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Information-theoretic environment features selection for occupancy detection in open office spaces

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Abstract

Knowing the presence or the actual number of occupants in a space at any given time is essential for the effective management of various building operation functions such as security and environmental control (e.g., lighting, HVAC). As occupants "interact" with the indoor environment, they will affect environmental conditions through the emission of CO_2, heat and sound, and relatively little effort has been reported in the literature on utilizing this environmental sensing data for occupancy detection. This paper presents the findings of a study to address this question by exploring the most effective environmental features for occupancy level detection. A sensor network with robust, non-intrusive sensors such as CO_2, temperature, relative humidity, and acoustics is deployed in an open-plan office space. Using information theory, the physical correlation between the number of occupants and various combination of features extracted from sensor data has been studied. The results show significant correlation between features extracted from humidity, acoustics, and CO_2, while little correlation with temperature data. Using features from multiple sensors increases correlation further, and nearly 90% information gain is acquired when nine of the most informative features are combined.

Keywords

occupancy detection,
environmental sensor network,
information theory,
feature selection

Article History

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1 Introduction

The actual number of occupants in a space at any given time is essential for the effective management of various building operation functions such as security and environmental control (e.g., lighting, HVAC). It is also important for first response decision making under emergencies such as an outburst of fire or poisonous gas leakage. For example, knowing the location of occupants and number of occupants before the emergency's occurrence will help with the decision of firefighter's rescue paths, and the operation modes of emergency fans and fire-doors. The earlier the decision is made, the higher the chance that the fire will be controlled or stopped (Lam et al. 2009). Furthermore, model based predictive control could use the occupancy information in the thermal model for the buildings, and real occupancy pattern can later be used to create statistical occupancy models for energy modeling work.

Sensor network deployments have become more and more common practice in buildings. Some research studies have been conducted on extracting higher level or abstract information from physical sets of data that are being collected. For example, sensor networks have been used for monitoring the structural health of buildings (Karp and Kung 2000), detecting a pollutant source in a building (Shhn et al. 2002), detecting the strength of gas source (Federspiel 1997), and detecting a pollutant source or leakage location of the water supply system (Laird et al. 2007).

This study is based on the hypothesis that as occupants "interact" with the indoor environment, they will affect environmental conditions through the emission of CO_2, exchange of heat, generation of moisture and creation of sound. Therefore, indoor environmental variables such as CO_2 concentration, temperature, relative humidity, and

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