Demo Abstract: iCEnergy: Augmented Reality Display for Intuitive Energy Monitoring

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Abstract

Energy saving is the main goal in most building energy monitoring applications. These systems, however, are operated by people. For this reason, an intuitive user interface is an essential element that will affect users’ data understandability, thereby determining the system’s usability. Traditional energy monitoring generally focuses on getting energy information by utilizing graphs or static text interfaces. However, these approaches are not related to the physical space. With the increase of information in energy monitoring systems, intuitive and efficient ways of displaying information are needed. In this demo, we present iCEnergy, a vision-based mobile information interface that provides power monitoring using augmented reality. Using existing system data, the system overlays an interactive “energy cloud” over corresponding devices in order to illustrate information about the physical environment. This approach aims to provide users with a comfortable interaction experience through its intuitive information display.

1 Introduction

With the proliferation of in-building sensor networks to obtain fine-grained energy consumption data, the potential of energy savings is becoming apparent [4, 5, 6]. One key component for realizing such savings is to provide users with a full understanding of the physical measurements from the devices being monitored. Existing energy saving systems usually fail to provide an understanding of the physical relationships in energy monitoring by providing only historical graphs and text information. Prior work generally utilized layered menus or still images to display power monitoring information that did not provide a direct physical relationship to the devices [2, 7]. Such methods simply used mobile devices as the interface medium and did not provide direct understanding of the relationship between measurements and their physical devices. Other work used Augmented Reality (AR) to allow users to see a live view of the physical world with virtually augmented elements superimposed upon it [1]. This approach provides an efficient way to connect measured data with the physical world.

In this demo, we present iCEnergy, an intuitive and efficient user interface for monitoring devices’ energy consumption using AR. Our system reconstructs the locations of registered devices in the environment and overlays the devices’ energy status using virtual clouds. Energy status (such as energy efficiency, absolute and average energy consumption, etc.) that is calculated from measurements of an in-building sensor network is communicated to the users using parameters of the virtual clouds, such as color and size. They provide users a fast and direct quantitative perspective of the energy status of the devices being monitored. iCEnergy provides users with a real time, physical awareness of devices energy status.

2 System and Implementation

iCEnergy presents a physically direct display of the physical devices’ energy usage statistics. Currently iCEnergy is integrated into the building energy system at the Rohm Building in Tsinghua University. In this energy monitoring system, virtual clouds of different colors and sizes present the energy efficiency status of devices based on the display rules set by the administrator. The display rules can be changed through a settings page. Different systems can set different default display rules to depict desired system pa-
rameters.

The iCEnergy interface is shown in Figure 1; the system consists of two components, the server and the client.

2.1 Client

The client has two main functions. First, it localizes the devices with visualized color landmarks. Second, it displays devices’ energy status and usage information using augmented reality. In our demo, the client is implemented on an Android HTC Sensation.

Device Localization: To simplify the localization portion for the demo, we use colored objects as landmarks as shown in Figure 2. The real world coordinates of landmarks and devices are recorded on the server as registration information. The landmarks have distinguishable hue, saturation and value values so they can be easily recognized.

To localize the device in the camera, we take three steps. 1) The locations of the devices are determined relative to the detected landmarks, which are used to identify the three dimensional space in which the devices reside. 2) The position and posture of the camera on the mobile device are determined using the relation between landmarks and their projections on screen. 3) Then the locations of the devices in relative space and their positions relative to the camera are determined through geometric projections. Although currently artificial landmarks are used for device localization (which is not realistic), methods such as keyframe-based SLAM [3] can be adopted; therefore no specific landmarks will be required for device localization.

Augmented Display: Figure 2 shows a screenshot of the client display. The transparent virtual cloud is drawn over the device in an energy-monitoring interface providing information on the device’s energy consumption and usage. The system can be set to display any information by changing the preference determined by the administrator. This can include wasted energy, or deviation from average energy consumption. Currently, as shown in Figure 2, if the cloud is green, it indicates the device has a relatively low amount of energy consumption compared to other similar devices registered in the system. If the cloud is red, it means the device consumes relatively high levels of energy. The size of the virtual cloud indicates absolute energy consumption, meaning the larger the virtual cloud is, the higher energy consumption the device has. The virtual clouds are clickable, and will navigate to the energy status historical graph page. The history can be viewed by hours, days or months.

Using the display, users can easily gain a quick overview of devices’ energy status in the current environment by scanning the physical environment using their mobile devices. The virtual clouds of different colors and sizes can provide quick and intuitive information of energy consumers.

2.2 Server

The server is integrated into the smart building energy saving system in the Rohm Building at Tsinghua University. It provides clients with two kinds of information: the registration information for the devices and landmarks, and the calculated energy consumption information from the devices in the system. The server will send the latest information to the client when the application periodically requests updates.

3 Demo Description

During the demo, we will provide 5 smartphones with iCEnergy App installed already at our demo booth. We will also provide the iCEnergy App to be downloaded to attendees’ smart phones/tablets. We will install plugged-in energy monitoring nodes on at least 5 energy-consuming devices such as lamps, computers, and monitors. In addition, we can register existing plugged-in devices in the demonstration area a priori. We will build a local server that records the information from these devices. During the demo session, the attendees will be able to use the devices with iCEnergy installed to investigate the energy usage of the registered devices in the demo area. The mobile phones carried by each visitor will then display the power consumption of registered devices using colored virtual clouds on the screens of the mobile phones. Users can adjust the parameters of display such as by changing the period of display.

4 References