Image size (96x96)	V = 1 H = 24 filter [9×9] pool [2×2]	V = 24 H = 48 filter [7×7] pool [2×2]	V = 48 H = 120 filter [5×5] pool [3×3]	V = 120 H = 360 filter [3×3] pool [3×3]

Networks (MLN) [10] for probabilistic reasoning. Our proposed MLN capture the complex interaction between objects, tools, grasp types, action pose and actions, their attributes from our defined relational database using the following formulas.

w1 has_object(?a, +?obj) ^ grasp_on(?a, +?obj, +?gp) ^ *action_state(?a, +?ast)*^ action_is(?a, +?act)

w2 has_object(?a, +?obj) ^ has_grasp(?a, +?gp) ^ action_is(?a, +?act)

w3 has_grasp(?a, +?gp) ^ grasp_on(?a, +?obj, +?gp) ^ action_is(?a, +?act)

w4 body_pose(?a, +?p) ^ motion_type(?c, +?m) ^ action_is(?a, +?act)

w5 grasp_on(?a, +?obj, +?gp) ^ action_is(?a, +?act)

Where the "+" operator specifies explanation of one individual formula for every value and 'obj' for objects or tools and 'gp' for grasp types and 'act' for action. The weights have been determined by supervised learning using pseudo-log-likelihood. Next section we evaluate the MLN model more elaborately.

Experiment and Result Analysis

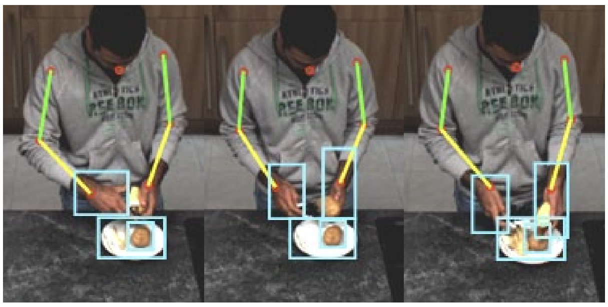
Our research experiment conducted with cooking dataset from MPII Cooking-2 [5] to understand human activities. From this dataset we created 25 different small video clips by considering 10 different actions like: open, close, move, peel, cut, put, pour, mix, wash and spread. We annotated 73,000 samples for 35 different objects, grasp-types and negative samples. We consider eight different grasp types: *precision-large-warp, power-sphere-warp, power-large-warp, precision-fingers, precision-lateral, power-small-warp, power-lateral* and *empty-grasp*. For evaluation we preserve 15% from total dataset. Our proposed object detection model reached training accuracy 96.3% and testing accuracy 93.6%. Our improved localization model CNN-kNN works 5 times faster than R-CNN. For pose estimation problem we annotated 7,300 human poses. Our pose estimation method performs better result with relatively small number of training dataset. Using two different GRNN for x and y coordinate we reaches 94.7% average precision considering normalize distance error within 25 pixels. Table 3 shows some results from our experiments. In some case it fails to detect the pose orientation correctly when it receive false human boundary. For action state identification from LSTM we get 97.2% training and 95.7% testing accuracy.

Our introduced probabilistic model MLN solves two problems: 1) inferring the action and 2) find out the missing objects. Few objects are not detectable due to its' low visual appearance. However, the grasp types for that object are possible to detect for better appearance. For this, we set a relation between object and grasp types using the predicate *grasp_on*. This make the perception model more efficient for unidentified object from the grasp types. Our system evaluated with the ten video clips. We achieve 92.6% correctly classified action while for reasoning it achieves 85% accuracy. We improve the performance using common sense knowledge KnowRob [12]. It assists the MLN by providing background scene knowledge. Table 3 shows experiment analysis. The left columns show the human poses and detected objects. The right most columns show the generated action plan.

Conclusion

In this paper we presented ActivityDescriptor a hybrid framework to understand human manipulation tasks. Our proposed object detection and localization method can efficiently applied on different domain specific problem. In high-level data processing the system efficiently infer the action as well as find out the missing objects. Our approach generalizes the human activities and generates high-level semantic information for the robotic agents.

Table 2: *Result from Proposed ActivityDescriptor*

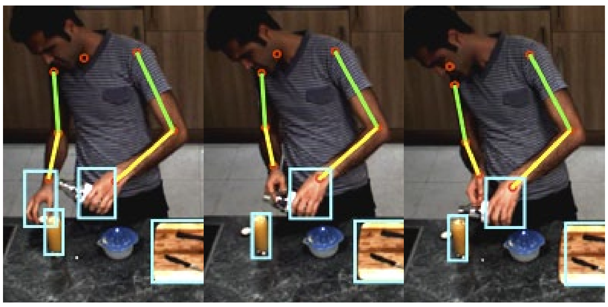


Detected objects:
potato, plate, power small warp, power large warp

Action-pose: pose-peel
Background-scene: processing-area

Inferring objects: peeler
Inferring action: peeling

(the action
(type peeling
(tool-type (peeler)
(grasp type (power-small-warp)))
(object-acted-on (object-type(potato)
(grasp type (power-large-warp)))))



Detected objects:
glass, cutting-board, power large warp

Action-pose: pose-pour
Background-scene: processing-area

Inferring objects: bottle, power-large-warp
Inferring action: pouring

(the action
(type pouring
(tool-type (bottle)
(grasp type (power-large-warp)))
(object-acted-on (object-type(glass)
(grasp type (power-large-warp)))))

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Fungus Detection in Intelligent Container Using Histogram of Oriented Gradients

Fungus is an important component in our ecosystem. It performs the important task of decomposition. But it is the main risk for human health, archives, food logistics and millions of euros lost per annum just due to different kinds of fungus. The main aim of this research is to develop an automated system for the detection of fungus spores in air. We have developed a novel system for fungus detection through an optical sensor system. Images of the sample are obtained. Since images have noise regions, pre-processing techniques have been applied. Then, the histogram of oriented gradient features were extracted and a trained Support Vector Machine was used for the purpose of classification.

Muhammad Waseem Tahir*

Introduction >>> One of the main crises presently confronting the world is a food crises. Loss of food is the prime reason for such a catastrophic crisis. One third of the produced food in the world is wasted [1] and fungus emerges to be one of the principle sources behind it, besides being an important impetus of natural process and it also grows at an enormous rate. So, in order to guard against food loss, protect human life or important document loss, one needs to watch out for fungus and its growth.

Recently, computer vision is being used to detect microbial contamination in food. That is primarily why the food industry is among the top ten industries that apply a computer vision system and the trend of computer vision applications is on the rise among the fastest growing industry [2]. Blasco et al [3] used it for the purpose of food quality control. Merten et al [4] utilize it for product classification, whereas Chelladurai et al [5] used it for the detection of microbial contamination in food. <<<

Related Work

Over the last decade scientists started working to solve the microbial problem using computer vision techniques. Some of the important work is summarized in this section. Firrao et al [8], presented an approach for the fast response, which is based on multispectral image analysis. The mycotoxin content was predicted from the calculated index through a trained three-layers feed forward neural network. One year later, Siripatrawan et al [7], proposed a HSI detection method for the detection of Esherichia coli contamination in packaged fresh spinach. Principal Component Analysis (PCA) was used to reduce the wavelength variables. Artificial Neural Networks (ANN) was Fig. 1: Flow chart of fungi spores detection [15] used to analyze the pre-processed data. Tallada et al [11] presented the use of near infrared spectroscopy for the detection of fungus in corn. They also used PCA, but followed that with linear discriminant analysis (LDA) to find classification models, in which they differentiated between uninfected and infected corn kernels. They also used a multilayer perceptron (MLP) neural network model for the discrimination of infected and uninfected corn kernels. On the other hand, E. Bauriegel et al [10] detected Fusarium infection in wheat ears using hyperspectral imaging. PCA was used to differentiate between healthy and diseased spectra. The components of PCA were used for the quality of separation. In later years, Zuzana et al [12] presented a comparison of spectra of artificially and naturally infected corn ears. They used Savitzky-Golay filtering along the wavelength. They performed threshold-based segmentation for isolating all contaminated pixels. All of these methods required skilled operator to screen microbial growth, other than being time-consuming and laborious technique. In spite of this fact, we can get reliable, precise and effective results using such time-consuming methods. However, outcomes of these methods will probably debilitate when we have to monitor huge volumes, that is, a container of food items.

Materials and Methods

Setup

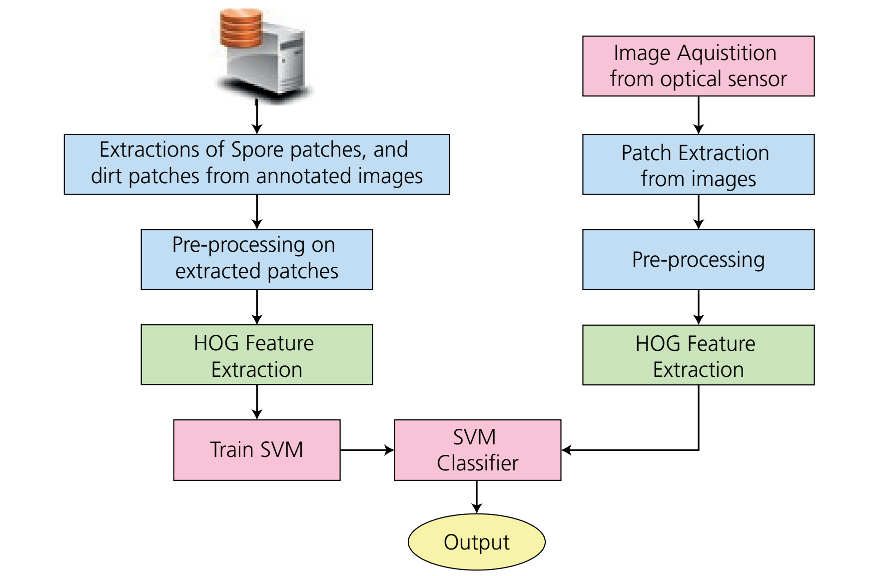
The development of a system for the identification of air born particles ranging from 1 µm to 7 µm, was a thought provoking job. An optical sensor, as presented in our first prototype [6] and its modified versions [14], [15], [16], [18] for the combination of bright-field and fluorescence microscopy, was used for the purpose of image acquisition. Currently, it contains an Imaging-Source industrial 5 mega pixel color camera (DFK 72AUC02), a high pass filter for visible light and a Nikkon 40X optical lens. In order to connect lens in front of the camera C mount connector is employed as shown in Fig. 2. The resolution of optical system is dependent on the numerical aperture (NA) of the microscopic lens and condenser lens. The required magnification of the system was achieved 0.65 NA microscopic lens and condenser lens with 0.54 NA.

Then equation (1) shows the maximum resolution r, according to Abbe-criteria [17], where λ is the wavelength of the used light source.

$$r = \frac{\lambda}{NA_{lens} + NA_{condenser}}$$

The images acquired from this system were in Red, Green, Blue (RGB) color space. In total 1928 images of air sample containing fungus spores, comprising of 2560 x 1920 pixels were collected and additionally stored in a memory. The spores in these images were manually annotated utilizing a specifically designed program in MATLAB. BMA Labour, Bochum, Germany helped us to verify fungus spores. Finally, the annotated images established fungus dataset.

Figure 1: Flow Chart of Fungi Spores Detection [15]



Methodology

Fig. 1 represents the flow diagram of the proposed method. The proposed approach consisted of patch extraction from images, pre-processing, feature extraction, and classification into spore and dirt. The method first extract patches of size 78x78x3 from the images. These regions of interest (ROI), fungus spores, were stored in fungus dataset. It consists of numerous spores and dust particles present in the images. For the purpose of annotation, a MATLAB graphical user interface (GUI) was developed, as shown in Fig. 3.

Annotation of images was the key for the accurate classification of fungus spores and dirt despite being a tedious job. A lot of days were required just to annotate the whole fungus dataset. GUI provides a platform to effectively mark around the fungus spores or dust particles. It actually makes a file in the background which stores all the x-y coordinates, which user want to save. These coordinates help to extract the patches from images. GUI provides plenty of options for the acquisition of annotation by using 10 different sizes of drawing line and five different colors. One can redraw the annotation whenever required. Eventually, user has a file which has all information of spores and dust particles in the image. This file was also stored in the dataset with the corresponding image.

Extracted patches were passed through pre-processing and in the first stage of pre-processing, smoothing was completed using a 7x7 Gaussian filter. Then, a histogram equalization technique of image enhancement was applied to all 3 channels of the image. Finally, sharpening of the image was achieved through a median filter.

Now the extracted patches were available for the application of feature extraction step. Two types of features were extracted: HOG features and other handcrafted features. Since the utilized fungus dataset consists of a large number of images therefore some pictures were considered for training and others were left for the testing purpose.

Within each of the 2x2, 4x4 and 8x8 pixel cells, we computed the gradient vector at each pixel. We took 4, 16, and 64 gradients for 2x2, 4x4 and 8x8 pixel cells, respectively, and then put them into 9-bin histogram. Each bin has 20 degrees, so in total it covers from 0 to 180 degrees in the 9 bins of the histogram (we used unsigned gradients so that the orientation only ranged from 0 to 180 degrees instead of 0 to 360 degrees).

In the end, we perform normalization of the gradient vector by dividing each bin with the sum of the magnitude. The normalization step was performed to make the gradient vectors invariant to multiplication. These gradient vectors of different cell

Figure 2: Image Aquisition Setup [18]

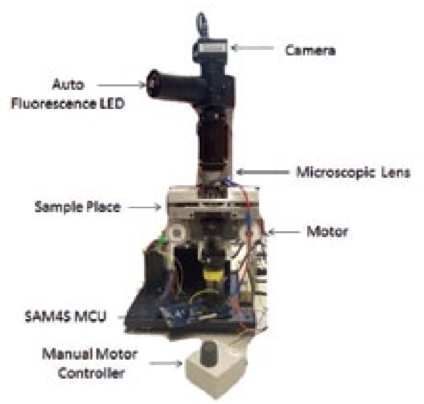
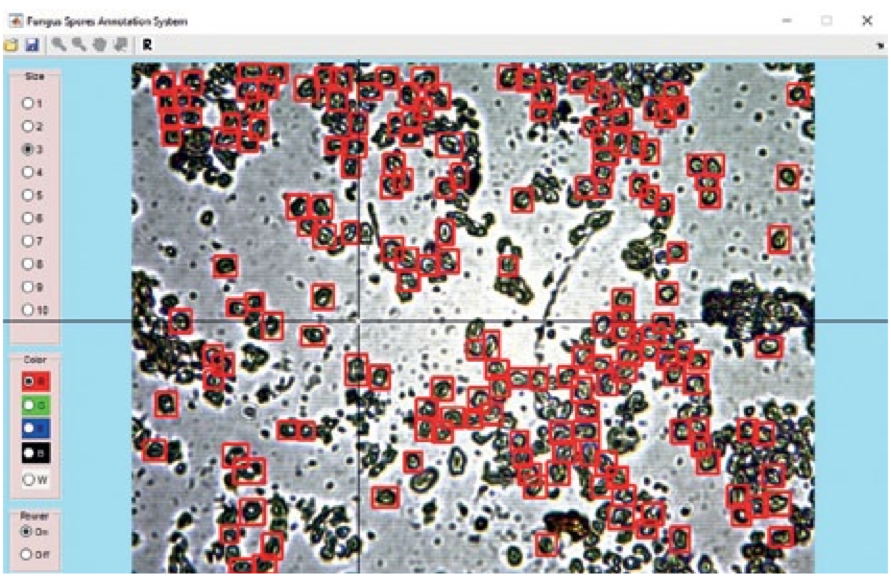
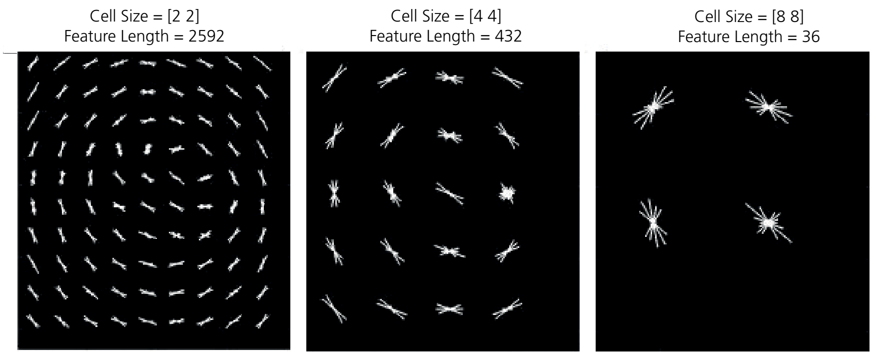


Figure 3: Fungus Spores Annotation System [18]



sizes can be visualized in Figure 4. Combination of these gradient vectors from the whole extracted patch formed our feature vector. In the end, we used a machine learning technique (SVM) for the purpose of classification.The SVM classifier first needs to be trained. So, the training was done on the images stored in our database. We extracted an equal number of positive samples (spores) and negative samples (dirt) from the images. Then, HOG features were extracted as explained above. Lastly, we trained the SVM classifier on these features.

Figure 4: HOG with Cifferent Cell Sizes [15]



Results and Discussion

Fungus dataset consists of images and spatial locations of fungus spores in the images. For the training purpose, fungus spore patches were extracted and marked as positive samples. Similarly, patches were extracted randomly from the images and marked them as negative samples. It has been assured that none of the randomly selected patches contains any fungus spore. These two storing acquired a primed importance for the training steps. In case any positive sample is present in negative sample then required results cannot be obtained with the trained classifier.

An air sample was collected on a glass slide using an air sampling system [13], which is normally used in biological laboratories. This sample was placed under an optical sensor system [6] to obtain the image. The image we retrieved from this system is shown in Figure 5. Then, we make a mask of size 18 x 20 pixels, which was of the same size as the spore patches on which our SVM was trained. This mask was run across the obtained image to extract patches of the same Fig. 5: Image obtained from optical sensor system [15] size. Then, pre-processing was performed on these patches and HOG features were extracted. These features were further used to help to train the SVM for classification and the output image that was obtained is shown in Figure 6.

This output image showed promising results for the fungus spores detection. It was able to classify fungus spores from the image. As we can see, it also incorrectly classified some objects as spores. These objects are called hard negatives. If the size of the feature vector is further increased, then these can be improved, but also at a higher computational cost. Furthermore, in the future, these hard negatives will be made part of the SVM training to improve the results.

Figure 5: Image Obtained From Optical Sensor System

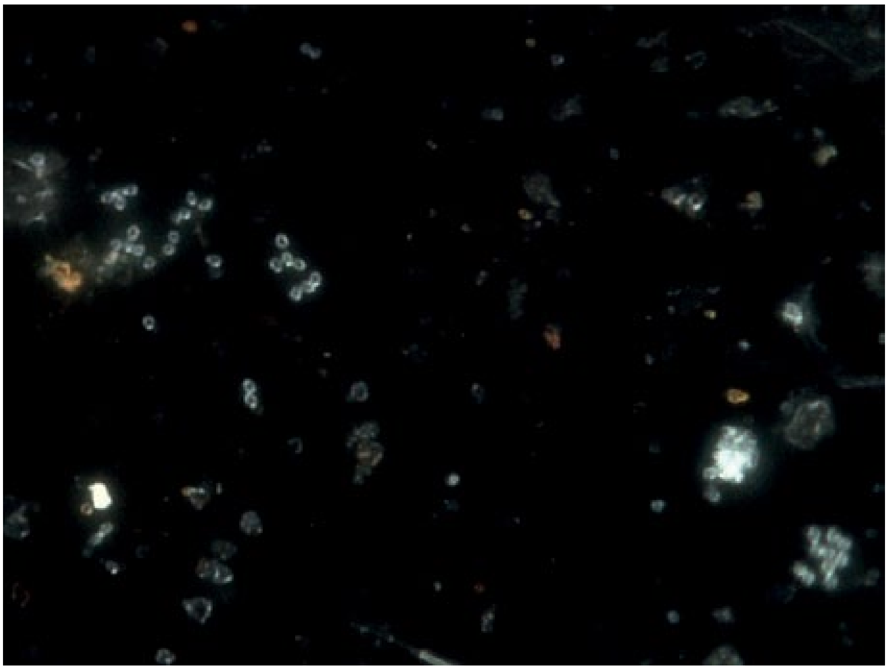
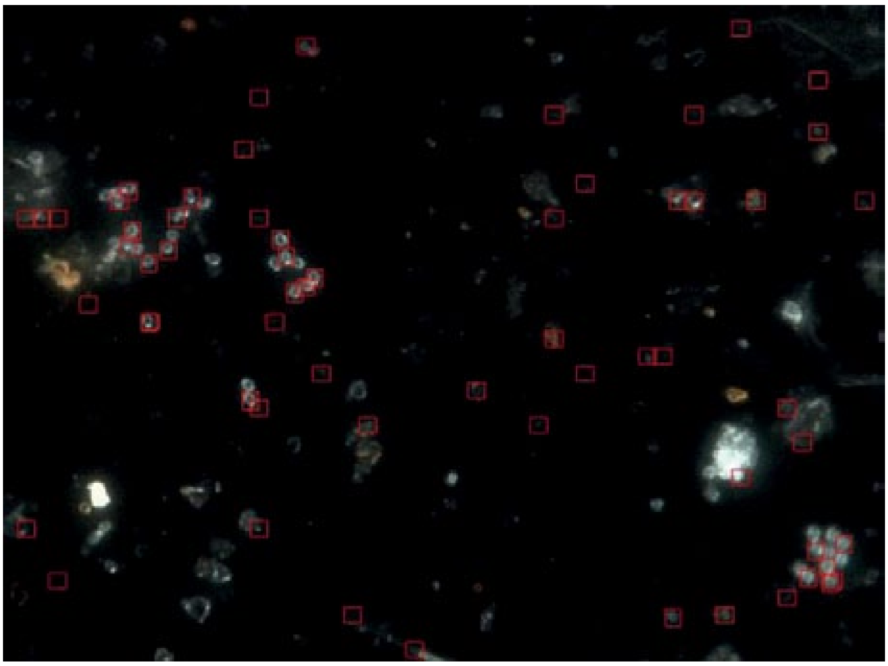


Figure 6: Output Image



Conclusion

In this paper, a HOG based approach has been presented for the classification of fungus spores and dirt. Images were collected from an optical sensor system and further fungus spores were detected using HOG and SVM. This provided a completely automatic system which can detect fungus spores in the environment. Results can be improved by incorporating hard negatives, but this will also increase the computational cost. Furthermore, the database can be increased to detect different kinds of fungus spores and airborne particles like pollen. This research also highlights the importance of this system for use in other applications.

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A Concept of Using Electric Vehicles for Green Urban Freight Transport

Replacing diesel commercial vehicles with electric commercial vehicles is a measure to achieve sustainable urban freight transport. However, there are multiple alternatives for urban logistic stakeholders to conduct the replacement. We reviewed existing corresponding work and observe that few models can estimate the economic, environmental, and social performance of multiple alternatives with considering time factor and logistical parameters. It results in a difficulty to complete the replacement. Accordingly, we propose a concept to numerically support stakeholders to assess and select appropriate alternatives for filling above gap with using multi-criteria decision making method.

Molin Wang*

Introduction >>> There are four vehicle types of Electric Commercial Vehicles (ECVs), which are possible to be employed in five markets of Urban Freight Transport (UFT). Their combinations are defined as alternatives in this paper. These alternatives provide possible solutions for urban logistic stakeholders to conduct replacing diesel commercial vehicles with electric commercial vehicles for achieving sustainable urban freight transport. However, how the stakeholders determine an appropriate alternative from the sustainable point of view is a research question of this paper.

In order to find an answer, we reviewed several existing models and summarized their purposes, advantages, and limitations in section 2. Furthermore, we propose a concept to help urban logistic stakeholders to assess and select appropriate types of ECVs according to their own fleet with taking into account the identified advantages and limitations of existing models in section 3. Finally, the conclusion is presented in section 4. <<<

Existing Models

We reviewed six existing models in this section to get insight into their purposes, advantages, and limitations (table 1). According to the purposes of these models, we divided them into vehicle-oriented models and logistics-oriented models.

There are three vehicle-oriented models. The first one is Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET Tool). This tool allows clean cities stakeholders to estimate life-cycle petroleum use, life-cycle greenhouse gas emissions, vehicle operation air pollutant emissions, and costs of ownership for light-duty vehicles and heavy-duty vehicles [1]. It involves a wide range of alternatives and is a time-dependent tool, since it takes into account the years of planned ownership to estimate the economic and environmental performance of alternatives from Well to Wheel (WTW). Moreover, this tool provides a relatively full database to support users, if they lack corresponding data.

On the other hand, this tool estimates the performance exclusive of logistical parameters. Secondly, the social impact as one dimension to assess sustainable UFT is paid no attention. Hence, the conclusion of this tool cannot show the interaction between the calculated results (GHGs, TCO, etc.) and the changes of logistic parameters (transported weight, traveled distance, etc). Moreover, the stakeholders can only partly understand the sustainability of their options from the results of this tool without considering the social dimension.

The Heavy Truck Benefits Analysis Models (HTBAMs) is the second model that is applied for estimating energy, environmental, and economic benefits by using a market-based approach [2]. The model incorporates driving cycles to calculate the fuel consumption. It implies that the fuel consumption varies with the velocity at each time step so that the accumulated results are closer to real life. Moreover, this model has the capability of predicting future market of heavy trucks to present a long-term view. Additionally, the calculation of total carbon-equivalent emissions covers the emissions from Well to Wheel (WTW). Nevertheless, the alternative fuel types and vehicle types of this tool are fewer in number than the AFLEET Tool. In addition, the HTBAMs estimate the change of fuel costs by applying advanced technologies, whereas the total costs for employing these advanced technologies are neglected. Finally, this model concentrates on estimating the economic and environmental benefits from the automotive point of view without involving the logistical parameters.

ADVISOR is the third model. It is abbreviated by Advanced Vehicle Simulator. The role of this tool is to provide the vehicle engineering community with an easy-to-use, flexible, yet robust and supported analysis package for advanced vehicle modeling [3]. The fuel economy, the performance, and the emissions of passenger and commercial vehicles with using conventional and alternative fuels can be quantified in this tool. This tool calculates the fuel economy according to driving cycles. Moreover, the regenerative braking system is integrated into the calculation. ADVISOR contains a wide range of vehicle and fuel types so that a number of stakeholders can benefit from the simulation results. On the other hand, this tool analyzes the various technologies simply from the environmental point of view. Additionally, the logistical parameters paid no attention in this tool.

Furthermore, we investigate three logistics-oriented models. Calculating GHG emissions for freight forwarding and logistics services is the first one published by CLECAT. The objective is to provide a practical tool for logistics service providers that seek to make use of the European standard EN 16258"Methodology for calculation and declaration of energy consumption and greenhouse gas emissions of transport services", in order to determine their environmental footprint and seek ways to reduce it [4]. The users can calculate the energy consumption and GHG emissions in compliance with sample calculations by applying standard values. The energy consumption of the lorries, trains, ships, aircraft as well as buildings, warehouses and handling are involved in this guide. The contribution of this work is providing clear methods with taking into consideration of logistical parameters and diverse transport modes. The corresponding equations and WTW standard values are provided in accordance with the EN 16258. Nonetheless, this work has paid no attention to driving cycles or planned service years. Furthermore, the economic and social dimensions are neglected to be involved. In addition, the alternative fuels, which has the capability of saving energy and reducing emissions, should be considered for the purpose of the sustainable development.

Straßengüterverkehr Berechnung und Allokation (SBuA) is one module of a tool called CO_2-Methodenbaukasten. The objective of this tool is to help small and medium-sized logistic enterprises with balancing their energy consumption, carbon dioxide emissions as well as GHG emissions [5]. This module focuses on the commercial vehicles of using conventional diesel, biodiesel, biodiesel 4%, 5%, 6%, and 7% blend. The energy consumption, CO_2 emissions, and CO_2 equivalent emissions from Tank to Wheel (TTW) and WTW are calculated by considering logistical parameters. The methods of calculation and the standard values are applied in compliance with the work introduced in the last paragraph. Therefore, this module contributes to the logistic enterprises numerically and comprehensively understanding their transport operations from the environmental point of view. However, this module only examines the environmental parameters. The differences of the expenditure are unclear from the economic point of view. In addition, the social dimension is lacking for selecting appropriate types of ECVs in sustainable UFT. Moreover, the vehicle types and the fuel types are fewer in number than the AFLEET Tool. Finally, this module has paid no attention to drive cycles or planned service years.

EcoTransIT World is an abbreviation of Ecological Transport Information Tool – Worldwide. It is free of charge internet application, which shows the environmental impact of freight transport for any route in the world and any transport mode [6]. This application aims to support the forwarding companies, carriers, logistic providers, political decision makers, consumers and non-governmental organizations. The

Table 1: Purposes, Advantages, and Limitations of Existing Models

Models	Purposes	Advantages	Limitations
AFLEET	To estimate and compare multiple vehicle types and fuel types from economic and environmental perspectives for clean cities stakeholders	Wide range of alternatives Time-dependent relatively full database WTW	No logistical parameters No social dimension
HTBAMS	To estimate energy, environmental, and economic benefits for heavy trucks	Drive cycles Future market WTW	Few alternatives No logistical parameters No social dimension
ADVISOR	To provide the vehicle engineering community an analysis package for advanced vehicle modeling	Drive cycles Wide range of alternatives	No logistical parameters No social dimension No economic dimension
CLECAT	To provide a practical tool for logistics service providers to determine their environment-zal footprint and seek ways to reduce it	Easy and clear methods Logistical parameters Diverse transport ,modes WTW	No time factor No economic domension No social dimension Few alternatives
SBuA	To help small- and medium-sized logistics enterprises balancing their environmetal parameters	Logistical parameters WTW	No economic dimension No social dimension Few alternatives No time factor
EcoTransIT	To assist freight transport stakeholders calculating environmental parameters and comparing them from logistic concepts including all transport modes	Logistical parameters Diverse transport modes WTW	No time factor No economic dimension No social dimension No alternative fuel vehicles

purpose is to assist them calculating the corresponding environmental parameters and comparing them thoroughly from logistic concepts including all transport modes. This application provides two input modes. The standard input mode allows users estimating the energy consumption and GHG emissions quickly and efficiently. The extended input mode provides users some options to adapt their own cases with standardized units, such as changing the goods types, running routes, transport modes, vehicle types, emission standards, load factors, and empty trip factors. This application transformed the standard EN 16258 into an effective tool. The diverse transport modes and multiple logistical parameters assist the corresponding stakeholders calculating and comparing their own cases. Nevertheless, this application has paid no attention to the time factor and has only estimated the conventional commercial vehicles from the environmental point of view.

A Concept for Selecting Appropriate Alternatives

On the basis of reviewing the purposes, advantages, and limitations of existing models, we observe that the models, which focus on estimating the economic and environmental performance from the vehicles' point of view, have taken into account the time factor. Moreover, these models involve a wide range of alternatives for users to do the comparison and selection. On the contrary, the models, which concentrate on estimating the environmental performance from the logistical point of view, have taken into consideration of logistical parameters. Nevertheless, there are few alternatives of vehicle and fuel types provided to the users. Furthermore, we notice that none of these models paid attention to the social dimension. Therefore, we propose a concept in this paper to support the estimates of economic, environmental, and social performance of multiple alternatives with considering the time factor and logistical parameters by extending the existing models. The goal of this concept is to numerically support the urban logistic stakeholders to select appropriate types for achieving sustainable UFT.

We define that the four types of ECVs are a set of vehicle types V . The five markets of UFT are a set of markets M. The set of alternatives A is derived from the Cartesian product of the set of vehicle types and the set of markets. The three sustainable dimensions are a set of criteria C for comparing the alternatives.

$$V = \{\text{BEVs, HEVs, PHEVs, FCEVs}\}$$
$$M = \{\text{Retail, Express/Post, HoReCa, Construction, Waste}\}$$
$$A = V \times M = \{(v,m) | v \in V, m \in M\}$$
$$C = \{\text{Economic, Environmental, Social}\}$$

We propose the concept in accordance with the theory of Multi-Criteria Decision Making (MCDM). MCDM is a branch of a general class of operations research models which deal with decision problems under the presence of a number of decision criteria [7]. In this paper, we assume that decision makers are urban logistic stakeholders. The decision problem is which type of ECVs is applicable for decision makers' fleets. The decision criteria are three sustainable dimensions. The decision matrix is illustrated in table 2, where $A_m \in A$, $C_{eco} \in C$ is economic criteria , $C_{env} \in C$ is environmental criteria, $C_{soc} \in C$ is social criteria , w_1 is the weight of economic criteria, w_2 is the weight of environmental criteria, w_3 is the weight of social criteria, a_{m1} is the performance of A_m when it is evaluated in terms of decision criterion C_{eco}, a_{m2} is the performance of A_m when it is evaluated in terms of decision criterion C_{env}, a_{m3} is the performance of A_m when it is evaluated in terms of decision criterion C_{soc}, and $r(A_m)$ is the score, which synthesize the three performances of A_m. The performance of alternatives by taking into account the time factor and the logistical parameters will be calculated by proposing three mathematical expressions. The decision makers determine the ranking of alternatives depending on the scores. The framework of the proposed concept is illustrated in Fig.1. First of all, the decision maker needs to identify the alternatives that they intend to estimate and compare from the set A. According to the identified alternatives, a set of corresponding data can be selected by searching in the database. Then, the set of data is inputted into three mathematical expressions. In order to confirm the accuracy of the conclusion, we validate the results calculated by proposed mathematical expressions. If the conclusion is not accurate, the procedure will move back to check and select a new set of data. If the conclusion is accurate, the procedure will move on to calculate the performance of alternatives for each criterion. Filling the calculated results into a decision matrix, the scores of each alternative by taking into consideration of three criteria can be calculated. The ranking is derived from the scores. In addition, it is possible to visualize the performance of alternatives to illustrate visible results to help with the decision.

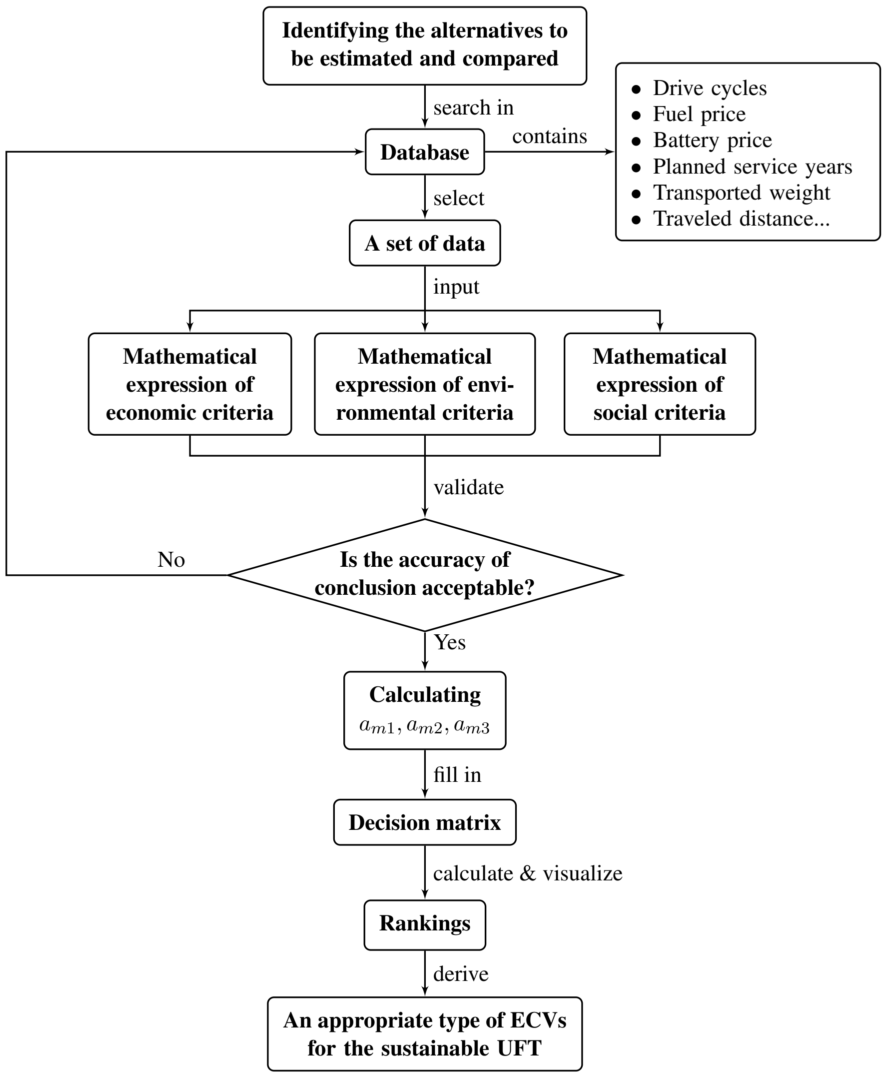
Conclusion

By reviewing several existing models, the first contribution of this paper is the identification that few models can estimate the economic, environmental, and social performance of multiple alternatives with considering the time factor and logistical parameters. Accordingly, we propose a concept to fill this gap by extending the existing models with taking into account their advantages and limitations. The goal of this concept is to numerically support the urban logistic stakeholders to select an appropriate type for achieving sustainable UFT. Future research can concentrate on specifying the mathematical expressions and extending the database for adapting to the various requirements of decision makers. Furthermore, the proposed concept can be connected to the Internet of Things and Industry 4.0 by collecting real-time data of drive cycles. Not only urban logistic stakeholders but also automobile manufacturers can benefit from this connection.

Table 2: Decision Matrix

Alternatives	**Criteria**			**Results**
	$C_{eco}\,(w_1)$	$C_{env}\,(w_2)$	$C_{soc}\,(w_3)$	
A_1	a_{11}	a_{12}	a_{13}	$r(A_1)=\sum_{j=1}^{3} w_j \cdot a_{1j}$
A_2	a_{21}	a_{22}	a_{23}	$r(A_2)=\sum_{j=1}^{3} w_j \cdot a_{2j}$
⋮	⋮	⋮	⋮	⋮
A_m	a_{m1}	a_{m2}	a_{m3}	$r(A_m)=\sum_{j=1}^{3} w_j \cdot a_{mj}$

Figure 1: Framework of the Proposed Concept



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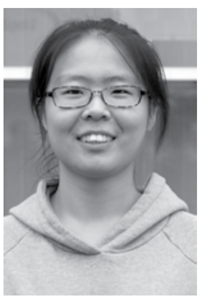

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Peak Height and Resolution Determination of Ethylene Gas Chromatographic System

For the control of fruits during transportation ethylene gas, which is a ripening indicator, has to be measured selectively with a resolution of 50 ppb. This is done with a micro gas chromatograph, using a chromatographic column made by 3D printing, a micro-machined preconcentrator and a SnO2 gas sensor. DAQ card is used as a controller for the gas chromatographic system. First we present measurements of ethylene gas in synthetic air with 400 ppb and 35 ppb concentration. The drift in the baseline is removed using curve fit technique and exact peak height of the chromatograph is determined. Furthermore, the resolution of the system is found to be 4.3 ppb, determined using Allan variance.

Nayyer Abbas Zaidi*

Introduction >>> Ethylene is an invisible, colorless and odorless gas emitted from fruits during the ripening process. The amount of emission of ethylene depends on the quantity and the ripeness state of the fruit. During the transportation bananas must be in the pre-climacteric state; however, sometimes banana start premature ripening. Ripening banana emits ethylene and generates heat, this way, surrounding fruit are triggered to start ripening, and a hot spot evolves. To detect this dangerous situation, ethylene detection in the lower ppb range is needed [1].

To detect the ethylene gas several methods and techniques have been proposed. The most common and ready to used methods are portable electronic nose (PEN) and electronic olfactory system (EOS835) [2, 6]. They consist of an array of metal oxide sensors and they are commercially available. These electronic noses are able to detect many gases simultaneously [2, 3].

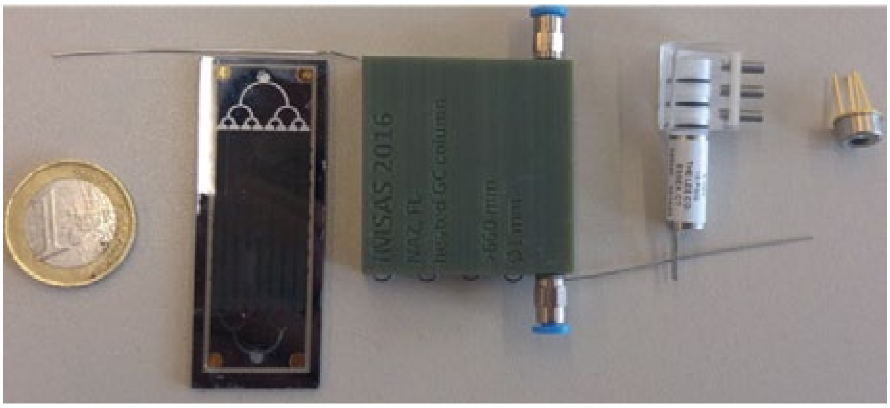
Another method used for the detection of ethylene gas is non-dispersive infrared spectroscopy (NDIR). The advantage of using this system is its selectivity when doing the measurement in a mixture of gases. This system consists of a chamber, an infrared source, lenses, and detector. To increase the sensitivity of the system, passive sensitivity improvements like the shape of the chamber and polishing the chamber with the silver coating are presented in [5]. The main absorption band of ethylene gas is at 10.5 µm. However, to detect ethylene in ppb range infrared sources with maximum power spectral density at 10.5 µm is required which is still a limitation in this research.

Several portable gas chromatographic systems with different detectors are available [6-11]. In 2016, a portable gas chroma-tographic system for the detection of BTX is developed [12]. This system is used to carry out field operation [13]. The system consists of BTX and nitrogen cylinders, mass flow controllers and mini pumps, sampling unit and photoionization detector.

Gas chromatographic systems are very powerful for the detection of ethylene in the lower ppm range. To achieve ppb resolution, a preconcentrator has to be integrated into the gas chromatographic system. In first experiments, measurement was made difficult by a large signal caused by humidity. Using a more appropriate stationary phase, the ethylene signal, and the humidity signal could be separated and a ppb resolution was achieved. Using a chromatographic column etched in silicon, Janssen [1] achieved a resolution of 3.8 ppb (3σ resolution).

The Allan variance is a technique developed in mid-1960 to study the random processes involved in a system. Initially, it is

Figure 1: Design of the System



One Euro | Gas Chromatographic Column | Preconcentrator | Solenoid Valve | Ethylene Gas Sensor

Figure 2: Ethylene Preparation

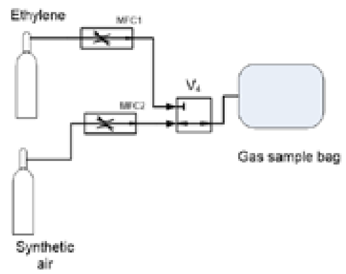
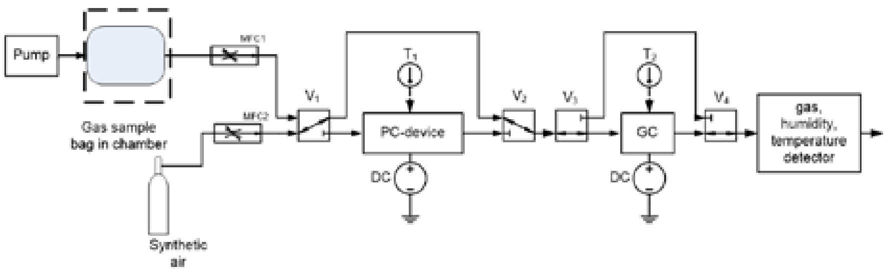


Figure 3: Taking Ethylene from the Gas Sample Bag to the Gas Chromatographic System



used for the frequency stability of precision oscillators. The work is further extended to determine the stochastic process present in the inertial sensors. El-Sheimy et al. use Allan variance for the modelling and analysis of inertial sensor [10]. Werle et al. uses Allan variance to measure the minimum detection limit and the type of noises present in the Tunable diode-laser absorption spectroscopy (TDLAS) [11]. We here further extend our work to compute the detection limit of the ethylene gas chromatographic system using Allan variance.

In this work, micromachined Preconcentrator, 3D printed column, SnO2 gas sensor, and a gas sample bag system to measure ethylene gas as lower ppb concentration as shown in Figure 1. Two novel techniques are proposed to measure the peak height determination and the system resolution. <<<

System

To test ethylene below 400 ppb, the necessary concentration was prepared in our laboratory. The block diagram of the setup used for ethylene preparation consisting of a gas sample bag and taking ethylene from the sample bag to the gas chromatographic system is shown in Figure 2 and 3. The system for ethylene injection into the gas sample bag consist of 400ppb ethylene and synthetic air cylinders, two mass flow controllers, a valve and gas sample bag as shown in Figure 2. Initially the gas sample bag is cleaned with synthetic air and flowrate tolerance in the mass flow controller is removed by using flow meter. The concentration of 35 ppb ethylene is obtained by mixing synthetic air with ethylene of concentration 400 ppb.

The equipment required to get ethylene from the gas sample bag consists of a pump, a sealed chamber, mass flow controller, flow meter, gas sample bag and valves as shown in Figure 3. Initially the gas sample bag is placed in to the chamber and then sealed. The pump gives positive flow to the sealed chamber which generates positive air pressure in the chamber. This positive air pressure presses the gas sample bag and ethylene comes out of the gas sample bag. The flow rate of ethylene is controlled by the mass flow controller.

System Working

The developed GC system for the measurement of ethylene gas consist of GC column, pre-concentrator (PC), SnO2 detector and four valves as shown Figure 3. The four valves V1 to V4 are used to direct the flow in to the preconcentrator PC and GC or bypass them. The carrier gas continuously flowing in the GC system is synthetic air. The concentration of ethylene is introduced to the PC in which the ethylene molecules are trapped. This process is called adsorption and normally in this process PC is kept at room temperature. This requires approximately 25 min to capture the ethylene in the Preconcentrator. After adsorption synthetic air is used that bypass the PC and enters in to the GC in order to flush out the ethylene from the pneumatic channels and to get a baseline. This baseline can be seen in a Labview program through a National Instrument DAC card used to interface the sensor to the computer. After getting the baseline the PC is heated to 250 °C for 10 min. Heating the PC detaches the ethylene molecules from the stationary phase. Synthetic air flow through the PC takes the detached ethylene molecules into the GC column. After the ethylene retention time within the GC column, the non-selective gas sensor gives an ethylene peak.

Ethylene Peak Determination

Figure 4 shows the result of a gas chromatograph obtained with a concentration of 400 ppb and 35 ppb ethylene in synthetic air. The gas sensor shows a temperature cross sensitivity, this generates a temperature drift in the output signal of the gas chromatographic system. When measuring at very low concentrations, this drift cannot be neglected. In order to determine exact peak height in spite of the baseline drift, we developed the following procedure: the drifting baseline is approximated with a polynomial of order v 6. The peak height is calculated from this polynomial fit. This procedure is shown in Figure 4.

Figure 4: Chromatograph at 400ppb

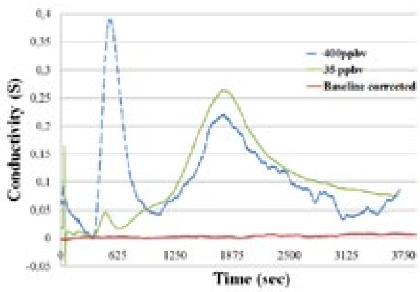


Figure 5: Chromatograph from Bananas

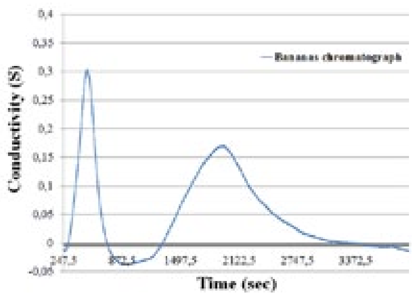


Figure 6: Statistical Calculation of Baseline

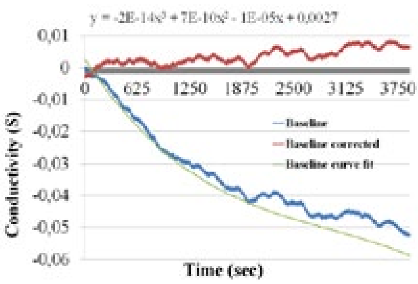
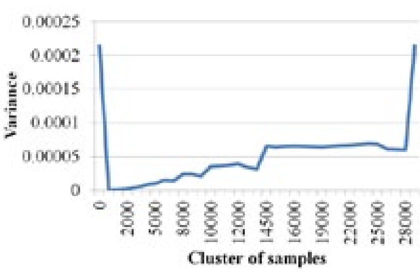


Figure 7: Allan Variance



System Resolution

To determine the resolution, we first calculate the standard deviation of the signals, which corresponds to $\sigma = 2$ ppb. The maximum drift of the baseline within the measurement time period is 0.05 S, which corresponds to a maximum uncertainty in the determination of peak height corresponding to a concentration of $\Delta C = 6$ ppb. This way, we calculate a resolution of $3\sigma + \Delta C = 12$ ppb.

Since the measurement of ethylene takes 10 minutes, drift is a serious problem for determining the resolution. The problem of determining resolution in systems under the constraint of long term drift has been discussed in inertial sensing e.g. micro gyroscopes. There, the algorithm of Allen's variance has become the standard method [7].

To measure the resolution of the gas chromatograph system in lower ppb the Allan variance is used. In Allen's variance, the variance is determined as a function of the sampling time (or the number of samples). We applied Allen's variance to the sensor data from the gas chromatographic system. Where the total samples in the baseline are divided into several clusters. The average of the single cluster is given as:

$$\overline{X}(q,n) = \frac{1}{n}\sum_{m=q}^{q+n} x_n$$

Where x_n represents the instantaneous output of data from the sensor and $\overline{X}$(q,n) represents the average of the cluster which starts from qth data point and contains the n data points.

The variance of each cluster is calculated:

$$б^2(q,n) = \frac{1}{n-1}\sum_{m=q}^{q+n}\left(x_m - \overline{X}(q,n)\right)^2$$

Where x_m represent the current sample and $б^2(q,n)$ represents the Allan variance of the single cluster.

The average standard deviation of the total cluster corresponds to Allan variance

$$\overline{б}(n) = \frac{1}{w}\sum_{w=1}^{m} б(q,n)$$

Where 'm' represents the total number of cluster and $\overline{б}(n)$ represents the Allan variance.

The sampling frequency of the system is set to be 4Hz in which contains about 29000 of samples that comes in the time period of about 7200 seconds. These samples are divided into a cluster of in the range from 500 with the increment of 1000 till they reach 29,000 samples. Figure 7 shows the Allan variance calculated using the samples in the baseline in terms of clusters.

From the Allen variance plot, the value of 2000 samples is chosen, because this value corresponds to the length of our chromatogram, where the ethylene peak shows at 2000 samples or 500 seconds as shown in Figure 4. The corresponding value of the standard deviation of Allan variance is 0.0016 S. The measurement noise at 2000 samples is calculated and a accurate resolution of $3\sigma = 4.8$ ppb is acquired.

Demonstrating the resolution in the synthetic air does not prove the applicability in a container. There could be other gases generated by bananas, such as alcohols, which could disturb ethylene detection. To check for this effect, we let banana ripen in a storage box and observe an increase of ethylene using our gas chromatographic system. Figure 5 shows the probe of ethylene extracted from the banana box. It can be seen that no further disturbing signals are generated, only ethylene and water, which can clearly be separated. The retention time of 470 sec confirms that the probe gas is ethylene and our system can detect ethylene from bananas. The ethylene from bananas in the storage box detected by the gas chromatographic system is 306 ppb concentration.

Conclusion

We demonstrate measurement of ethylene by a gas chromatographic system in the lower ppb range. The drift in the baseline creates a serious problem in determining the system resolution, which is resolved using Allan Variance and found to be 4.3 ppb. For early warning systems in fruit transport, detecting the onset of premature ripening and the possible development of a hot spot, we need to resolve 50 ppb. We demonstrate that this is possible with a micro gas chromatographic

A comparison on the specification with the commercially available ethylene gas detection system is presented in Table 1. We predict that the production cost of the system would be 2200 € which is more than 50 % less than the commercially available ethylene gas detection system.

Table 1: Portable Gas Chromatographic System for the Detection of Ethylene Gas

Specification	F-900 [8]	ETH-1010 [9]	Gas chromatographic system
Air sampling rate	0.2 Liters/min	500 ml/min	10 milliliter/min
Dimension	18.3x11.1x12 cm^3	28x11.4x 25 cm^3	23X11x19.5 cm^3
Weight	Nil	5 lb	Nil
Sensor type	C2H4 Electrochemical sensor (0 - 2ppm) (Resolution 0.001ppm) C2H4 Electrochemical sensor (0 – 200 ppm) (Resolution 0.1ppm) CO2 Infrared sensor (0 - 2000ppm) Resolution 0.1ppm CO2 Infrared sensor (0-20%) (Resolution 0.01%) O2 Electrochemical sensor (0-100%) (Resolution 0.1%)	Electrochemical sensor (0-1000ppm) and integrated CO2 sensor	Metal oxide gas sensor
Lower detection	40 ppb	10 ppb	4.8 ppbv
Offset recalibration	Daily for ethylene	Nil	Nil
Data logging	yes	yes	yes
Portability	yes	yes	yes
Sales cost	€ 10,263.75	€ 7000	€ 2000

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Hand-Free Interaction in Complex Situation

Foot-based interactions have recently received a great deal of attention as an input modality for direct control of interactive devices, especially in medical systems when sterility is the main concern, such as in the operating room (OR). In this paper, we present a new haptic sensor-integrated shoe named Medi-Mouse. It allows surgeons in the OR to manipulate and interact with visual 3D data through foot movements on the floor. This wearable system is portable and consists of three parts: a sensing module, a computing module, and a data visualization module. The proposed system was explored by the intended users. The results show reduced cognitive load in comparison to the control condition.

Ambreen Zaman

Introduction >>> In general, users use their own hand to control computing devices (e.g. personal computer, mobile etc.).
In some circumstances, people want to interact with computing devices to extract information and also simultaneously want to perform other tasks, such as, cooking or carrying bags, surgeons are busy in the process of surgery using both hands, etc.
In such situations, it is necessary to provide information more effectively and efficiently with a comfortable, precise and sterile interaction technique, where feet can be considered alternative means for a hand-free interaction technique.
During surgery, surgeons require a great amount of information in order to operate the patients as efficiently as possible. Digital data is the key for successful diagnosis and intervention planning. However, there exists an interaction gap when looking at input devices for pre-operative planning compared to the possibilities for intra-operative interaction [1]. Before surgery, surgeons have access to innumerable amounts of digital information to plan surgical interventions. Software tools support this planning by collecting data from different sources and segmenting structures of interest, e.g., for building 3D model representations of tumors, surrounding tissues, and organs [2]. During operations, access to these tools is severely limited since all interaction tools need to be sterile if surgeons want to use them by them-selves. Often, only a selection of images is defined beforehand and can then be browsed during operation by an assistant, who would go through a complex 3D or 2D data set slice by slice, acting on verbal instructions as given by the operating surgeon.

In such scenarios, it would be an improvement to provide surgeons with a comfortable, precise, and sterile input device to efficiently manipulate and interact with visual datasets by themselves, e.g., to rotate a 3D image, browse through slices, or select a menu item. Compared to other touch or touch-free modalities, the feet can be an effective means to accomplish this goal. <<<

Background Studies

During surgical procedures, surgeons usually operate with manual surgical instruments. Therefore, hand-driven interaction is often not feasible due to the constraints of sterile interaction. In principle, this leaves voice, gesture or gaze interaction as potential options. While some studies show that speech recognition systems can be used under certain circumstances as input modality [3, 4], they are problematic if the OR is too noisy. Others have looked at hand gestures or gaze as input modalities [5, 6, 7], but these input channels are also limited as they may conflict with the primary task of the surgeon if their hands are busy otherwise or if the gaze is too hard to control without resorting to tedious methods like time-based thresholds for filtering unwanted interactions. Therefore, surgeons often still depend on their assistants to navigate visual data indirectly during surgery. For example, Graetzel et al. [7] illustrate a scene where an assistant follows the instruction of a surgeon taking approximately seven minutes to click on the particular correct location.

Communication with a substitute operator for manipulation of visual data may become even more complicated if the operator and the surgeon do not have an equal level of professional experience [8]. In addition, according to Wachs et al. [9] touch-based interaction also has issues with asepsis, i.e., surgeons must reach a required position and move away from the patient to where the technology is located, in order to manipulate and interact with images.

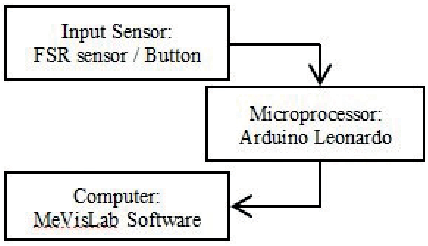
To overcome the barrier of dependency and detachment from the patient, we present a foot-based interaction technique, which can be operated by surgeons during surgery and enables them to manipulate and interact with visual data in a hygienic way.

Figure 1: *The Medi-Mouse*

(a) Button based Medi-Mouse (b) Sensor based Medi-Mouse

Figure 2: *Backside of the Medi-Mouse*

Figure 3: *General Medi-Mouse Architecture*



Interaction Design and Concepts

Our goal is to design an interface, which is self-controllable, easily accessible, less complex, comfortable, sterile, and precise, by which surgeons can easily access the desired visual data during operation. The pose of the user (sitting, walking, and standing), the accessible input senses through the lower limb (intrinsic, extrinsic, and mediated), and the movement of three joints of lower limb (the ankle, the knee, and the hip) need to be considered for the interface design phase [10]. The human foot itself, however, is quite complex and consists of 26 bones (tarsals, metatarsals, and phalanges). It can be divided into three different parts: the hind foot (the heel), the mid foot, and the forefoot (where the ball and toe are located).

Regarding this structure, the feet have a distinctive and asymmetrical shape. In addition, due to shorter length of the toes compared to the other fingers, which causes a pressure on the design, use of foot based mouse instead of the regular mouse is unsuitable for grasping through feet. Therefore, foot-based interaction requires a specific foot-mouse design [10]. Weizhong et al.'s shoe-mouse [11] and Fukahori et al.'s pressure-based sole [12] inspired us to design a novel sensor-integrated shoe-based mouse.

With these design considerations in mind, we introduce Medi-mouse, a shoe-based mouse designed specifically for the surgeons to interact with visual data during surgery. This paper presents two prototypes of shoe-based mouse that both include an optical sensor system (i.e. off-the-shelf computer mouse) as shown in Figure 2, for detecting spatial movements, and two variants for simulating button clicks: one is based on pressure sensors and the other uses micro-switch. Both prototypes as shown in figure 1 include an embedded wireless mouse and an activation button on the outside that is used to toggle the mouse activation (activate/deactivate). Inside the shoe, the sensor-based mouse includes a pressure sensor (Interlink Electronic Force Sensing Resistor 400; FSR) for the big toe, which is used for triggering left mouse clicks. The other variant uses a micro switch at the same location and for the same purpose.

During the initial stage of development, we did a qualitative evaluation of Medi-mouse with surgeons in order to inform our human-centered design process and get quick feedback from the users. In interviews and first sessions with initial prototypes, surgeons suggested focusing only on the most important mouse functions that are most often used during operations. This led to our decision to only integrate one (left) mouse button detecting left mouse clicks only.

Hardware Design

The general architecture for both mice are shown in Figure 3. The proposed Medi-mouse has three subsystems:

Subsystem 1 is for sensing the user activity in the shoe using an Interlink Electronic FSR sensor 400 or by pressing the push button. These sensors are placed inside the shoe where the big toe is positioned. The sensor or button acts like a left click of a normal mouse. In addition, a small micro switch has been placed by the side of the shoe, which is used to toggle the mouse activation state. On activation, the sensor or button sends a signal to the micro-controller in subsystem 2.

Subsystem 2 is for gathering signals from the sensor or button. It is based on an Arduino Leonardo micro-controller and processes the signals. It sends the transcoded signal to the computer for triggering the desired action, such as rotating 3D images, selecting a menu command, etc. Furthermore, the embedded wireless mouse sends signals to locate the mouse pointer on the screen. Although this paper focuses on rotating 3D images, in principle, it covers any mouse-controlled interaction.

Subsystem 3 (data visualization module) is the medical visualization system using a custom-built MeVisLab application. It loads and displays medical 3D image data, which is relevant to clinically used 3D visual data. Compared to the default keyboard / mouse controls, the visualization in our prototypes is controlled via subsystems 1 and 2.

For the construction and implementation of the shoe, we used foam rubber, a material that has a similar look and feel as the original shoes used in the OR. The shoe itself was then shaped in a laser cutter, which allowed for computer-aided construction and customization of the prototypes. Figure 1 shows the button-based Medi-mouse, the sensor-based Medi-mouse, and Figure 2 shows the backside of the Medi-mouse

Expert Opinion

Three surgeons interacted with 3D visual data within the both variations of our Medi-mouse (i.e. button-based vs. sensor-based) and participated in an interview where they had to fill out questionnaires. The study was done as part of a half-day workshop that was held in a hospital. Participants interacted with visual data displayed on a Lenovo Laptop where MeVis software consisted of the 3D images. After that, they answered pre-defined questions.

Surgeons appreciated the idea of Medi-mouse. At first, they assumed that the interaction with Medi-mouse might be difficult. But after they had worn it and interacted with visual data, they found that the proposed systems are comfortable, independent, easily controllable, and easily adaptable. According to our measurements, surgeons became familiar with the Medi-mouse in less than a minute. They also appreciate incorporating Medi-mouse in their operation room. However, according to their experience, they feel that it might be difficult to operate the Medi-mouse when there is liquid on the floor. We acknowledged the expert concern in this regard, however, our vision in this study was to provide the proof-of-concept for foot-based interaction and the principal feasibility of the approaches.

Case Study

The performance of the proposed Medi-Mouse was evaluated in a user study. The goal of this study was to provide a proof-of-concept and investigate the feasibility of the two approaches. The study design was inspired by clinical tasks and included the elemental task of browsing medical image data, which is relevant to clinical settings. We found it interesting how well users could manipulate the visual representation to reach a certain view on the visual data in limited acclimatization time and under any effects with respect to cognitive load. The motivation for the experimental design was based on surgeons' demand for independent interaction with visual data during surgery. Therefore, we defined a task where users had to align 3D MRI data in our visualization software using Medi-mouse. The target view was defined by random images presented on flip cards. This experiment also aimed at measuring interaction efficiency.

The overall concept behind this experimental design was that surgeons mostly look for specific orientations and they try to match the orientation of 3D data as closely as possible to a desirable target orientation (e.g., matching the current orientation of the patient as closely as possible to help them acquire an accurate mental model of the current situation to proceed with the intervention).

Setup and Procedure

The study was conducted with the help of twelve (8 men and 4 women, mean age 29.08 years) novice participants. The participants were considered for a preliminary analysis to evaluate the general usability of our Medi-mouse. The participants had no known disorders, no prior experience with foot-based interfaces and did not know the background of the underlying experiment. All participants were right-footed as no left-footed participants volunteered for the study.

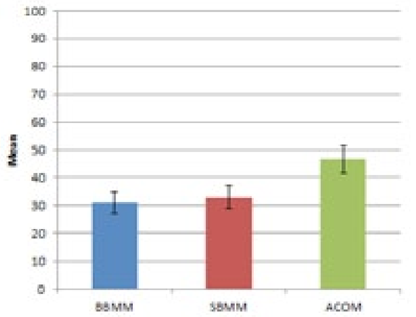
All users used both variants of Medi-mouse to interact with 3D medical data. To measure cognitive load and general usability we used two standardized questionnaires: NASA TLX [13] and the System Usability Scale (SUS) [14]. To complement these subjective measurements, the task completion time has been considered as an objective measurement for efficiency. We also asked the participants' opinions on pros and cons of the both versions.

The individual sessions were organized as follows. Before the beginning of the experiment, each participant signed an informed consent form and filled out a demographic questionnaire. We applied a within-group design with three different conditions. Each participant had to do the same tasks using three different methods. These were the button-based Medi-mouse (BBMM), the sensor-based Medi-mouse (SBMM), and verbal instructions of a human assistant who operated an optical mouse ("assistant controlled optical mouse", ACOM). The control condition (ACOM) captures the situation as it currently is in the OR with a human assistant being present. To minimize the potential influences such as a certain noise or bias in the data, detailed instructions were provided for the assistant on how to act. Tasks were presented in a randomized order and the order of conditions was counter-balanced for learning effects by a Latin square scheme [15].

Each participant had a short training period before starting each condition, so they could familiarize themselves with the device and the environment. Images were presented on a 32" monitor placed on an otherwise empty desk. A Lenovo Thinkpad T410 laptop was used to record task completion time, activate Medi-mouse functionality, and run the visualization software. A video camera and a webcam were used for recording the user performance. The facial expression was captured by the video camera and the foot movements were recorded by the webcam using the free screen capture video software Icecream Screen Recorder.

For each task, the users had to align3D MRI images according to a flip card of MRI images that was provided to them in a randomized order. They performed the assigned task three times for each method using three different images. For the control condition (ACOM), users got a random image and they had to take the assistant through verbal commands (i.e. rotate clock-wise, anti-clock wise, left, right, up and down) in order to align the image on the screen accordingly. While the participant could see both the target image on the card as well as the computer screen, the instructor could only see the computer screen. The assistant followed the verbal instructions, and finally when the flip card image matched with the on-screen 3D image, the instructor confirmed that the orientation had been accomplished successfully. The task was designed to model how surgeons instruct their assistants or nurses in the OR.

Figure 4: *NASA TLX Overall Performance*



For each task, the completion time was recorded using a logging software programmed in Java, which assigned a generic and unique user id to each participant. For each user, the task completion time was recorded for all experimental conditions together with date and time of the experiment. After completion of each method, the participants completed the post-task questionnaires. The whole procedure took on approximately 45 minutes per participant.

Results and Discussion

The overall NASA TLX scores are presented in Figure 4. This figure is showing that the average score for BBMM is 31.11 and SBMM is 33.05, whereas ACOM score is 46.74. The NASA TLX sub-scales (mental demand, physical demand, temporal demand, performance, effort, and frustration) are presented in Figure 5. In each subscale, the cognitive load of Medi-Mouse is comparatively less then the control condition, except physical demand, which is at an expected level since users operate Medi-mouse physically by themselves compared to when verbally instructing an assistant.

The results of the SUS questionnaire are presented in Fig 6. Both BBMM and SBMM were rated around 80 points, which is a very good rating, while ACOM achieved an average SUS score of 50. Task completion times are presented in Table 1. Both BBMM and SBMM took approximately 60 to 70 seconds on average to successfully perform the presented task. However, with ACOM, it took participants approximately 130 seconds on average, which again suggests that the proposed methods are more efficient than the control condition.

Conclusion

In this paper, we presented a foot-based input device for intra-operative interaction with 3D image data while the surgeons' hands are occupied. The main motivation of the proposed device providing surgeons with a comfortable, precise and independent device. Following development, the proposed system was explored by the intended users. The results show reduced cognitive load in comparison to the control condition.

The proposed methods, however, are in a preliminary stage. Further evaluation of the system is required within the real OR environment with regard to additional variables like durability, unintended inputs, shifting weight, and strain.

Table 1: Task completion time result by method and task

Method	Image 1	Image 2	Image 3	Mean (seconds)
BBMS	66.03	78.05	73.16	72.41
SBMM	70.21	59.3	50.6	60.04
ACOM	117.14	137.54	126.34	127.01

Figure 5: *NASA RLX Outcomes*

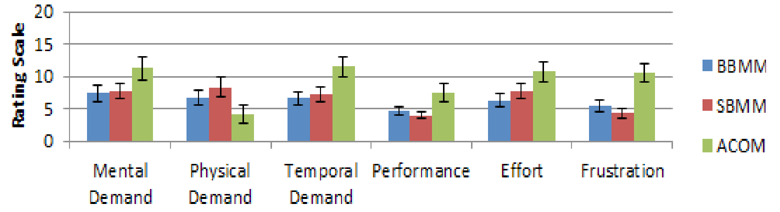
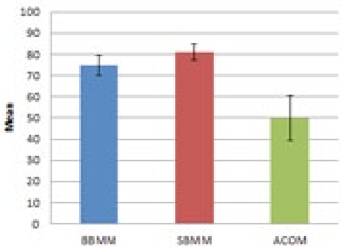


Figure 6: *System Usability Scale*



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Predictive Capacity Adjustment in Job Shop Systems by Using RMTs

Demand fluctuations with high customization and cost-effectiveness disturb the normal work plan and lead to performance deterioration. In order to improve the flexible capability to deal with such fluctuations in dynamic manufacturing process. Reconfigurable machine tools (RMTs) are employed to adjust capacity in a dynamic job shop system. Furthermore, we propose a closed-loop feedback system based on model predictive control (MPC) to align uncertainties and dynamics in terms of logistic objectives. The proposed method provides a new solution for manufacturers to optimize available resources and enhance the production performance in a dynamically changing environment. The proposed method is confirmed by simulation results.

Qiang Zhang*

Introduction >>> Capacity adjustment is one of the major effective strategies to compensate and balance capacity to cope with demand fluctuations. Generally, an adjustment of capacities is done by reallocating operators or overtime to temporarily increase/decrease the capacity, which are all comparably expensive and is not a sustainable way. Instead of the mentioned methods, we consider adjusting capacity through changing number of machines. In the view of machine equipments, traditional machine tools such as dedicated machine tools (DMTs) and flexible machine tools (FMTs), it is difficult to meet such challenges [1]. Reconfigurable machine tools (RMTs) are designed for a specific customized range of operation without any waste of flexibility and with high productivity [2]. However, RMTs are only the enabler in the manufacturing process. Therefore, we adopt model predictive control (MPC) method to promote the usage of such machine tools effective in a job shop system. <<<

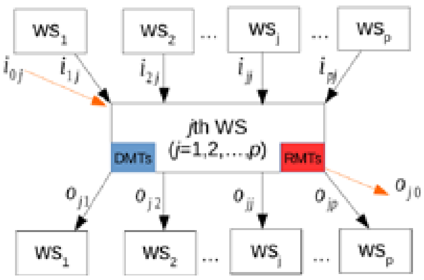
Problem Definition

In the context of production planning and control, manufacturing system with a high percentage of parallel machines, small lot sizes and a large variety within series are of particular interest, which is a characteristic of job shop manufacturing. This kind of system provides a high inherent flexibility in conjunction with cross-link information and multi-directional flow, which is particular beneficial for production systems with often changing products [3]. However, this system also has some disadvantages, e.g. high work in process (WIP) level and long lead time, which disturb the normal work plan and lead to performance deterioration. RMTs are an appropriate alternative in such an environment to change capacity among workstations in case of bottle while minimizing WIP level. Here, the capacity is defined as the maximum rate of production and the ability to yield production, affected and changed over time in the dynamic processes due to introduction of a new kind of product, machine breakdowns, unreliable deliveries or rush orders [4], [5]. These uncertainties will extend the throughput time and decrease the capacity to perform operations for tasks. Additionally, it is difficult to predict the demand and ensure reliability of due dates, typically leading to high variations in the dynamic process.

In the context of operational planning and control for manufacturing systems, several strategies are known to predict and improve the dynamic behavior, which include queuing network (QN) theory, discrete event simulation (DES), as well as the system dynamics (SD) approach [6]. However, QN is not capable of studying detailed behavior of the system within a short time horizon [7]. DES entails rather high modeling efforts and typically not capable of predicting the dynamic behavior under transient conditions [8]. SD allows the decision-maker model a series of scenarios and observe system behaviors under different settings [9]. Yet, this technique does not provide analytical solutions. Additionally, a trial and error method is needed to get the best solution by using DES and SD approaches. Control theoretic approaches such as MPC are known to be able to handle with permanent and stochastic changes well. With the development of automation technology, the factories will be equipped with advanced sensors which allow to capture the accurate data of current state and make decisions in real-time in terms of dynamic control [10].

The main goal for manufacturers is to pursuit a balance between conflicting objectives (e.g. high machine utilization and low WIP) while meeting customers requirements with low cost. WIP is essential in the manufacturing model and typically the capacity of buffers pro-

Figure 1: *j th Workstation of System*



vided for the WIP is normally small and a job cannot be delivered to the next workstation when the buffer is full. This leads to fluctuations concerning product types, quantities and delivery dates.

Additionally, WIP levels of workstations are mutually linked. Therefore, the WIP level should be optimized to compensate for these fluctuations and will be used as controlled variable in this study. The number of RMTs is considered to be the control variable which allows us to adjust capacity by reassigning RMTs to different workstations. To render capacity adjustment effective, it is necessary to complement these tools with respective modeling and control strategies. In this case, a closed-loop feedback control is desirable to compensate for short-term demand fluctuation or exceptions with RMTs.

Mathematical Model

For a multi-workstation system, the model of the jth workstation is depicted in Figure 1, which shows the relationship between inputs and outputs in a manufacturing system. The jth workstation can receive tasks from the original stage or any other workstation, and then send its products to any workstation or a final stage. In Figure 1, $i_{0j}, i_{1j} \cdots i_{pj}, (j = 1 \cdots p)$ represent the input rates of each workstation to jth workstation, and $o_{j0}, o_{j1} \ldots o_{jp}$ represent the output rates [11]. The input and output rate of orders for jth workstation can be expressed as

$$I_j(n) = \sum_{l=0}^{p} i_{lj}(n)$$
$$O_j(n) = \sum_{l=0}^{p} o_{jl}(n)$$

The dynamics of multi workstation are given by

$$\begin{pmatrix} \mathbf{x^i}(n+1) \\ \mathbf{x^o}(n+1) \end{pmatrix} = \begin{pmatrix} \mathbf{x^i}(n) \\ \mathbf{x^o}(n) \end{pmatrix} + \begin{bmatrix} \mathbf{P}^\top \\ \mathbf{I} \end{bmatrix} \mathbf{c}(n,u) + \begin{bmatrix} \mathbf{i}_0(n) \\ \mathbf{0} \end{bmatrix}$$

$$\mathbf{WIP}(n) = \begin{bmatrix} \mathbf{I} & -\mathbf{I} \end{bmatrix} \begin{pmatrix} \mathbf{x^i}(n) \\ \mathbf{x^o}(n) \end{pmatrix}$$

where, n is the time instant, i_0 is the initial input from external for all workstations. X^i_j is the quantity of input orders for WS_j, x^o_j is the quantity of output orders for each WS_j . P is a $p \times p$ flow probability matrix representing the job shop configuration

$$\mathbf{P} = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1p} \\ p_{21} & \ddots & \cdots & p_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ p_{p1} & p_{p2} & \cdots & p_{pp} \end{bmatrix}.$$

Here, p_{jl} represents the flow probability of an order from workstation j to workstation l, which is dynamic according to the considered time-varying output rates. c_j is the capacity of WS_j :

$$c_j(n, u_j) = a_j \cdot r_j^{DMT} + u_j(n) \cdot r_j^{RMT}$$

a_j is the number of DMTs, $u_j(n)$ is the number of RMTs,r_j^{DMT} and r_j^{RMT} are the production rate of DMTs and RMTs respectively. The number of RMTs should be a positive integer and the sum of number of RMTs is limited and fixed, which reveals the constraints

$$\begin{cases} 0 \le b_j(k) & j = 1, \ldots, n \\ \sum_{j=1}^{n} b_j(k) \le m & m \in \mathbb{N} \end{cases}$$

Hence, $\hat{x}^i(k)$ and $\hat{x}^o(k)$ can be obtained via

$$\hat{\mathbf{x}}^{\mathbf{i}}(k) = \mathbf{x}^i(k) - \mathbf{P}^\top \mathbf{x^o}(k)$$
$$\hat{\mathbf{x}}^{\mathbf{o}}(k) = \mathbf{P_0} \mathbf{x}^o(k)$$

where $\hat{x}^i(k)$ represents the total number of input orders to each workstation from outside of system, and $\hat{x}^o(k)$ represents the completed orders, P_0 is the flow probability to the final stage

$$\mathbf{P_0} = (p_{10}, p_{20}, \ldots, p_{n0})$$
$$p_{j0} = 1 - \sum_{l=1}^{n} p_{jl}$$

Based on the model of multi workstation job shop system with RMTs, the model predictive control algorithm will be used to support the usage of RMTs.

Model Predictive Control

Model predictive control is an optimization based method to generate a static state feedback for a possibly nonlinear system subject to constraints and uncertainty [12]. Although the method is demanding from both a computational and modeling point of view, it is widely applied in various industries [13]. Based on the mathematical model, model predictive control method is employed to support the usage of RMTs to balance capacity and load. The principle of MPC algorithm can be summarized as three steps. First, obtain current state of the system at time instant k.Second, compute an optimal control $u(k)$ for the process over a finite prediction horizon N minimizing predefined key performance index J. Thirdly, implement only the first portion of optimal control sequence until the next sampling time $k+1$ and then $k \Leftarrow k+1$ and go to 1.

The task is to steer the states $WIP_j(n)$ of each workstation j of the job shop system to a reference value r_j while minimizing a key performance indicator and satisfying the constraints 2. To this end, we consider the cost function as:

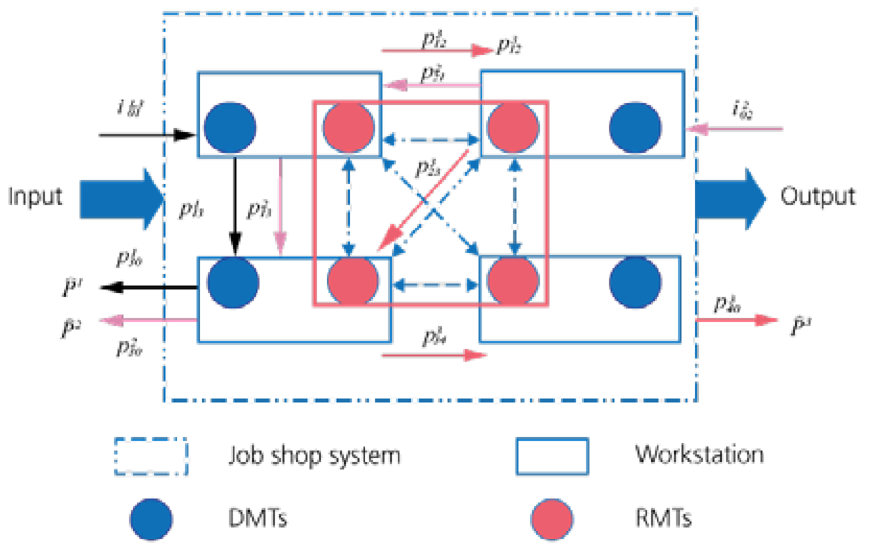
$$\ell(WIP(k), u(k)) = \sum_{k=0}^{N-1} \|r - WIP(k)\|_Q^2 + \|u(k)\|_R^2$$

$Q = Q^\top \geq 0$, $R = R^\top > 0$ denote respective weighting matrices.

Case Study

We consider an example of a job shop manufacturing process, which is composed of four workstations (1-turning, 2- drilling, 3-milling, 4-grinding) and each worksta-

Figure 2: Three-Product Four-Workstation Job Shop System



tion contains several DMTs and RMTs. The product flows are sketched in Figure 2 and relevant statement is given. To account for the corresponding products $\hat{P}^1$, $\hat{P}^2$ and $\hat{P}^3$, the flow variables are extended by a superscript. We take $p^3_{23}(n)$ as an example to cite the dynamic floww probability, the left probabilities are omitted. Additionally, we impose the following assumption.

$$p^3_{23}(n) = \frac{p^3_{12}O_1(n)}{i^2_{02}(n) + p^3_{12}O_1(n)}$$

Assumption 1:

i. The input sequencing order for each workstation is First In First Out (FIFO).
ii. The demand fluctuations are sin function.
iii. Transportation and reconfiguration times are negligible.

Now, the total input orders of the system can be expressed via

$$\widehat{x_1^i}(n) = x_1^i(k) - p^2_{21}(n) \cdot x_2^o(n)$$
$$\widehat{x_2^o}(n) = x_2^i(k) - p^3_{12}(n) \cdot x_1^o(n)$$

while the final product quantities of $\hat{P}^1$, $\hat{P}^2$, $\hat{P}^3$ are given by

$$\hat{P}^1(k) = p^1_{30}(k) \cdot \widehat{x_3^o}(k)$$
$$\hat{P}^2(k) = p^2_{30}(k) \cdot \widehat{x_3^o}(k)$$
$$\hat{P}^3(k) = p^3_{40}(k) \cdot \widehat{x_4^o}(k)$$

For our case study, we considered the probability p^3_{12} is equal to p^1_{13}. Note that the inputs $i^1_{01}(n)$ and $i^3_{01}(n)$ may be different as they represent two types of products. To cover for the different input rates and transition probabilities, we set the desired WIP levels of the workstations to $r_1=19$, $r_2=14$, $r_3=19$, $r_4=6$ respectively. The initial WIP level for each workstation is set to $WIP_1=WIP_2=WIP_3=WIP_4=40$. Here, we set WIP at a high level to ensure our requirements to be met.

Within the dynamics in the cross-link product flow, we considered the parameters $a_1=a_3=5$, $a_2=4$, $a_4=2$, $r_1^{DMT}=r_2^{DMT}=r_3^{DMT}=r_4^{DMT}=3$, $b_1=b_3=2$, $b_2=1$, $b_4=0$ and $r_1^{RMT}=r_2^{RMT}=r_3^{RMT}=r_4^{RMT}=2$. Last, our controller settings are chosen as $N=8$, $Q=\mathbf{Id}_{4\times4}$ and $R=0.1\cdot\mathbf{Id}_{4\times4}$, $T=1$. In a certain period, the demand for $\hat{P}^3$ is increasing and to see the effect of input order changes, we included a variation for i_{01}. We use MATLAB to simulate the dynamic process with the MPC solver from [12]. Within Figure 3, we observe that the capacity computed by our method is changing along with the fluctuation by reassigning RMTs to different workstations. The variations regarding WIP can be seen in Figure 4. The unit of WIP is orders and the unit of time is shop calendar day (SCD). Here, we observe that the method is capable of tracking the desired WIP levels for each workstation nicely. Additionally, we considered the number of manufactured products $\hat{P}^1$, $\hat{P}^2$, $\hat{P}^3$ as well as WIP_4 for a comparison of the proposed method and the uncontrolled case, cf. Figure 5. Because WS_4 usually only works with two DMTs to finish the normal order requirement of $\hat{P}^3$, now we consider its behavior at a high initial WIP level and demand fluctuation. For the uncontrolled case we observe that the system shows a stable behavior for the considered input, but the WIP level remains far from the desired value without effective measures. In contrast to that, the proposed method allows to force WIP to track the desired level. As an effect on the manufactured products, we observe that by controlling the WIP level, the number of completed product $\hat{P}^3$ increases. In fact, the output rates and the number of completed products for each workstation are influenced by the WIP buffer level. Note that if

Figure 3: Dynamic Changes of Number of RMTs

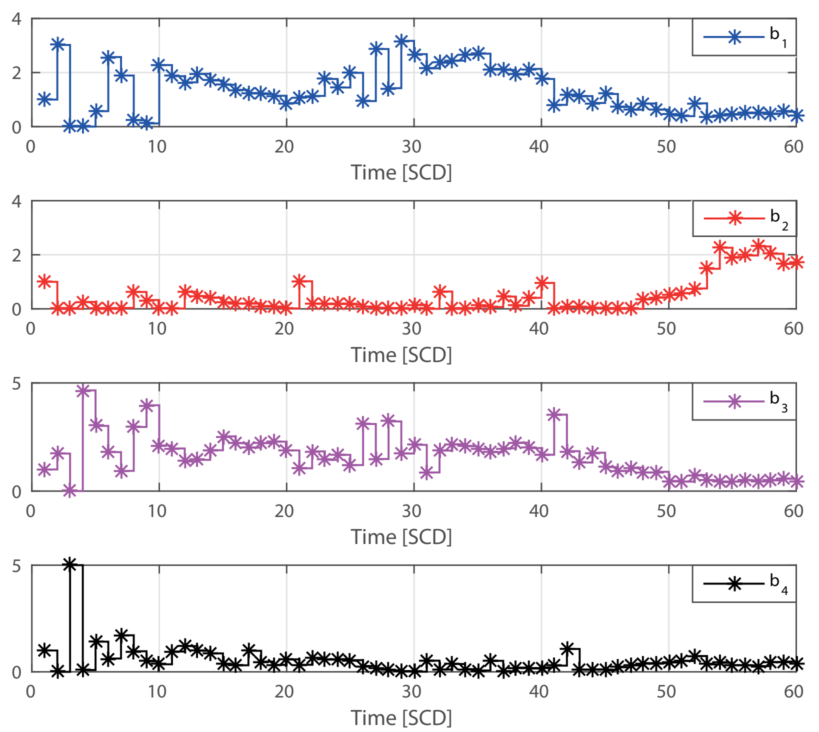


Figure 4: WIP Level Changes in Each Workstation

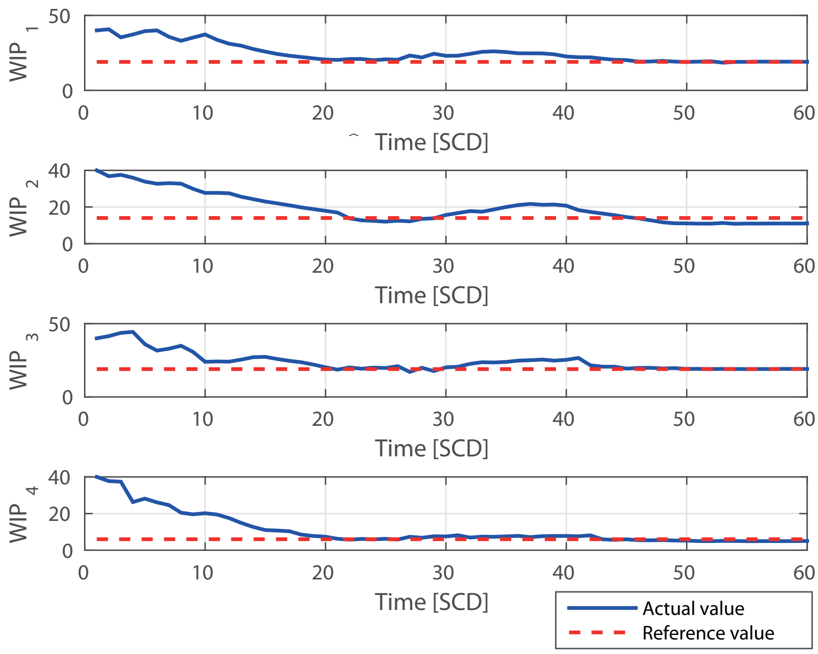
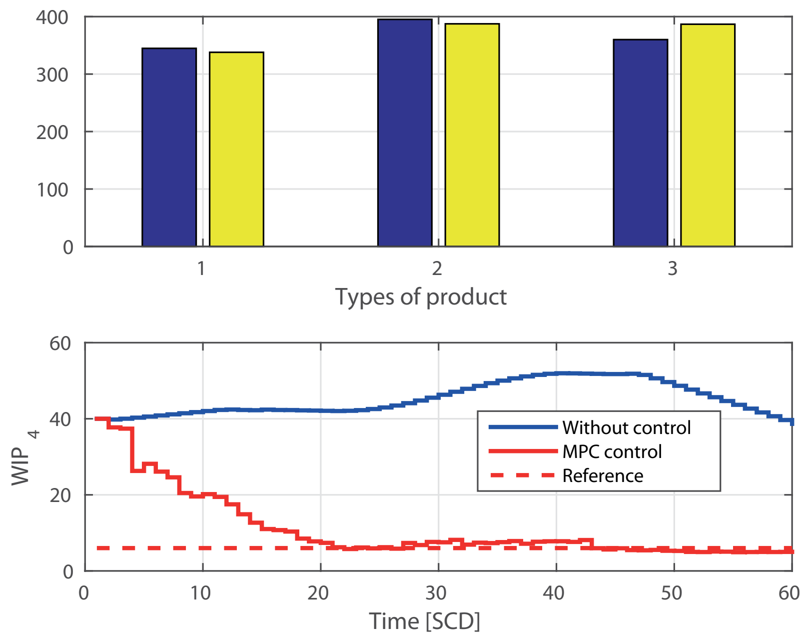


Figure 5: Comparison of Final Number of Products and WIP4



the *WIP* level was to increase beyond the maximum buffer size, the system performance would be even worse.

Conclusion and Outlook

Compared with tradition machine tools, RMTs show the strong potential capability to react to fluctuations in case of bottleneck in the manufacturing process. Within this project, we proposed a framework to complement the abilities of RMTs to change capacity and functionality by high level key performance index based feedback method. A general mathematical model for a multi-product multi-workstation job shop system with RMTs was built and WIP was considered as one of performance indicators. The most efficient balance of machine allocation can be obtained by means of MPC algorithm in terms of capacity and WIP levels. It is observed that even a small modification of capacity adjustment by means of RMTs based on MPC will enable the system without significant performance deterioration. We were able to show the feasibility of our approach in the context of fluctuations.

In our future work, we will replace the continuous optimization in MPC by a branch and bound method to solve the integer assignment problem. Additionally, the model will be extended to incorporate the reconfiguration and transportation delay and more performance indicators will be considered within an economic criterion.

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