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A ubiquitous power management system based on environment perception

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Abstract

Energy conservation is an important measure to protect the environment and conserve resources. To reduce power consumption of appliances, automatic and remote controllable smart meter has become one of the most advantageous means for power energy management. By integrating several internet-of-things (IoT) technologies, this paper proposes a ubiquitous power management system, which comprises a monitoring, ubiquitous controlling, and power management modules. In the monitoring module, multiple sensors are integrated to detect ambient information, such as temperature, humidity, and foreground moving objects. For real-time video surveillance, we develop a fast foreground segmentation algorithm using parallel computation. In the ubiquitous controlling module, the sensed datasets as decision making basis are reported to smart meters via a wireless network. Based on both environment perception and remote controlling signals, the power management module utilizes the smart meter to operate appliances automatically by specifying operation parameters or switching power supply. The proposed system was tested in a building and reduced around 35.7% power consumption, which show a significant portability and effectiveness in IoT.

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Keywords: Energy conservation; smart meter; environment perception; IoT.

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1. Introduction

In the past few decades, carbon dioxide is massively discharged and the Earth's resources and environment are destructed[1]. Many countries have adopted solutions for global warming, such as wind energy, nuclear energy, and hydrogen energy to replace traditional fossil fuels[2]. More than half energy is consumed by the applications in home, company, and other indoor environments. In terms of energy saving, researchers make a significant breakthrough to reduce electricity power, as the largest part of the energy consumption[3]. The appliances are not able to adjust and control their own behavior automatically. Even that the requirement of application user is satisfied, the application keeps on an open state so as to cause unnecessary waste of energy consumption[4]. To realize an automatic control of electrical appliances, researchers integrate internet of things (IoT), cloud controlling, and monitoring technologies for electricity reducing.

With the maturity and development of the IoT technology, smart meter has become an inevitable trend[5]. By multiple sensors integration, smart meter acquires ambient environment information to determine whether a potential user of electrical appliances exists in the current environment. This monitoring result supports the intelligent behavior planning basis of appliances controlling. Currently, the monitoring equipments are utilized commonly in the form of infrared, temperature and humidity sensors, and even cameras. Besides, the limited layout of cumbersome wired communication is replaced by wireless communication network such as Wi-Fi, Zigbee and Bluetooth[6]. The wireless sensor networks provide convenient communication and controlling interfaces of various devices in the intelligent power controlling system. The emergence of mobile devices enables remote monitoring and controlling of electrical appliances.

Using a wireless network, this paper proposes a ubiquitous power management system, including a monitoring, ubiquitous controlling, and power management modules. In the monitoring module, multiple sensors acquire environment information which is transmitted to a cloud server for reporting surrounding datasets. In the ubiquitous controlling module, the users control a smart meter by transmitting an operation signal to the cloud server. By analyzing the controlling signal and the environment situations, the server determines an appropriate operation to remote control electrical appliances though a smart meter. Meanwhile, users or administrators operate electrical parameters of appliances by a local computer or a mobile terminal device.

Our proposed system is able to automatically change the operating state of electrical appliances based on environmental varieties. For example, the air conditioner decreases temperature when the number of surrounding people increases; the light in a garage is turned on when moving vehicles or people exist. In such applications, foreground detection of moving objects is a key issue of environment monitoring. In this paper, we developed a feedback foreground segmentation algorithm in video images. A graphics processing unit (GPU) programming technology is utilized to accelerate the foreground segmentation process for real-time monitoring[7].

The remainder of this paper is organized as follows. Section 2 provides an overview of related work. Section 3 introduces the proposed ubiquitous power management system. Section 4 evaluates the performance of the proposed algorithms of the system. Section 5 concludes the paper.

2. Relation works

Smart controlling of household appliances aims to save electricity with effective means of power consumption in sustainable energy systems, especially in smart homes. Paetz et al.[8] demonstrated the effective energy strategies in a smart home, including variable electricity tariffs, smart metering, smart appliances, and home automation. Besides saving electricity charges based on the fluctuating supply price, the smart home monitored electricity consumption of the appliances in real time by smart meters. The smart appliances were able to make automatic decisions of energy controlling so as to realize a home automatic approach for reducing electricity charges. Zhou et al.[9] developed a home energy management system for remote controlling of distributed appliances in smart home. In this system, energy consumption and operation status of appliances were monitored and stored in real time by smart grid infrastructures. Based on the electricity usage and remote controlling signal, the system enabled remote control and automatic control by Zigbee. Furthermore, appliance scheduling strategies were proposed to improve energy efficiency and reduce electricity cost. Yang et al.[10] proposed a home energy schedule to deal with decision making