LogDynamics
International Graduate School

Airflow Pattern Recognition in Containers Using Wireless Microsensor-Embedded Custom Platforms

The Intelligent Container (www.intelligentcontainer.com) has paved the way to research clusters within the University of Bremen and worldwide. It is a project that involves multiple disciplines of engineering fields and dynamic logistic approaches, with the target set on providing the customers with high quality produce and saving commercial losses.

Many countries are not self-sufficient in the food items they consume. Therefore, many food items need to be imported from other countries. There is also a seasonal effect on this. For example, many countries in the winter season are incapable of meeting the full demand of certain food items that are grown only in greenhouses. The balance needs to be imported; this is where good, scientific practices in dynamic logistics play a major role in helping to save money and increase the food quality.

Research Problem

Among all research conducted in logistics concerning refriferated containers trasporting perishable foods, airflow measurement is a rarity, apart from few laboratory experiments conducted by few researchers. The perishable food transports, for example, bananas, pineappls, and mangoes, suffer from high loss of quality during transportation. For aforementioned mass, commercial transports, the monetary loss due to quality degradation is considerable. The main problem for such degradation is the unforeseen, non-monitored, localized high temperature pockets within the containers and trucks, especially in inter-continental journeys.

The maintenance of temperature and humidity as desired within the containers is highly important in preserving the quality of the transported produce. Fig. 1 shows one such measurement box inside a banan box in a container.

Figure 1: Temperature measurement in a banana box

The unpredictability of high temperature air pockets – above the desired temperature set point – is further enhanced by not having any means of effective airflow measurements and lack of thorough knowledge in airflow pattern behavior in refrigerated containers. It is, therefore, highly relevant to device a reliable means of measuring the airflow without disturbing the existing conditions in transports, thereby to create a spatial aiflow profile in order to assess and uderstand the localized high temperature zones.

Research Goal

The main goal is to have a reliable sensor-based mechanism for spatial airflow pattern recognition in containers and trucks. A secondary goal deducible off the primary goal is the development of case-based (for individual packing schemes and type of perishable food) quality degradation warning system based on both the temperature and the airflow data measurements.

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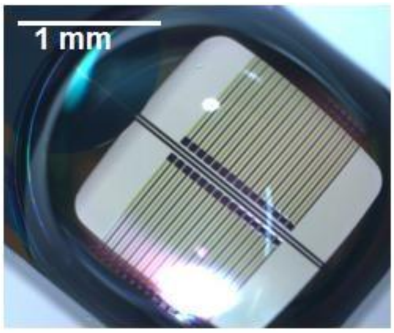

Figure 2: Thermal flow sensor - a heater element sandwiched between two thermopiles.

Methodology

The initial research work intends to provide a wireless solution to the aforementioned measurement problem. Its main categories are:

1. Thermal microsensors (Fig. 2) that measure airflow and calibration.
2. Custom made embedded system based on a new, ISO-pending 433 MHz wireless protocol (DASH7 M2). SoC CC430 is used as the radio-integrated microcontroller.

(1) and (2) above encompasses an in-depth electronic solution. It enables the measurement of airflow inside containers at preferred spatial locations. The new custom made wireless embedded system will be miniaturized to have a very small form factor. The current prototype solution seen in Fig. 3 *(*A TelosB integrated with a miniaturized Constant Temperature Difference (CTD) circuit and a thermal flow sensor mounted on a PCB (top) under an air channel.) is one such system. Another solution, using (2) above,is under development. The intention is to make the system more energy efficient and focus on the temperature/humidity and airflow measurements, leaving out other energy draining aspects of the current wireless embedded systems which is an over-design for the task at hand.

The second phase of the research work involves statistical analysis of parametric airflow data and temperature data to yield an effective forewarning system for perishable food transports. This phase is dependent on the test data obtained using the systems developed above. Real-time experimensts wil be carried out inside a banana container. Different, innovative banana packing schemes will be tested, too.

Temperature models for containers carrying perishable goods are already available. In addition, the wireless platforms developed above can measure temperature as well. The spatial airflow profiles will be statistically analyzed along side the new and old temperature spatial profiles. The expected result is the evidence of how hindered ventialtion gives in to increased temperature air pockets.

Figure 3: Prototype of the used hardware

Research Outcome

After establishing the predictability and the relation of temperature and airflow, a warning system can be developed to reduce the warning period. The currently available models to predict an apparent increase in temperature can give warnings in multiples of days. However, since measurement of change in airflow is almost instantaneous and time constant of change is almost neglegible compared to temperature, integration of both these parameters results in a better, faster warning system. In addition, the spatial airflow models are useful in assessing the existing packing schemes and to change them accordingly to maximize ventilation within containers in food logistic processes.

This research is not just applicable in refrigerated containers carrying perishable food. It can be used in a variety of other commerical applications where the measurement of airflow is required.

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