

Improving Sustainability Concept in Developing Countries

Implementation of Household's Amenity Maintaining System Based on Behavior Estimation

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Abstract

Research of residential EMS (Energy Management System) is mainly being promoted with a focus on energy saving initially. After that, it began to focus strikes the balance between the indoor comforts of the occupants and energy saving. Moreover, the control object is diversified in the home, there is a need for more detailed parameters of individuals to satisfy the comfort of the individual. This paper presents a novel method to estimate behaviours of the resident in a house. Also, it is to provide a comfortable environment at the same time energy saving by using the estimation results.

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1. Introduction

Energy saving is currently one of the main issues in the world. Many countries face various energy challenges due to limited fossil fuels and to growing electric consumption. In the case of Japan, EMS (Energy Management System) attracts more attention because of the increasing demand for efficient energy management, especially after the Great East Japan Earthquake in 2011.

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From the aspect of responsivity and energy saving, levelling peak load through air-conditioning control is widely studied in residential EMS. Furthermore, home automated system including lightings and windows are considered to improve the overall comfort of the indoor environment^{1, 2}. Existing control system of home appliances (e.g. air-conditioner, windows, and lights) apply motion sensor to detects motion of human body³. Hence, integration of motion detection with location measurement can enhance the control system.

This paper presents a novel method to estimate behaviors of the resident in a house. Indoor information about the location and the amount of activity, are utilized for the behavior prediction. In this method, a control system of home appliances is enhanced by the estimated information. The position of a person is detected by using BLE (Bluetooth Low Energy). The proposed indoor positioning system exploits trilateration that takes account of three independent measurements from beacons to a smartphone. Besides, activity information is measured by using a gyro-sensor and a three-axis acceleration sensor mounted in the smartphone.

The presented behavior estimation and control system are applied to the experimental house placed at Keio University in Japan. Results are validated through a series of questionnaire gathered from residents, and the proposed control method proved an improvement of indoor amenity over the non-control method.

This paper comprises seven sections. In Section 2, introduce EMS. In Section 3, explain the Behavior Estimation system. In Section 4, introduce the experimental house. In Section 5 explain in the advance experiment. In Section 6 and 7 describe the experimental method and results. Finally, conclusions are presented in Section 8.

2. Energy management system

There is an energy management system EMS (Energy Management System) as an effective means for leveling of power demand. EMS monitors energy consumption of the resident and is a management system that controls electrical equipment. Although EMS is the primary purpose of reducing the electric charges, it is also the environment-oriented system to achieve optimal management of the energy demand. For example, a power consumption monitors systems and demand control system^{4, 5}. The demand control system monitors power consumption of the customer. It also controls electrical devices as needed. Our target is mainly air conditioning and refrigeration. If the power consumption is likely to exceed a predetermined demand value, EMS controls the outdoor unit and pump electrical equipment to reduce the power consumption. Such EMS built for the household is called HEMS (Home Energy Management System).

2.1. Home energy management system

The purpose of HEMS is monitoring the indoor environment and energy usage. HEMS achieves energy saving controls the equipment. In general, HEMS is composed of a sensor, controller and home appliances are controlled. Local information network in which these devices are connected is referred to as HAN (Home Area Network). Studies have been conducted on a wide range of devices as the control object to the home appliances, air conditioners and EV (electric vehicle) in HAN⁶.

In Japan, research of HEMS shows good progress. Housing in which equipment is introduced is called Smart House in Japan. It demonstrated experiments had been conducted in various places. For example, Sekisui House was a demonstration of the smart house with solar panels and electric cars in Yokohama, Kanagawa Prefecture⁷. Mitsubishi Electric built the smart house that enables device control of a variety of housing facilities in Kamakura, Kanagawa Prefecture 2010-2014⁸. Tokyo Gas build a housing complex rather than the House and collect the data of the hot water system used solar heat, and fuel cell system⁹.

Additionally, Toyota Home and Misawa Home sell a smart home that implements the HEMS, Several electrical manufacturer also sells HEMS^{10, 11}.

3. Behavior estimation system

Research of HEMS is mainly promoted with a focus on energy saving. Then it began to focus strikes the balance between the indoor comforts of the occupants and energy saving. Subsequently, the indoor comfortableness varies between individuals. Moreover, detailed parameters are required to satisfy comfortableness because control object at

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