Low-Cost Appliance Control System for Home Automation and Energy Management Using Image Processing

Nagaraj Shet, C. Shreesha, P.V. Rao and Abdullah Gubbi

Abstract In the stressful life, enhancing the quality of life at home is the need of the hour. Smart home automation is being incorporated with an intelligent system. Existing systems are creating major challenges in terms of cost and energy management. In a home network environment, keeping the sensors and devices always on consumes more electrical power and increases the cost paid for consumption of power. In the proposed work, energy management has been carried out with an intelligent algorithm. Image processing has a very big potential to do virtually anything. The challenges of cost have been overcome using image processing. Algorithm is developed for image processing-based appliance control system. The method proposed in this paper reduces the cost of sensors used in home automation. With image processing-based home automation there is less energy consumption, reduction in umber of sensors, and also optimized maintenance cost of home automation networks.

Keywords Electric power · Sensors · Energy management · Image processing · Home automation · Appliance control

N. Shet (✉) · P.V. Rao · A. Gubbi
Department of ECE, VTU Belgaum, India
e-mail: shet_nagaraj@yahoo.co.in

P.V. Rao
e-mail: pachararao@rediffmail.com

A. Gubbi
e-mail: abdullahgubbi@yahoo.com

C. Shreesha
Department I&CE, MIT Manipal, India
e-mail: shreesha.c@manipal.edu

S.S. Dash et al. (eds.), *Artificial Intelligence and Evolutionary Computations in Engineering Systems*, Advances in Intelligent Systems and Computing 394,
DOI 10.1007/978-81-322-2656-7_12

1 Introduction

Due to improvement in living standards, everyone loves to have all the facilities without difficulty and at the earliest. This resulted in the use of advanced technology for home automation. So home automation has become the center of research. People want all the things to be automated from very simple tasks to many complex tasks. User satisfaction and comfort is the main criteria for home automation. There are plenty of electrical appliances in every modern household. Automating the operation of all the electronic and electrical equipments and providing security improves the quality of life and provides more comfort to the dwellers. User requirements for home automations [1] are broadly classified into the following groups:

(1) Efficient automation of routine tasks
(2) Security of automation systems
(3) Ease of use
(4) Local and remote access
(5) Telemonitoring
(6) System cost and flexibility.

When we look in a wider extent, gestures came out from human body is natural. From Concise Oxford English Dictionary, gesture is a movement of part of the body, especially a hand or head, to express an idea or meaning. As for this work, the development portion is to develop a new practical technology for alternative human interface. This gesture definition has been narrowed down to only hand and is given particular attention on details that Indian hands has. We aim to design technique that reduces the number of sensors are being used for different applications. Image processing is a branch of knowledge that tries to reach the same goal as human vision does. The process will not be the same but the objective is. The concept may or may not differ, depends on what subtask of the whole system is to be accomplished first. Machine look on something trough segregated details to do matching based on system's hardware capability. Human on the other hand, used as much information as possible and will decide at that instance, fulfilling directly to the objective of the vision task itself. That is why trying to have the same par with human capability especially from the recognition accuracy perspective is impossible with current technology advancement available. Image processing consists of various processes like image enhancement, image segmentation, and image perception. These processes help the designer to extract the proper input from images. (ii) Image Thresholding: Image thresholding is a part of image processing that converts the intensity or grayscale image to binary image. In binary image, high-intensity values are represented as white colour and low-intensity values are represented as black colour. This process helps us to identify the objects from images by eliminating the background of the image. Finally to summarize, the objective of this work is

i. Human detection system using surveillance camera or PIR sensor to detect the human
ii. To develop a hand gesture recognition system
iii. To develop a system that can translate snapshot of hand gesture to a set of actions.

The organization of the paper is as follows. In Sect. 2, literature survey is described. Proposed architecture of the system is discussed in Sect. 3. In Sect. 4, methodology is discussed. In Sect. 5, results are shown. In Sect. 6, the conclusion is discussed, and future work is discussed in Sect. 7.

2 Literature Survey

Home automation is also popular as digital home, e-home, and intelligent house or smart home. For building the home automation system, automation technology, computer technology, telecommunication technology along with electromechanical technology is used. Quality of entertainment, security, and safety has been improved using home automation. It helps people with less work and better management of household work with automation and interactive closed-loop system. Home automation technology and smart home was considered science fiction during 1920s. We do not have details about exact date of the invention of home automation. Based on available facts home automation, one of smart technology, evolved over a period of time but did not happen with immediate invention. It happened step-by-step with significant improvement in recent years. There was a gradual change to the next step in development of home automation technologies compared to previous step. At the earlier stages, people noticed the use of high technology in dwelling. Slowly, electrical equipments were controlled through wired connections. That home automation in 1960s called as "wired homes." It was built by some hobbyist. Official name of home automation was used by the American Association of House Builders only during 1984. That became the key development to the modern smart homes. People at that time were able to make difference between interactive home automation technologies used in smart home [2] and technologies that were used to build better homes by effectively using space with environment friendly features. Home can be considered to be smart home depend on to what extent interactive technologies are used in it. Those are still useful rules for home automation technology today.

According to Mitra [6], gesture recognition is an image-processing technique. Man-made gestures are captured and system recognizes it. This technique can be easily used to interact with machines by making different gestures according to required message to be conveyed. Database of different messages for different environment according to application syntax is stored. System is made to give them particular message according to the environment and application syntax. Even people who cannot communicate orally (sick, old, or young child), they would also

get benefit from this technology. During 1960s, hardly there were any interactive technologies. It is possible to make a gesture recognition system for these people. For the people who cannot speak due to disability from birth or old age problems, a mechanism can be provided to express themselves using gesture-based systems. Gesture-based systems can be connected to speech processing systems to generate oral messages from stored database after selecting suitable message for particular type of gesture. Nowadays, mobile companies are trying to make handsets which can recognize gesture and could operate from little distance also. Here we are focusing on human-to-machine interaction (HMI), in which machine would be able to recognize the gesture made by human. Even though Stanford University researched a lot of this kind of technology, they did not become so successful. They concluded some principal reason for not succeeding is scientific research. (a) Lacking of motivation to increase productivity in domestic work. (b) Less involvement of users of the technology in the design process. (c) The view held by product designers that domestic technology is unexciting. (d) A continued focus on stand-alone appliances in the design of new technology. Today smart energy management is very important for energy saving [3]. Due to lot of popularity of mobile communication, GSM-based home automation [4] is popular. But lot of sensors and GSM-based communication itself is not consistent, becomes unreliable [5]. FPGA-based home automation system does not make a universally acceptable solution [6]. Zigbee-based HAM becomes very costly with increase in number of functionalities and devices [7]. Simulation is not close to practical things. Two types of approaches to HGR are discussed.

i. Appearance-based approaches where hand image is reconstructed using the image properties and extraction.
ii. Model-based approaches where different models are used to model image using different models to represent in computers. In this paper, we proposed a new algorithmic-based technique in two possible combinations as follows: (1) Sign based (2) Person detection and shown that it is a cost effective and energy efficient.

3 Proposed System Architecture

Many researchers proposed methods like hand gloves fitted with flex sensors or wires. Variation in resistive values with movements of gloves is analyzed to match with the required response. But contact less gesture recognition became a research area in machine vision or computer vision and is as natural as human to human interaction. In proposed algorithm, enhancement of home automation system has been focus for appliance control system with a real-time scenario. The real-time scenario has been defined in Fig. 1. Here two cameras are placed in a room. One camera is used for capturing the sign to turn on the appliances. Another camera is used for capturing whether any person has entered in the room to turn on the

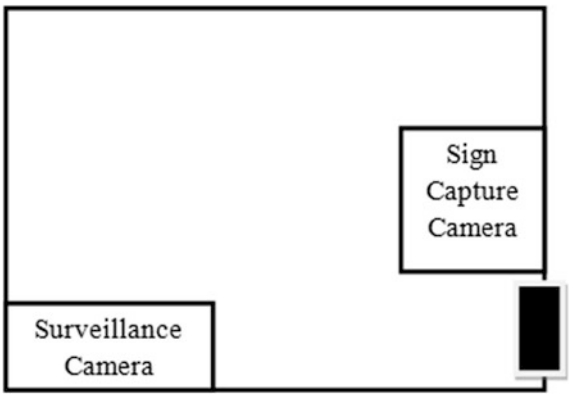

Fig. 1 Appliance control scenario for home automation

appliances or come out of the room to turn off the appliances. The functional block diagram of proposed algorithm for appliance control system is shown in Fig. 2. First it is capturing inputs from sign capture camera and surveillance camera. Captured images are not suitable for appliance control. Therefore, image processing has been carried out using thresholding method.

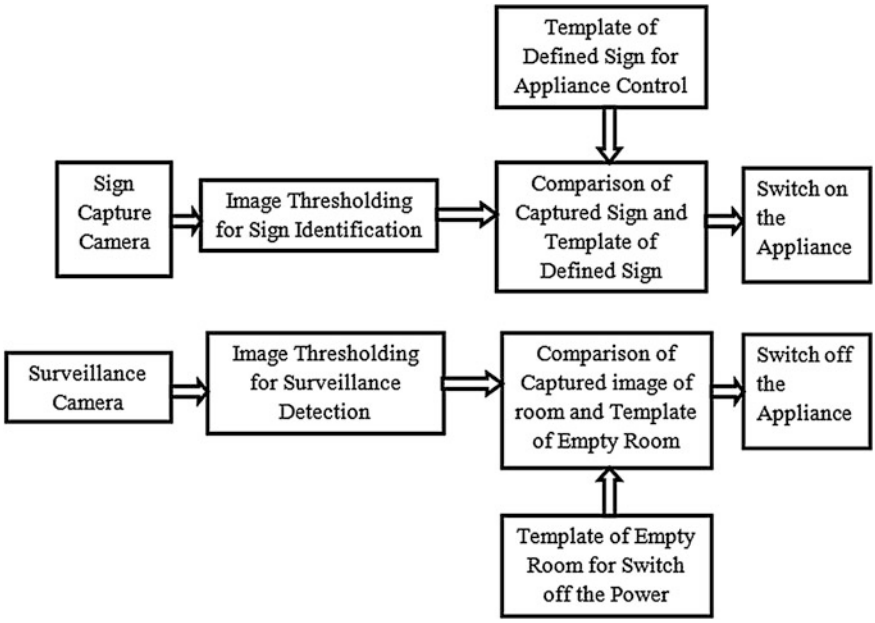

Fig. 2 Functional block diagram of appliance control system

After thresholding, threshold images are taken for template matching to identify the sign for turning on different appliances. Simultaneously, same template matching will happen for person identification to turning off the appliances.

4 Methodology

Natural hand gesture recognition (HGR) is hot research areas in the computer vision. Hands-free operation of machines is possible using hand gesture recognition systems. Using NHGR can help people to interact with machines without using any extra device. Such systems are also useful if the users do not have much technical knowledge about the system. Machines can be operated without physically touching, but just by indicating hand gestures. They still will be able to use the system with their normal hands. Gesture made using human hand can be any, but few have a special meaning. Human hand can have movement in any direction and can bend to any angle. For human face detection, the Voila Jones code which is available from MATLAB latest version is used. Once the face or human is detected in the room than hand sign camera is activated, that will capture the hand gesture. The captured image is a color image. First color image is converted to grayscale image, then followed by binarization of image is done. In order to convert the image to binary image, proper threshold should be selected.

The steps are involved for the carrying out the work is as follows. (i) Most important thing is the presence of human being in the room that is carried out by voila Jones code. Voila Jones code is based on the Haar wavelet transform. (ii) Take the input sign image. (iii) Threshold the sign image to capture the sign from image. (iv) Take the Threshold template of all the sign. (v) Then count the number of ones in captured sign. (vi) Match the count with template sign. (vii) The match is found by 80 % then turn on the appliance else switch off the appliance. (viii) For turn off, the appliance match the surveillance image with template of empty rooms. (ix) If it matches with template of empty room then turn off the appliances.

5 Results

For tuning on light, fan, and high-volt AC three templates have been taken. The threshold images of template are shown in Fig. 3a–c. Figure 3a is for turning on the lighting appliance. Figure 3b is for turning on the fan and Fig. 3c is for turning on high-volt AC appliance.

Real-time input is shown in Fig. 4. In Fig. 4 five fingers are shown that all are indicating to turn on the high-volt AC appliance.

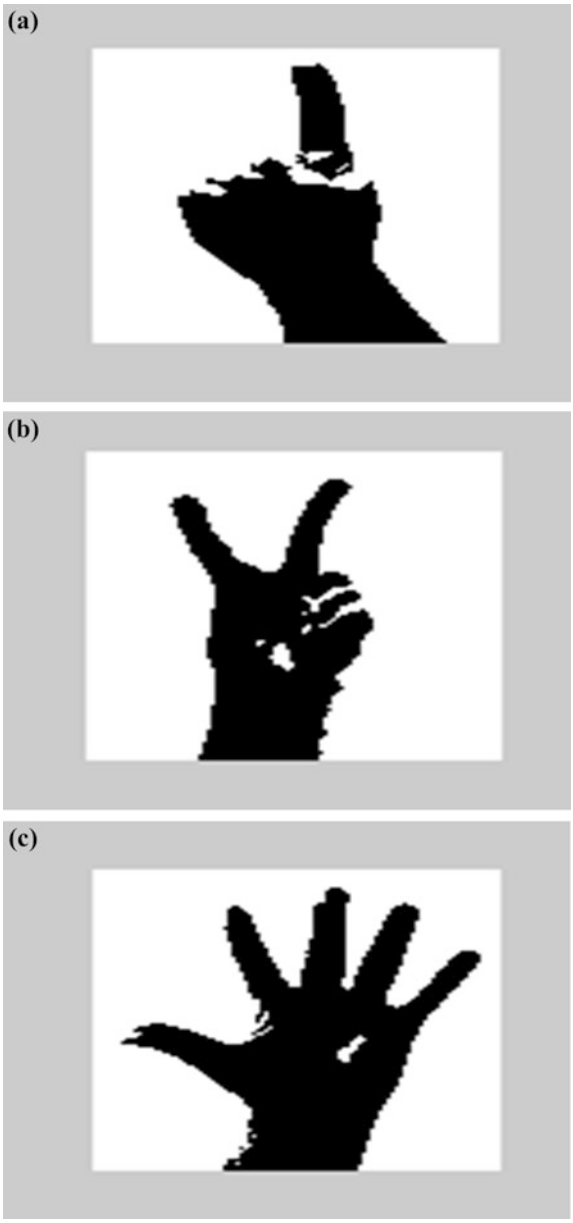

Fig. 3 **a** Template for light control. **b** Template for fan control. **c** Template for HVAC control

For tuning off light, fan, and high-volt AC empty room template has been taken. The threshold images of template are shown in Fig. 5a. Figure 5a is for turning off the lighting appliance, fan, and high-volt AC appliance. Real-time input is shown in Fig. 5b. In Fig. 5b human being is present. Therefore, the appliances are kept in same state.

Fig. 4 Real-time input capture by algorithm

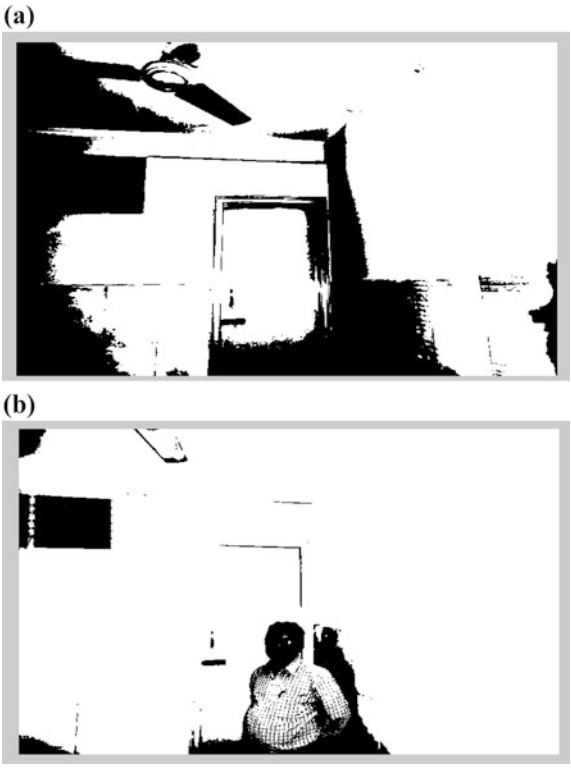

Fig. 5 **a** Template for turning off appliance. **b** Real-time input for person detection

For tuning off light, fan, and high-volt AC empty room template has been taken. The threshold images of template are shown in Fig. 3a. Figure 6a is for turning off the lighting appliance, fan, and high-volt AC appliance. Real-time input is shown in Fig. 6b. In Fig. 6b human being is not present. Therefore, the appliances are turned off.

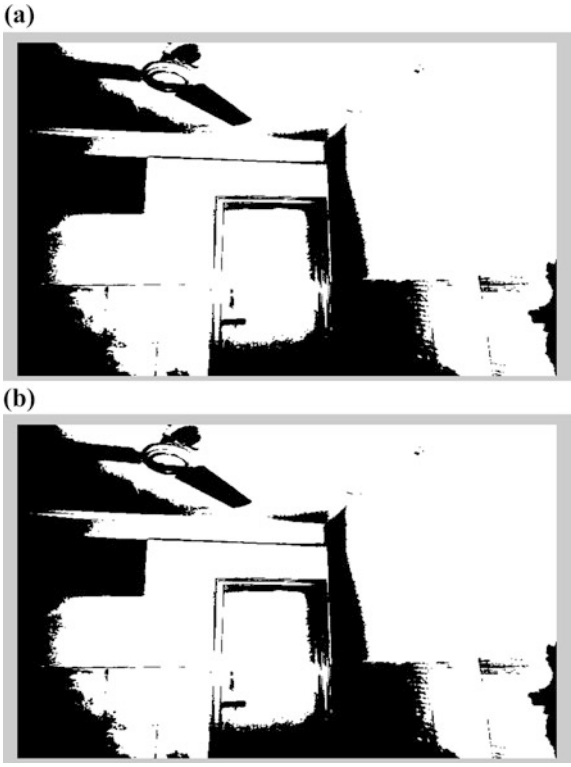

Fig. 6 **a** Template for turning off appliance. **b** Real-time input for person detection

6 Conclusion

Hand gesture-based electronic device control is gaining more importance nowadays. Different applications of hand gesture recognition have been implemented in different domains from simply game inputs to critical applications. Hand gesture recognitions is natural to interact with vision-enabled computers and other machines. This paper primarily focused on the study of work done in the area of natural hand gesture recognition using computer vision techniques. From the results obtained in this work, that the proposed algorithmic-based methodology has been reduced the complexity of controlling appliances and energy management has been carried out with intelligent algorithm. The number of sensors is required in a home automation system is also reduced and which in turn reduces the maintenance cost of home automation. The number of devices is reduced by approximately by 10 % and almost the cost by 5 %.

7 Future Scope

In this proposed work, home automation can be done by adopting the image-processing techniques. The implementation becomes cost effective, consumes less power, and can be easily converted to security-based home automation system along with controlling home appliances. Further work can be carried out to analyze individual finger position, figure bending detection, and finger movements. Works carried out with such implementations are few. Present investigations are carried out with full hand position detection or the fingertip position detection to generate or match required response. With additional enhancements, better security and surveillance system can be developed with improved features and characteristics in home automation while considering the cost, power consumption, security along with main task of automation.

References

1. Maikowski M. X 10 Home security systems. Jefferson Technology Press; 2006. pp 190. ISBN:10:096789171X.
2. Park W-K, Choi C, Jang J. Energy efficient multi-function home gateway in always-on home environment. 2010 IEEE, Consumer Electronics, IEEE Transactions; 2010. ISBN:978-1-4244-4316-1/10/$25.00.
3. Al-saedi FAT. Peak saving energy management system for smart house. IJCSET. 2013;3 (10):359–366. ISSN:2231-0711.
4. Gopu S, Kishore GS. Monitoring of home & activation of automated system via GSM through FPGA. Int J New Trends Electron Commun IJNTEC. 2014;2(1):11–14. ISSN:2347-7334.
5. Debono CJ, Abela K. Implementation of a home automation system through a central FPGA controller. IEEE; 2012. p. 641–644. ISBN:978-1-4673-0784-0/12/$31.00.
6. Gill K, Yang SH, Yao F, Lu X. A ZigBee-based home automation system. IEEE Trans Consum Electron. 2009;55(2):422–430.
7. Coral Lozada MA, Fernando De la Rosa R. Simulation platform for domotic systems. IEEE; 2014. ISBN:978-1-4799-4340-1/14/.