LogDynamics International Graduate School

Energy Management in Wireless Sensor Networks

Model Identification of temperature (T), relative humidity (H) and air flow (F) in air-conditioned closed spaces is considered in the first step of this research work. This thesis introduces a new floating-input approach (FIA) to facilitate an accurate model of the environmental conditions (ECs) in a closed space container in the place of the specific wireless sensor node, slept for reducing battery-consumption or inactive due to either empty batteries or out-of-range, using surrounding active sensors.

It will also state a new logarithm to attain minimization of power consumption in the sensor nodes. At the end a better estimation of the ECs in the position of the sensor nodes as well as a near optimal energy consumption method will be accessible. The model developed could be used for possible use in different applications such as designing model base controllers to adjusting the ECs as well as an estimator in fault diagnosis and energy management methods. The proposed approach is independent of the type of ventilation system and it is robust in the presence of disturbances.

Problem to be solved

According to fig. 1 and fig. 2, the nonlinear multivariable nature and interconnections between the variables of the ECs in addition to the presence of the load as an unpredictable, immeasurable disturbance, measurement noise and effects of flow dynamics, surfaces and walls inside the container, increase complexity of the model which we are looking for. Disturbance can appear in different ways in the container:

(i) Opening the door of the container.

(ii) Changing either direction or rate of air flow in the case of some obstacles or freights.

(iii) Thermal or moisturizing surrounding influences of pallets.

(iv) Any other unpredictable events in the container which influence the parameters.

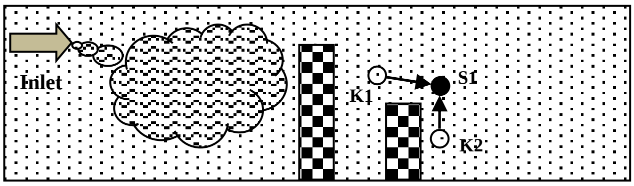

Fig. 1. A container with inlet, key sensor nodes and ordinary sensor node

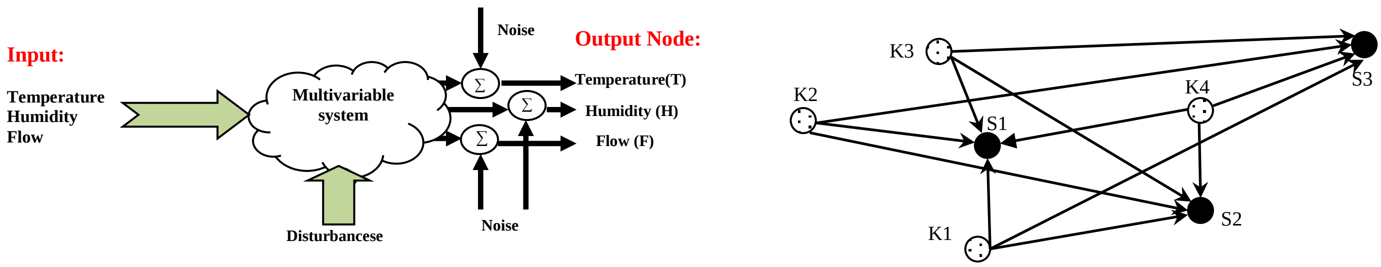

Fig. 2. Schematic of the Container as a MIMO model and proposed sensor network

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In addition to encounter some complicated conditions while solving partial differential equations or identification problems common to the white-box model, disturbance cause a big estimation error. Thus, FIA deals with finding a way to consider the influence of disturbance on the ECs estimation using the achieved model, independent of the type of the air flow system. All attempts in the first step of the present research are towards introducing a grey-box nonlinear model of the ECs between inlet and some desired places. In the next step, it will use previous data of a deactivated sensor in addition to the present and previous data of surrounding sensors to estimate unknown parameters of the simplified model in the place of desired wireless sensor node. Finally, a technique to combine several models to achieve unit estimation will be introduced. The nonlinear model will be made based on the knowledge of the effects of the environmental parameters on each other, and the ultimate estimation of simplified linear model will be compared with that of nonlinear model. It is noted that a part of parameters, such as time constant of temperature in simulations, have been inspired by actual behavior in real experiments, and the rest are based on primary assumptions of the authors. According to the desired method used in energy management of the wireless sensor network, there will be a few special key sensor nodes (KSN) which will send some specific information to the main processor and/or to the other sensor nodes. KSNs should be in active mode during operating mode of the system.

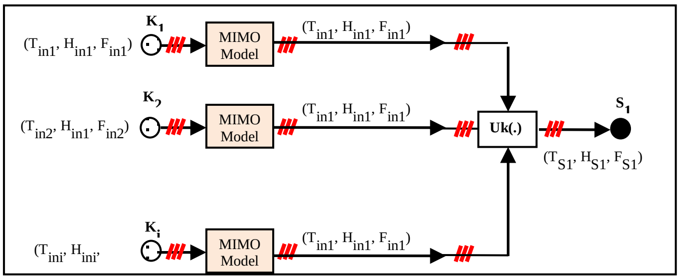

Figure 3 represents the whole proposed multivariable system.

In addition to ordinary characteristics like an ordinary sensor node (SN), KSNs have three major tasks:

(i) They measure environmental conditions alternatively.

(ii) They evaluate measured value and do some estimation of the ECs in place of the other sensor nodes and update previous models, based on the new measurements.

(iii) They will deactivate SNs when operational conditions are normal and there are no big changes in the ECs.

Desired sensors can be in sleep mode or they might even have been disturbed. KSNs can be located anywhere in the container; near the door, near to inlet or surrounding other SNs. If they are located in some key points, mismatch error due to not considering unpredictable phenomena would be avoidable because while identifications based on the grey-box model, most uncertainties are considered indirectly as the input change in KSNs surrounding the desired SN. Variation in the rate of flow changes the measurement results and disturbance may change all the results so that based on the existing conditions, measured values might be different even in the same place.

According to the proposed approach, when using sensor networks, in addition to the use of data from surrounding sensors, several previous data measured in place of desired sensor will be used to model identifications and the present measurements of the desired sensor can be compared with the model output and improve the parameters of the models. It goes one step ahead and identifies multivariable models between desired sensor and surrounding sensors, not between the input (inlet) and the other sensors. Furthermore, it introduces a near optimal combination of several models obtained from surrounding sensors which will be discussed in the next parts. In such a way, non-modeled disturbance is modeled as an implicit input change, not as a pure disturbance. In accordance with fig. 3, there some new models will be created which can be updated optionally in some predefined instants of the time.

Motivation and Aims

- Making an applicable model for the environmental conditions inside the container.
- Investigation of performances of the models
- Decision about the optimal positioning of sensors.
- Investigation of the new energy management approach.
- Plausibility check with proposed model based method.
- Implementation of the proposed methods.

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