IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

SMARTCARE SYSTEM FOR INCAPACITATED POPULATION

[1]Ashish Chaudhary, [2]Nilansh Khurana, [3]Dr. Parneeta Dhaliwal

[1]U.G Student, Department of Computer Science & Technology, Manav Rachna University
[2]U.G Student, Department of Computer Science & Technology, Manav Rachna University
[3]Associate Professor, Department of Computer Science & Technology, Manav Rachna University

Abstract: In recent times, many home automation techniques have been adopted by us so as to make our lives more comfortable. These systems were based on the technology of Internet of Things (IoT) but were found to be very costly for common man. To overcome these challenges, we have proposed an adaptable, versatile, and secure Home automation framework that may even ease the lives of the incapacitated population with disabilities. The proposed system has been designed mainly to help the semi incapacitated or incapacitated individuals in running the home appliances independently using either phone, voice commands or hand gestures. The user runs an Android mobile application or wears a glove that sends signals to the micro-controller, thus operating the various appliances under control. In addition to switching ON or OFF the device, the gesture recognition module has a velostat attached that helps to even control the speed of the device. Using this system, the disabled people can also control the appliances from anywhere, anytime independently with minimal technicalities.

Keywords: Home Automation, Incapacitated people, Internet of Things, Bluetooth Technology, Gesture Recognition

1. INTRODUCTION

Internet of Things is termed as the most active network globally with self-configuring features based on networking protocols, where each device has its own identity. It has proved to be the fastest growing network, potentially transforming human lives, making more easy and comfortable. The base of this technology is to embed sensors in various electrical devices, making them smart devices. IoT has its application in various domains like Healthcare, Automation, Security, Greenhouse monitoring and intelligent transportation [1] etc. In Health-care industry, fitness bands have been designed which enable the users to know about their vital statistics such as heart-rate, calories burnt, body temperature on a regular basis.

Human beings have tried to achieve solace at their homes through various means such as thermal comfort, visual comfort etc. These smart homes have made life easy for every person irrespective of their age, health or level of intelligence. It has been achieved through a controlled system at homes, where the various electrical appliances are being managed either through Bluetooth [12,13], Mobile applications[14,15], gesture recognition [18,19], voice command [20,21] or short messaging service[16,17]. In gesture recognition system, a hand movement or a facial expression is received as a command for the system to operate the various appliances. Voice commands is a well-known concept used in many software's like Google Assistant, Siri etc. where microphones are used to detect the speech that works as a command. An android mobile application works as a manual remote control to the user for operating the various electrical appliances.

Elderly or incapacitated individuals form a critical part of the society that needs utmost care and support from the family for their day today activities. As a consequence they at times become a burden for the family. Our proposed SmartCare system has been designed to enable people to control the various electrical devices either through gesture, voice control or a mobile manual control. The system is an IOT device that uses the power of either Bluetooth or Wi-Fi to operate the various appliances. Our system would make every segment of society such as young, old, disabled people etc. independent and confident in their living. SmartCare would provide an economically feasible solution to their problems, affordable by every section of the society.

The paper has been organised as per the following sections. Section II describes the existing techniques in home automation. The following section gives a detailed description about the composition, features and working of our proposed system. In Section IV, we perform the evaluation of the SmartCare system as compared to the existing systems. In the last section, we give the conclusions and the scope for future work.

2. Related Work

Various technologies have been developed in the past that have helped in automating our homes. Some of these techniques are based either on gesture recognition or a mobile application installed in our phones. They either use Bluetooth or Wi-Fi technology to connect the various appliances.

A Bluetooth based home automation system [17] with stand-alone Arduino BT board controls the various home appliances connected through relays. However, the system uses python scripts to access the appliances whereas applications developed in java are preferred nowadays. A general-purpose smart home automation system [16] has been developed that has additional features as compared to the conventional systems like an ultrasonic sensor used for detecting water level and a soil moisture sensor used for automated irrigation. Ramee and Raza research work[18] presented a Bluetooth android application based home automation system. However, it can control only four devices at any given moment.

Voice based home automation system uses human voice commands to operate the various in-house electrical appliances. The prototype in paper [14] uses Kinect sensor for receiving a voice command and a learned computer to separate voice command from noise. The main limitation of the system is a higher setup cost as it uses Kinect sensor that is highly expensive. Another system [15] based on the speech technologies: VoiceXML, SRGS, MRCP and SISR, provides high scalability and dynamically adapts to the changes in the number of electrical appliances in a room. The use of distant speech recognition and keyword spotting makes it a highly effective system even in a noisy domain.

Gesture recognition refers to recognition of the motion of the human body parts like face, hands etc. A gesture recognition system [19] based on an object detection MATLAB algorithm identifies a hand gesture and maps it to a pre-recorded gesture, resulting the microcontroller to operate the specific device. A novel approach [20] based on gesture uses a simple deterministic algorithm that runs on a received gesture, triggering a specific event. Hand gesture recognition system [9] is based on soft computing methods like neural network, genetic algorithms etc. giving a comparative analysis with the various existing systems.

Multiple wireless techniques like web server, mobile application and SMS [12] etc. was used to make homes smarter. A Smart home mode [13] based on the above mentioned technologies reduce the efforts of physically challenged and elderly individual. In the following section, a detailed understanding of the various components of the system has been given. The section further gives a description of the systems' features along-with the detailed working of the SmartCare solution.

3. SmartCare system for home automation

The proposed SmartCare system is based on the technology of Internet of Things. The system comprises of various hardware devices being controlled by a software application through a Wi-Fi module. A Bluetooth module is also being used by the hand glove used for operating and regulating the various appliances. The mobile application was developed in Android Studio 2.1.2, so it can only run on an Android Mobile platform.

3.1 System Components

The various components that have helped us in successful implementation of the proposed system are as follows:

1. MEMS Accelerometer[21]: MEMS accelerometer is a micro-electromechanical system used to measure the static and dynamic force of acceleration in the various axial dimensions. In our system, a 3-axis accelerometer sensor is used that analyzes the hand movement in XY plane, YZ plane and ZX plane.
2. Microcontroller [22]:AtMega 328 micro-controller is the controlling unit of the system. The miniaturized scale controller receives the command either through mobile application (Voice command or Manual Control) or from hand movement. As per the signals received, the microcontroller performs the specific action.
3. Velostat[23]:Velostat is a pressure sensor that measures the variation in the applied pressure and changes the resistance accordingly. The finger movement in the glove controls the speed of the appliances using Velostat.
4. HC05 [24]: It is an easy to use Bluetooth Serial Port Protocol (SPP) module, designed for transparent wireless serial connection. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication. The serial port Bluetooth module V2.0 uses CSR Blue core 04 External single chip Bluetooth system with CMOS technology and Adaptive Frequency Hopping Feature (AFH).
5. Wi-Fi Module ESP82663 [25]: The ESP8266 Wi-Fi Module is a Wi-Fi chip with TCP/IP convention stack that helps the microcontroller Fig.1 The components of Smartcare System to control the various devices through a Wi-Fi connection. By using ESP82663, the microcontroller connects to the internet and sends the data on cloud. The detailed hardware composition of the SmartCare system has been shown in Fig 1.

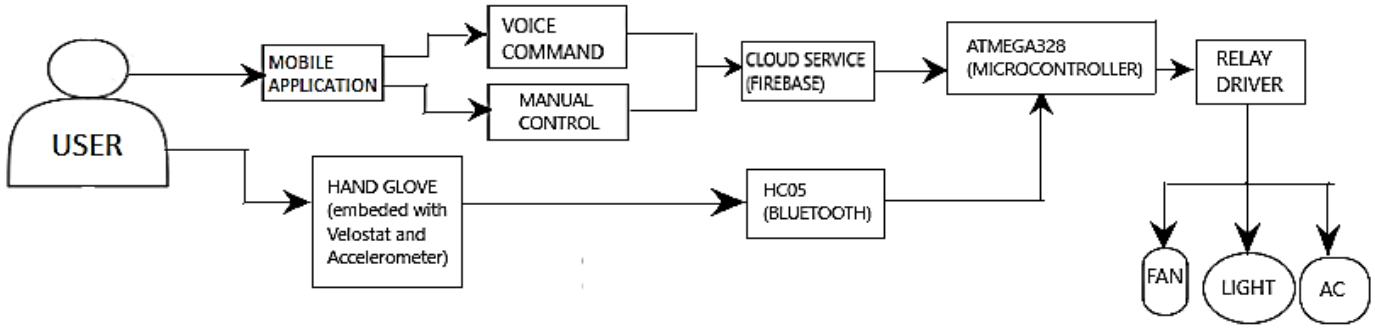


Fig.1 The components of SmartCare System

3.2 Features of the SmartCare System

The proposed system gives better user experience as compared to the existing systems, providing the following features: Mobile application User Interface both with a voice module and a Manual control system; and a Hand Gesture Recognition module.

Mobile Application Manual Control: A mobile application has been designed that controls appliances as simple as a remote control. All the commands given via a single tap on phone will be sent to microcontroller through cloud. This helps in accessing the various devices from anywhere anytime with the support of internet services. All the data regarding usage of appliances is stored on cloud for future reference.

Mobile Application Voice Control: The voice command is given to the microphone embedded in a mobile phone. The microcontroller operates the home appliances through the cloud services, as per the mapping with the real commands that were initially stored for the various device controls.

Gesture control: MEMS Accelerometer (embedded in the glove) is used to control the electrical appliances through hand gestures. The movement of the hand in various directions is linked with the operation of various appliances. The presence of Velostat in the glove helps to regulate the devices, controlling the variation in the speed of the fan.

3.3 Working of SmartCare System

The section provides a detailed description of the working of our proposed SmartCare system. The basic mandatory requirement of our system is Internet connectivity. An individual irrespective of their age, disability and technical expertise can operate the system independently. The user of the system operates the various electrical appliances through any one of the following means:

- Mobile Application o Through Voice Command o Through Manual Control
- Hand Gestures using a Glove

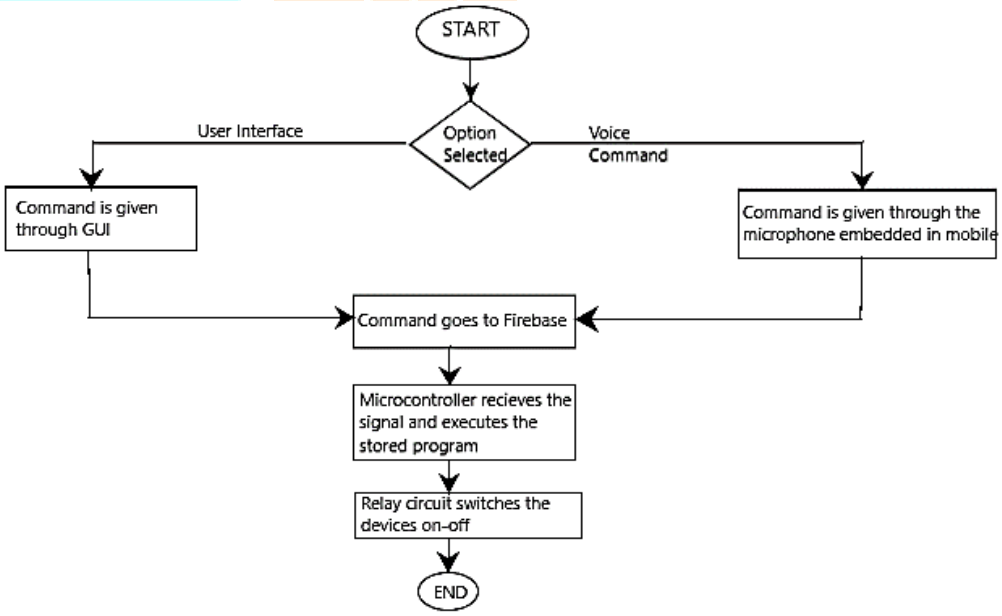


Fig.2. Working of Voice and manual control modules .

The mobile phone can work as a remote control for the multiple home appliances. The user of the Mobile Application gives the voice command through the microphone embedded in our mobile phones. The given command is then received by the microcontroller through firebase (cloud service). This command is further transmitted to the relay driver circuit. The relay driver circuit controls the functionality of all the appliances, mapping with the respective commands stored to operate the devices.
The mobile application also provides a manual control, giving the options to connect with each of the home appliances. A single tap by the user sends the signal to the firebase that is received by the microcontroller to operate a given appliance. The detailed working of the voice module and the manual control has been shown in Fig.2.
Another way to control the devices is through hand movement (in a glove) along the different axial dimensions. The movement is detected by the Accelerometer that sends the signal to the microcontroller through Bluetooth connection. In addition to the basic on-off of the device, the user can also regulate the speed of the device. This is achieved through the movement (flexing) of the finger, being detected by a Velostat attached to the glove. The same signal received is send to the microcontroller that regulates the specific device. The complete working of Glove has been shown as a flowchart in Fig.3.

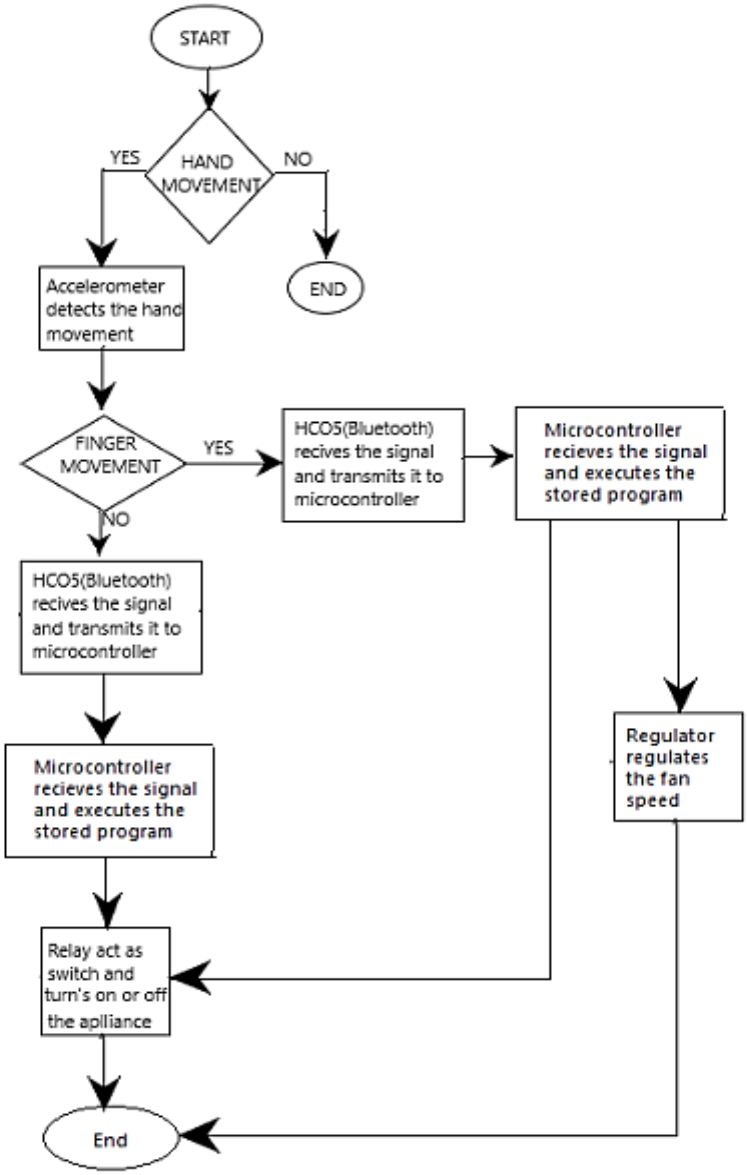
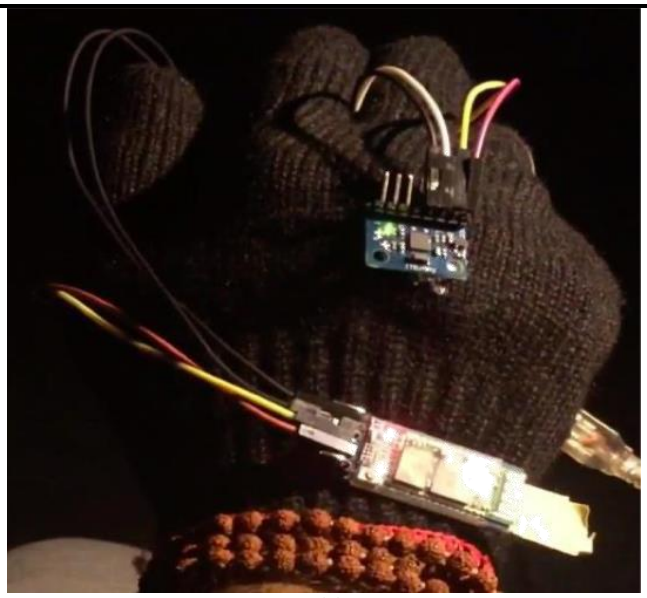


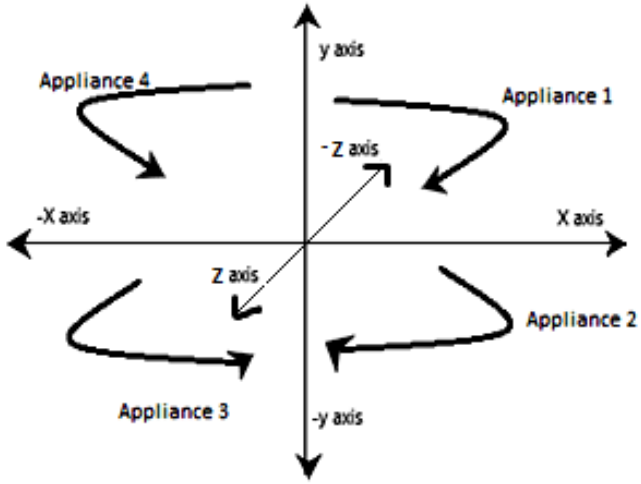
Fig 3. Working of Hand Glove System

4. Evaluation of SmartCare System

The experiments were conducted by 10 volunteers on their Android mobile phones over 20 runs for each of the modules. The system was tested using 4 electrical appliances (fan, light, A.C., T.V.) at their homes. Fig. 4 (a) shows an individual wearing a glove to control the appliances. The movement of the hand in the axial dimensions is linked to operating each of the 4 appliances as seen in Fig. 4(b). A single rotate switches ON the device and another rotation in the same plane switches the device OFF. The finger movement as seen in Fig. 4(a) helps to regulate the speed of the device. If the number of devices is more than 4, each of the fingers can be linked with the various device controls.



4(a)



4(b)

Fig 4. Working of Glove Module (a) Hand Glove (b) Movement in Axial dimensions

Fig. 5 shows the complete mobile Application Module. The front console of the Application as seen in Fig. 5 (a) provides an alternate option to control the appliances either through manual control or voice command. The Manual control provides options to connect with any or all of the four appliances through a single tap on the respective icon. A tap on the fan icon send the command to the firebase as seen in Fig. 5(b), switching the fan ON. Another tap on the fan icon will turn it OFF. A single tap on the voice icon invokes the microphone, sending a voice command 'TURN ON FAN' to the firebase as seen in Fig. 5(c) and switches the fan ON. The 'TURN OFF FAN' voice command is to turn the fan off.

We have performed a comparative analysis of Smart care System with the various existing home automation systems as shown in Table 1. Smart care system proves to be highly suitable for a real time domain. The proposed system uses the cloud service which is freely available and so one can operate the home appliances even from a remote location, a feature unique to our system. Our system is comparatively less expensive as compared to Gesture based home automation system [19] that needs a camera for hand recognition, which is costlier than the Accelerometer embedded in Smart care System. All the other systems do not provide any hand gesture support to the system. The speed regulation feature is present only in our system, using the velostat embedded in our glove.

The accuracy of the various modules was calculated, averaged over the experiments by 10 volunteers, with 20 runs of each module. The voice module showed almost 90% performance accuracy. The manual control module gave an accuracy of almost 92% when tested on all the four appliances. In hand gesture recognition, some volunteers faced problem due to the size of glove but accuracy of the gesture system was also highly impressive around 90%. However, the response time of the pressure sensing mechanism that controls the speed of the devices was higher.

Table 1. Comparative Analysis with various Home Automation Systems

Home Automation System	Mode of Mobile Application	Hand Gesture	Speed Regulation
A Smart Home Model Using Android App. [13]	Uses a local server to give commands.	Does not support	Does not support
Voice Operated Home Automation System Based on Kinect Sensor [14]	Does not support	Does not support	Does not support
Smart Home Automation System Using Bluetooth Technology [16]	Uses Bluetooth technology to control devices.	Does not support	Does not support
Gesture Based Home Automation System [19]	Does not support	Camera based hand gesture recognition	Does not support
Smartcare System	Uses cloud services (firebase) for controlling devices.	MEMS accelerometer detects the hand motion	Velostat regulates the speed as it has variable resistance property

Conclusions and Future Work

Nowadays home automation systems are being developed to ease the lives of humans. In our work, we have developed a home automation system with voice module, manual control module and a gesture recognition system. The gesture recognition system even helps to control the speed of the devices, within the Bluetooth range.

Tests were conducted with the support of volunteers in real time domain. The various modules proved to be highly accurate and easy to use irrespective of the age, health or technical knowledge of an individual. All the work logs were stored on the Cloud to be used later on, when required.

The manual control system provided images on the various icons, enabling even an illiterate person to operate the devices. The voice control system was calibrated to its best and gave quite satisfying results. The pressure sensing through the velostat proved to be a boost to the system. The use of the velostat technology helps to cut the cost of the system, making it highly affordable by all.

For future work, the glove can be made adjustable to fit in anyone's hand. Further, the response time of the speed control system needs to be improved. The mobile application user interface module could be extended to operate more than 4 electrical appliances. Further, the application could be designed to run on an iOS platform.

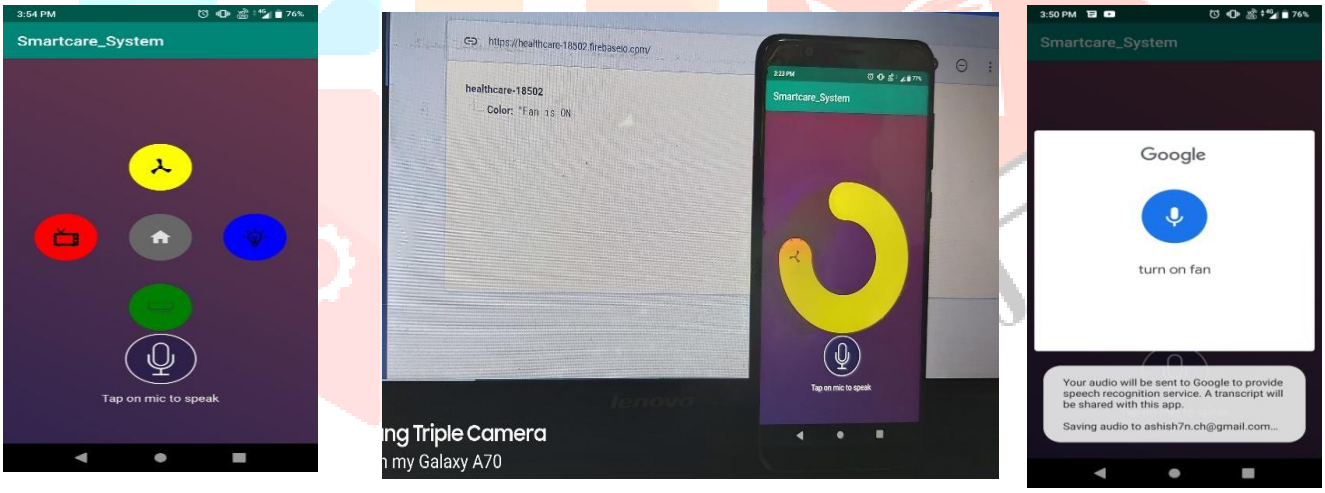


Fig 5. Working of Mobile application Module (a) Main Console (b) Manual Control (Turn ON Fan) (c) Voice Control (Turn ON Fan)

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