GreenerBuildings

An ubiquitous embedded systems framework for energy-aware buildings using activity and context knowledge

Editorial

Welcome to the GREENERBUILDINGS newsletter!

The ongoing development of the GREENERBUILDINGS living-lab installation reached several major milestones: The initial buildup phase is completed and first studies have been performed that resulted in peer-reviewed publications in scientific conferences and journals.

The living-lab consists of two installations: one in the Potentiaal building at TU Eindhoven campus, and another one at the neighboring MetaForum building. The installation in the Pootential building comprises three shared offices, one private office, a pantry area with a kitchenette, coffee machine, and tables, as well as a meeting room. In our lab, various sensor installation allow recognition of dynamic usage patterns in the occupants' behaviours, which, in consequence, provide excellent opportunities to minimize energy consumption. The living lab installation currently comprises the following sensors:

- **Passive Infrared (PIR) sensors** for motion detection and counting number of people
- **Ultrasound rangers (USR)** in order to measure distances and detect presence
- **Microphones** to recognize office activities
- **Light, temperature, humidity and CO2 sensors** for detection of environmental conditions
- **Magnetic contact switches** to recognize use of windows and doors
- **Plug-in power meters** to measure consumption of appliances

In order to allow acting towards reduced energy consumption, the installation is completed by the following actuators:

- **Light switches** to activate and dime lights
- **Plug-in power meters** to be able to activate and deactivate appliances
- **Blinds motor/controller** for controlling angle and height of window blinds
- **Portable air conditioner** to control and adjust temperature, humidity and CO2 level

In a next step the living lap installation will be extended to the MetaForum building. In contrast to our current installation in the Potentiaal building, the MetaForum provides an office environment with modern and up-to-date BMS technologies. An application of our current results to a building that was constructed in 2012 will enable novel and exciting research opportunities.

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At a Glance

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Studies: First Results

Estimated people count per building space is a key information to dynamically control building systems related to HVAC and lighting. Based on unmodified PIR sensors, an approach to estimate the number of people per room was developed and results from real-life tests in the living lab showed excellent results for estimated people count by means of various algorithms.

Using sensors that are already installed in modern or refurbished office buildings can be a valuable data source. A second study investigated generalisation properties of an office activity recognition approach based on frequently installed sensors. Results from this study confirmed that the use of already installed sensors in office buildings is a feasible strategy to improve energy efficiency without extensive installation needs. By identifying user activities and people count per room, it is possible to save 21.9% and 19.5% of energy, respectively, in comparison to widely-used BEMS systems.

In scenarios where no pre-installed sensors are available, it would be favorable to apply and install as few sensors as possible. We investigated a novel generation of 2D-matrix thermopile sensors for recognising objects and object-occupant interactions from their heat patterns. Therefore, we conducted a comprehensive study that comprised a total of 21 complex activities in a pantry area, e.g., serving coffee. The results showed that activities with a clear thermal signature can be recognized with more than 96% accuracy by means of a single sensor installation.

A last study investigated a system architecture to control desk appliances such as computer screens based on recognised desk and computer work activities. In a real-life study at seven desks, we use screen-attached ultrasound sensors and explore a proximity-based activity recognition approach for saving energy by automatically turning computer screens off when not using them. The results from this study showed that energy savings of up to 43% and 55% for proximity-controlled computer screens compared to computer-controlled and non-controlled scenarios, respectively.

In conclusion, the results of all studies indicate that a dynamic control can indeed lead to substantially reduced energy consumption. These findings confirm the relevance of building energy management based on activity sensing: dynamic information on user activities provides a valuable source for building control in general and building energy management systems in particular.

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