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IoT based Intelligent Home Appliances System

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Abstract**—**the intelligence for home appliances becomes more and more necessary in recent years. It can be developed based on the techniques from intelligent surveillance systems, and integrated with video sensor. In this paper, we propose an implementation of intelligent home appliances. This system typically involves several tasks including foreground detection, noise reduction, object labeling, object recognition and wireless transmission. To realize it on IoT (internet of things) era, we use the transmission device with Bluetooth 4.0 protocol. As a result we will receive the signal on mobile device applications if some dangerous situations is happened. We implement the whole system on embedded system to make a demonstration result. This system will help us to take care of our children prevent from danger appliances and inform the danger situation immediately.

Keywords**—***intelligent home appliances; foreground segmentation; object labeling; IoT; bluetooth.*

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I. INTRODUCTION

Internet of Things (IoT) concept envisions the interaction and cooperation among smart objects surrounding us (such as home appliances, mobile devices, portable medical devices) to reach common goals [1],[2]. In IoT, it comprises of interconnected smart objects with access to internet, provided by networking technologies traditionally, the pervasive presence of these devices and their connectivity requirements consume large amounts of data transmissions, and thus conduct the research on communication technique. Currently the commercial standards have been well constructed such as Bluetooth, ZigBee, and Wi-Fi. This alleviates the techniques on communication.

As one of the fastest growing fields of the IoT technology, smart homes comprises of a network of smart devices which belong to different applications. As an example in Fig. 1, it shows a typical smart home scenario on IoT. Any device at home that uses electricity can be put on the home network and at one's command. The home can be controlled by voice, remote control, tablet or smart phone. Most applications relate to lighting and heating, home security, home theater and entertainment, and energy conservation.

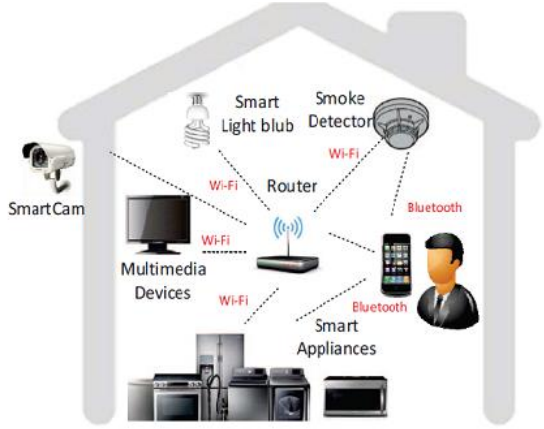

Fig. 1.An example of intelligence home consisting of connected devices belonging to different applications.

In-house video surveillance systems have as main goal to control the safety and the security of materials and of people l living in a domestic environment [3]. With the popularity of IoT and smart home, the intelligence of home applications could be improved based on the techniques on intelligent video surveillance. Smart home based on IoT through various sensors will be a core technology to develop IoT-based smart home services [4].ġ it can not only help to enhance the quality of life but also provide some sensing to people. One of the important features is to prevent people from dangerous situation. For example, adult and children should be differentiated for safety issue on some home appliance such as heater, wave oven, and so on.

In this paper, we propose the intelligent home appliances. The most important feature is to prevent children from danger appliances for home security section. We cope with many advanced techniques from intelligent video surveillance system to implement the real system. To realize a real system, a device embedded with Bluetooth 4.0 transmission is included to interact with remote users. The remainder of the paper is organized as follows. In Section II, the proposed identification method includes foreground detection; object labeling; object recognition is discussed in detail. In Section III, we show the experiment results and evaluate the object recognition rate in a real IoT environment. Finally a conclusion is given

II. PROPOSED METHOD

The most important feature of intelligence on home appliances is the ability on object detection and recognition. We illustrate the whole method on object detection in Fig. 2. The main body on this method includes foreground segmentation, noise reduction, object labeling, and object recognition. In details, several specific techniques are arisen for this application such as height recognition and wireless transmission are discussed later.

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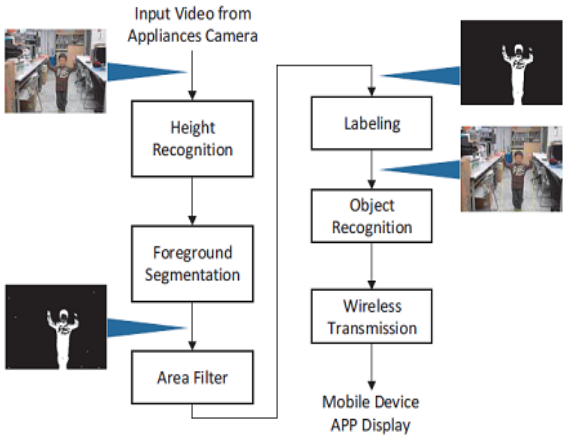

Fig. 2. Block diagram of intelligent home appliances system

A. *Height Recognition*

The height is largely correlated to the detected object. A base height for the position of appliance is needed on the following development. An intuitive method is to measure the position and record it on appliance. As an intelligent objective, we provide an automatic method to recognize the height information. When the camera is set in different height, the object in a frame will have a different position. With this difference on frame position, it can reflect to a real position of the appliance. As a result the height of difference is set from 1 meter to 1.8 meter in this system.

B. Foreground Detection

Foreground detection is mostly complicated on computation. In order to achieve real-time processing, we concern the foreground detection algorithm with low computational complexity consideration. The foreground extraction is performed by comparing background pixel with threshold *Td*. Then we can calculate foreground or background by follow equation

$$F_{td}(x,y,t) = \begin{cases} 0, if(|B(x,y,t) - I(x,y,t)| < T_d) \\ 1, if(|B(x,y,t) - I(x,y,t)| \geq T_d) \end{cases}$$

If *Ftd (x, y, t) = 0*, the pixel *(x, y)* is extracted as background. If *Ftd (x, y, t) = 1*, the pixel *(x, y)* is extracted as foreground.

C. Object Labeling

After the foreground binary mask is derived, we must label the connected pixels to make object more integrated. Based on [5], we will integrate each object and the cases of object labeling are illustrated in Fig. 3. As the labeling procedure, it gives each object a label value. Small area objects will be considered as noise and removed later. In order to prevent crushing situation, we will use the object grouping to integrate crush object to enhance the quality of system.

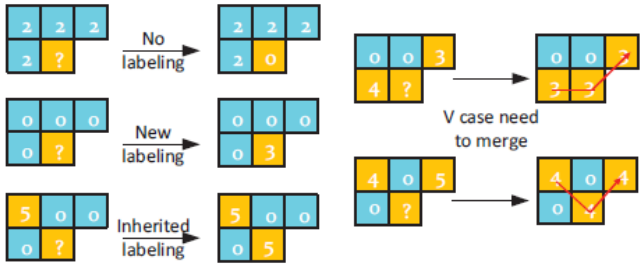

Fig. 3. The cases of object labeling.

1) If the current pixel is a background pixel, then it is assigned label ‘0’ţ

2) If all neighboring pixels are background and the current pixel is a foreground pixel then a new label is assigned.

3) If only a single label is used among the labeled neighbors and the current pixel is a foreground pixel, then the current pixel inherits the label.

4) If different labels are assigned to neighbors and the current pixel is a foreground pixel then the current pixel will merge the labeled regions and the current pixel and all labeled pixels will be labeled with the smallest label in the neighborhood.

B. *Object Recognition*

In this step, we will classify the object which is interpreted as an adult or a child. We use the height of object and combine the camera height of information. In order to evaluate the distance between object and camera, we use the concept of pseudo environment depth map and give each interval different threshold to judge. The *Oy2* is the bottom right coordinate of object and *Oy1* is the upper left coordinate of object. We can calculate object recognition by follow equation:

$$Recognition = \begin{cases} 0, |Oy2 - Oy1| > T \\ 1, |Oy2 - Oy1| \leq T \end{cases}$$

III. EXPERIMENT RESULTS

The experimental result is presented in this section. We use ASUS k01b tablet computer and Texas Instruments pandaboard with ARM Cortex-A9. We test our system for one hundred times with six objects which contain three adults and three children. The implementation result is illustrated in Fig. 4. The accuracy of object recognition is showed in Table I. In all situations, above 90% accuracy can be achieved.

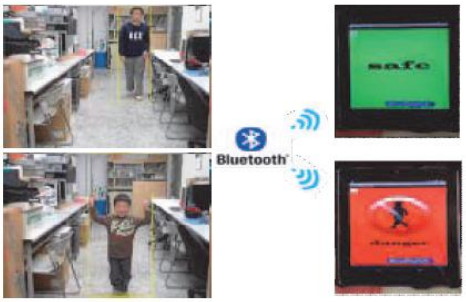

Fig. 4. Experiment implementation result with Bluetooth 4.0.

TABLE 1: ACCURACY OF OBJECT RECOGNITION

Subject	Accuracy of different height status		
	1m	*1.4m*	*1.8m*
Adult 1	92%	94%	95%
Adult 2	90%	93%	92%
Adult 3	93%	94%	93%
Child 1	93%	95%	94%
Child 2	91%	91%	93%
Child 3	93%	94%	92%

IV. CONCLUSION

In this paper, we propose an intelligent home appliance. It is constructed based on some intelligent techniques on video surveillance. With the recognition ability, user can be identified and different action on the appliance could be addressed. To realize it on IoT, we use a device of Bluetooth 4.0 to transmit the immediate information to user on remote area. Once a dangerous situation is happened, it can be alarmed immediately. We implement the whole system on embedded system to make a demonstration result. Several experiments are evaluated with different objects on people. In all situations, above 90% accuracy can be achieved.

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