Sensor Selection and Placement for CO² and Temperature Fields

Mehdi Massoum1, Danielle Marie Griegoo2, Alberto Sangiovanni-Vincentelli1, Kamleshwar Paolla1
1University of California at Berkeley, 2Energy Research Institute (ERI@N)

Motivation
The number of sensors in buildings tends to be large. Besides the increased capital cost, this introduces significant maintenance cost and vulnerability in the sensing and control system. Reducing the number of sensors in future smart buildings is the main purpose of this project. Here we propose a methodology to use sparse sensors, occupancy information and models to infer CO² and temperature fields in a networked collection of rooms.

Information about the strength of gas sources (e.g. CO²) and the air temperature in buildings has a number of applications in the area of building automation and control, including temperature and ventilation control, fire detection, and security systems. The estimation problem can be formulated as a Kalman filtering problem, where the states estimated by the Kalman filter are the unknown process parameters, the source strength and the air temperature.

2012 Main Objectives
- Step A: Site selection, instrumentation, developing the infrastructure for gathering CO², occupancy, temperature data.
- Step B: Develop field model, use complete data set for parameter estimation, disturbance estimation
- Step C: Write estimation/inference code
- Step D: Verification and testing. Use data from selected sensor locations to estimate field values at other locations under various operating conditions.
- Step E: Decide on placement strategy in general based on results from Step B. Understand parameters that guide placement strategy, error bounds etc.

Site Selection: SMPS Building, Level 4

Alternative 1: SMPS Building, Level 4
- 7 office spaces
- 1 discussion room
- 1 hallway
- Served by same AHU

Decision: SMPS building

Due to the following reasons:
- The area is totally enclosed and the amount of infiltration and exfiltration are minimal (as opposed to SADM where there is a staircase to the below and above floors.)
- Manageable number of rooms in terms of sensor deployment, data collection, and initial analyses.
- Danielle is already working on this building. She will help us in this project.
- The residents of the rooms in our study are very eager to conduct energy reduction related projects on the SPMS building.

Equipment Selection
The data required for the study includes temperature, RH, CO² concentration, occupancy and supply airflow rate in the defined spaces. The airflow rate and temperature are available from the existing BMS. The lab users and facility operation and maintenance team have noted that the temperature sensors may not be accurate. Therefore additional temperature and RH sensors are recommended for the study.

Additionally, the CO² sensors were selected with a measurement range of 0-2500 ppm. Additional equipment selection criteria are listed below, while the image includes the equipment which meets the study requirements:
- Temp RH data acquisition
- Connectivity is not required (no control strategies will be tested in this study)
- CO² sensors, Temp RH sensors at each VAV box (11 in total, reference

Building Management System (BMS)

Snapshots of Building Management System of SPMS

Future work
- Sensors are going to be purchased and installed in the SPMS building within the next month.
- Data will be collected by the Singapore colleagues.
- In Berkeley the team will work on the theory and developing the estimation code to be used on the data.

References
[1] CC Federspiel “Conditions for the input-output relation of perfect-mixing processes to be first order with application to building ventilation systems”. Journal of dynamic systems, measurement, and control, 199

Schematic of the airflow in the HVAC duct network

Analysis of the Space Under Study

Supply Air Duct
Return Air Duct
Return Air Grille
Optimal Sensor Placement

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