AN INTELLIGENT INTERFACE FOR GPS AND GESTURE-BASED HOME AUTOMATION

YASEEN UL HAQ[1,*], ASLAM TAHIR[2], RABIA SANA[3], SAIRA MOIN U DIN[4], RIDA ZAHRA[5]

[1,2]Department of Computer Science and Engineering, University of Engineering and Technology, Lahore, Pakistan

[3]Virtual University, M.A Jinnah Campus, Lahore, Pakistan

[4]Department of Computer Science, The University of Lahore, Lahore, Pakistan

[5]Department of Computer Science, University of Wah, Wah, Pakistan

Abstract. Home automation is one of the fields working on automating home or household activities. The core objectives of the domotics technology are to save time and effort. Home automation can be implemented in various ways to achieve desire results. Currently, no home automation system can track the location of the person to perform some task at a particular time. We can make home automation more effective and efficient if we can implement a combination of techniques. This research aims to design and implement a hybrid technique based on the Global Position System and hand gestures in the field of home automation. Global Position System works when a person is outside the home, and the hand gesture technique is implemented when a person is present at home. By implementing a hybrid technique, we can overcome the limitations of the Global Position System and hand gesture technique. It is designed to replace sensors used in home automation system with another state-of-the-art technology, the Global Position System. Global Position System is a satellite-based technology that provides location and time information in all weather, anywhere on or near the Earth and hand gestures are used for making it intelligent by setting the trend. Idea is to integrate these two technologies and develop an automatic home automation system using Cellular Global Position System and moves a step forward in the field of automation. This research is useful for the disabled and elderly people for convenience, energy efficiency, and safety benefits and the general population as well.

Keywords: Graphic Processing Unit, Central Processing Unit, Resource management, Computation, Image Processing, Apache Tomcat.

1. INTRODUCTION

The emerging developments in information technology have changed the way people manage their daily tasks. The era of pervasive computing was ushered in by these developments, where all the work for these machines

remains. The advent of smart homes has been influenced by social trends and the idea of helping and supporting elderly and disabled people. Improving the quality of life for people with disabilities and the elderly is everyone's business. A comfortable home environment could help improve the quality of life [2]. Home automation is a technology that allows things to happen in the home without human intervention. The first things that come to mind when people think of home automation are robots, flashing lights, and complex electronics. Examples of some simple forms of automation such as garage door openers, remote controls, irrigation/sprinkler control systems, motion-activated lights, security systems, programmable thermostats, programmable light timers.

Global Positioning System (GPS) is the only satellite-based system; it is a navigation technique based on radio signals, capable to show a person's position around the earth at any time in any weather conditions. Today, this remarkable technique GPS is integrated with a smart phone. GPS technology determines the exact position of the mobile user accurately by calculating the user's coordinates with the help of satellite signals.

Automation in simple words means 'the use of machines' thus avoiding human interface with the machine. The condition of implementing the control of equipment with advanced technology usually involving electronic hardware. Home automation or 'Domotics' is a wide and varied field that involves devices as small as temperature and light sensors, and as powerful and complex as modern mobile devices and smart phones. These devices are making their way into residential environments based on home security, convenience, medical assistance, and energy savings [1].

Domotics term was first introduced in 1984 as a short form of domestic robots, used to describe any system in which informatics and telemetric were combined to support activities in the home. Idea was to introduce robots in automating household activities and since then work has been started to get it implemented. Domotics involves many different disciplines like construction, electronics appliances, and communications. Home automation is the narrower term mainly used in USA.

A typical automation system consists of Sensors, Actuators, and Hardware controllers. A sensor is any device, like a thermometer, that detects a physical state of the environment. Actuators are devices, such as boards and switches that perform some actions such as turning things on or off or making adjustments in an operational system. Automating home considers multiple areas as mechanics, electronics, and computing according to the architecture of a building. It is related to ergonomics (Human Factors) [4]. It focuses mainly on facilitating a home user in his or her daily home activities. Majoraly home automation involves light and climate control (Heater and Air Conditioner), control of doors and windows, the security system of the home, and digital equipment. Modern home automation also involves automating watering, pet feeding, and multimedia control of the home. To provide more comfort and relaxation to a home user, the home automation scope has been increased to different levels.

Installation of a home automation system can be done during the construction of a new house or in an already constructed house. A typical Home automation system is installed by adding control wires to the desired equipment of a house and plugged single or multiple control panels into different walls. Automation is mostly controlled by motion sensors. For example, when a human enters a room its motion is being detected by sensors and room lights turn on. Same way when an intruder movement is detected at the doorstep by a motion sensor, the house security system is activated, and so on. A centralized controller can be used, or multiple intelligent devices can be distributed around the home [7].

The main focus of this paper is to provide a hybrid solution of GPS and hand gestures for an intelligent home automation system. By GPS we control the load likes fans and lights from some distance, but with the help of hand gestures we set a trend, this event automatically occurs without even GPS. GPS is used to control the load,

in the meanwhile hand gestures track the routine. A timer is used to get a start and end time. If the routine is the track for some load, then there is no need for GPS to ON or OFF. The rest of this paper is organized as follows. Related work behind this paper is described in Section 2. Section 3 introduces a proposed solution of basic Interface for GPS and hand gesture-based home automation. Section 4 provides the working of the system. The concluding remarks and future work of this paper are presented in Section 5.

2. Related Work

Kaleebu Fred, from the Department of Computer Engineering at the Faculty of Engineering, conducted a research project based on an Internet-based home automation system. The main objective is to design Internet-based home automation to control home appliances. Designing an Internet-based home automation system to control home appliances, the specific objectives of the study are to design a flexible, Internet-based wireless home automation system and to simulate and test the designed system. This project focuses on the remote control of the fan, light, and television (TV). With a fan and a light, it is considered on and off. But for television, in addition to turning on and off, changing the channel is also under consideration. Devices with a Bluetooth transceiver through which it can communicate with other devices. The Bluetooth transceiver operates in the 2.4 GHz ISM band (industrial, scientific and medical) [2].

Qinglong Wu, Fei-Yue Wang, and Yuetong Lin proposed a system architecture, a three-level distributed control architectural structure based on a mobile agent. They gave the hierarchical distributed control system for home automation and intelligent control. In this architecture, CORBA and mobile agent technologies work together to provide distribution of service control and location-sensitive adaptability and to achieve high accessibility and interoperability for distributed control [5]. University of Hertfordshire a research project was carried out. The research objectives are the implementation of a wired and wireless starter kit, the evaluation and implementation of wired and wireless sensors, and the implementation of wired and wireless cameras. This project concerns the surveillance, control, security, and automation of the house. The software components include a user interface, web pages, and a C-programming tool. Install a set of sensors and cameras when necessary. A website is displayed with a drawing or image of a house with rooms and floors. The results were successful as expected [6].

Hestia France is a company specialized in home automation system but also small to medium-size buildings. Their solution handles all the management issues energy, security, access control, automatism, technical monitoring, and communication. It uses several technologies for renovation and new constructions: traditional wiring architecture, bus wiring, carrier in line, and radio. The company developed a new home and building automation system that handles both IPv4 and IPv6 [3].

Marry Tom gave a dissertation An Initial Technology Road Map for Home Automations and Personal Life Management to develop an Initial Technology Roadmap for Home Automation. It is a pioneer study to provide the new dimensions and guidelines to be followed. The main components of the study are Market needs, Product Ideas to satisfy the identified market needs, and technology investment needs. The study has focused on those features of home automation contributing to the efficient management of the home and personal life. A model is developed to understand the family life cycle, relationship, and interaction with the external environment. The model enabled learning about future requirements for a family by investigating automated collections [8]. Dr. Leslie Haddon A study carried out for the purpose of this article aims to reflect on some of the problems that home automation poses for researchers in information and communication technology. Smart homes represent a vision of a specific "home of the future", as well as a family-related, if not identical, to home control products.

Therefore, it is important to understand how the evolution of this technological route interacts with older products, always revitalized and widely used. This case study shows an ambitious attempt to design a new product area that involves considerable collaboration between different agents and examines the problems encountered in researching an ICT that is still under development and therefore somewhat under-defined [5].

Ajitha Rajan, Lydie du Bousquet, Yves Ledru, the Germans Vega, and Jean-Luc Richier present in this article an approach to the specification of test oracles for services in the home automation system. To check the behavior of the service during dynamic reconfigurations, a scheme is used that notifies dynamic changes along with the runtime assessment of the JML specifications. An example of service on H-Omega HAS, which was developed on the service platform OSGi and iPOJO [9].

Rosslin John Robles1 and Tai-hoon Kim1 had an overview of security in the development of smart homes. This article will discuss the smart home, security, and the smart home security tool. Security technologies for home automation were discussed: user authentication for home automation using neural networks and defense against DDoS attacks caused by spam [5]. Delgado, Picking, and Grout examines the problems involved in implementing home automation systems. Also, possible solutions are developed using various network technologies. Several problems that affect home automation systems, such as lack of robustness, compatibility problems, and acceptance by the elderly and disabled, are discussed [6]. Potamitis, Georgia, Fakotakis, and Kokkinakis, G. suggest the use of speech to interact remotely with appliances and perform a specific action on behalf of the user. The approach is aimed at individuals who, due to their disability, are unable to perform real activities at home by directing devices through speech. The speech separation strategy is selected to make an appropriate decision through speech recognition [11].

Mohamad Ridhwan Bin Mohamed Rodzi suggests a system for home automation using X-10 technology. This project is about power line communication using X-10 technology to control an appliance. In this project, Visual Basic 6 software was used as a computer input. The microcontrollers functioned as controllers to receive and send data and signals from the input and send them over the existing power cables. He designs two sets of power line communications using X-10 technology as a receiver and the other as a transmitter [13]. Tan, Lee, and Soh, in their article, recommend the development of an Internet-based system to allow the monitoring of critical process variables from a distributed control system (DCS). This document suggests hardware and software design considerations that will allow the user to access process variables remotely and effectively in DCS using only a publicly available web browser. In their work, Liang, Fu, and Wu propose a software architecture that creates a home automation system (HA) based on the concept of multi-agents. The architecture consists of five main components, each referred to as spatial agents, functional agents, agents for personal preferences, environment variable servers, and kernels to control access rights to resources [15].

Mobile Based Home Automation: Chew Kean Chai presented a project on electric appliances controlled by cell phone (home automation with Power Line Carrier technology). In this project, an old GSM mobile phone is implemented as a GSM modem. The selected GSM phone is Sony Ericsson K700i. Power Line Communication (PLC) technology is implemented for the home automation part. The X-10 standard is used in the project. The microcontroller for controlling the PLC modem and household appliances is PIC16F877. The PIC is used to detect zero crossings and a 120 kHz X-10 carrier signal on the line. A MAX232 is used for communication between the microcontroller and the computer. The modem of the power line operator is used as a translator to establish data communication on the power line, since the power line is an analog environment, while the microcontroller is a digital environment. Two types of power line carrier modems are discussed in this study, namely, TDA5051A and ST7537HS1. TDA5051A uses the ASK modulation technique, while ST7537HS1 uses the FSK modulation

technique. For safety reasons, an isolation transformer is used in the AC power supply. Also, the device supplied with power must be protected from the power supply by isolating it [14].

Ciubotaru-Petrescu, Chiciudean, Cioarga, and Stanescu present a project and implementation of an SMS-based control for surveillance systems. The article contains three modules with a sensor unit to monitor complex applications. A processing unit, that is, a microcontroller and a communication module using a GPRS modem or a cell phone via the RS-232 serial interface. SMS is used for status messages such as power failures [11].

Jawarkar, Ahmed, Ladhake, and Thakare propose remote monitoring via cell phone using spoken commands. The spoken commands are generated and sent to the control system in the form of text SMS, and then the microcontroller decides on a specific task based on the SMS [8].

C.K. Das, M. Sanaullah, H.M.G. Sarower and M.M. Hassan proposed a system. Development of a remote-control system based on cell phones: an effective switching system for the control of home and office equipment. This document presents a new method by which users can remotely control their appliances and systems via a cell phone-based interface. GSM (Global System for Mobile Communication) technology is used to control the home or office using an authentication code (DTMF) [13].

Murthy examines primary health management for the rural population. One solution suggests using mobile web technologies that provide PHC services to the rural population. The system includes the use of SMS and cell phone technology for information management, exchange of transactions, and personal communication [9]. N. Sriskanthan, F. Tan, and A. Karande presented a solution for a Bluetooth-based home automation system. This document describes an application of Bluetooth technology in home automation and the network environment. A network is proposed that includes a remote mobile host controller and several client modules (home appliances). The client modules communicate with the host controller [12] via Bluetooth devices.

Ganiyu R.A., Arulogun O. T., Adetunji A. B. and Okediran O. O. The British Journal of Science Development of a GSM-Based Household Power Management System. In this document, you will focus primarily on the design and implementation of a GSM-based home energy management system to remotely control a maximum of ten home devices via a cell phone short message service connected to an automated device's microcontroller using technology wireless. They provide resources to manage energy consumption and prevent unauthorized people from controlling your devices [11]. Few companies implement and deliver end-to-end home automation solutions, including application software. E-Home AUTOMATION is a renowned Arab company that offers software and manufactures systems for home automation. They also offer some interesting features, such as remotely controlling your home using your cell phones over the Internet. You can sit anywhere in the world [7].

At present, in building/home automation enough work has been done. Biggest challenges faced in the field of electronics. However, all the systems work with the help of sensors to automate activities. There is no well-known system designed for Home Automation that is based on cellular phones GPS to automate house activities. GPS based home automation system enables us to control our devices remotely. In this way, human life becomes easier and relaxed. A person can control the devices remotely without their presence. Disabled and elderly people can easily facilitate by this technique. This technique is very useful for those persons who are not able to remember things. If a person forgets to OFF the AC, this will automatically OFF when it well outside the range by implementing.

The reviewed studies have some weak points such as limitations in the range of coverage for the wireless devices; power failure, high cost for implementation, and others that require an improvement in their performance. Therefore, a design of a low cost, flexible, effective GPS based home automation system is inevitable [8, 9]. GPS may not work in the absence of the internet. So home automation can be a failure in such a scenario where the

internet or your cell phone is not working due to network failure or battery critical down.

In human life, gestures play a major role in daily activities. It provides easier understanding during communication. By this, we can communicate more effectively and efficiently. In other words, gesture recognition refers to recognizing the meaningful expression of motion by a human, involving the hands, arms, face, head, and /or body [11]. Hand gesture plays an important role which helps us to express more in less time. Appliances can be controlled by the gestures are investigated such as robots, media players, lights, and fans. Hand configuration, hand movement, orientation, and classification are the four basic components on which hand gestures particularly sign languages can be interpreted [11]. To recognize the gestures two approaches commonly used are 1) Vision-based systems and 2)Glove based systems.

A vision-based system provides more non-contact and natural solutions like the camera to perceive the information of human motion and their surroundings. Because of complex background, it requires intelligent processing making it difficult to design. For enhancing the robust performance of vision-based approaches, color gloves or multiple cameras are used for accurate hand tracking, segmentation, and recognition [11, 12].

Gesture-based technology has also some limitations such as gestures cannot be recognized properly. You have to send a specific gesture to control the appliances without it appliance can't work according to our desire. A disabled person cannot be able to send gestures. So, we need make such a solution which covers the limitations of GPS and gesture-based system. The proposed solution provides a unique way to make home automation. ASMYR system is a combination of GPS and Gesture-based home automation system. It works more effectively and efficiently than applying the individual technique. When user want to ON the appliances from geographically distance, he can send command by using GPS technology otherwise by hand gesture appliances can be ON or OFF.

3. ASMYR SYSTEM

The ASMYR system is the breakthrough technology for home automation using a mobile global position system. This system development is in two folds a personal computer act as a hardware controller and a mobile phone which is a Smart Phone that sends GPS data to the hardware controller, both devices are connected to the internet all the time. This system provides a cost-effective solution to use cellular GPS for Home Automation by eliminating the Sensors which are usually high in cost.

An application developed in java would be installed on the hardware controller which is an interface through which the user can interact with the controller. The database developed in MySQL has all the records of the registered users with mobile id. All the user-defined rules are also embedded with the user profile data in the database. A rule can be defined with any of the four directions north, south, east, and west. Each hardware controller which is a personal computer has its unique IP address. The hardware controller authenticates the user and manipulates the GPS data which that particular mobile has sent and then performs an action according to the user-defined rules. To perform the required task/action the assistance of the Home Automation System would be required.

The second major module is the mobile phone. Every mobile phone comes with its unique id which is its IMEI number, this unique ID is used to detect a particular mobile phone. An application is installed on the mobile phone. This application sends the calculated GPS data to the Home Controller via internet/GPRS. For this mobile phone should also be connected to the fast-track internet. To execute the application two technologies would be required Global Position System and General Packet Radio Service. The proposed solution provides the freedom that any kind of mobile could be attached to the home controller.
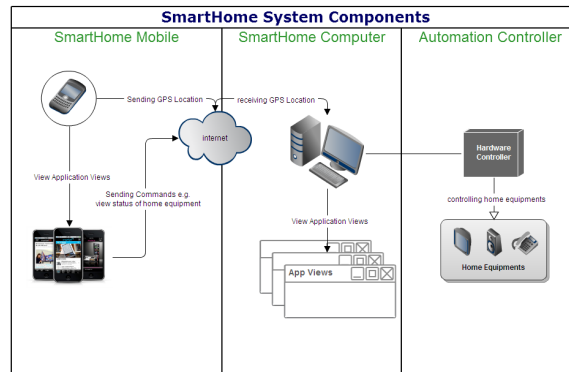
FIGURE 1. Smart home application system design

The present study facilitates users to navigate into the pages with easy-to-use graphical user interface GUI through which users can interact with a system. A new user can register himself by providing his basic account information, user id, and password along with mobile id, a registered user can define rules according to his convenience for managing and controlling household activities, manage his account, updates rules.

This proposed solution is a pioneering technology to enjoy the Home Automation System without the participation of the sensors. The elimination of the sensors reduces a noticeable cost to deploy a system.

Smart Home System. The proposed system consists on three modules smart home computer/server, smart home mobile, and smart home controller.

Smart Home Computer/Server. Smart Home Computer (shown in Fig 1) consists of two parts one is Server and the other is the Application that is hosted on the server. It is the main unit of the system. It is installed on a computer placed at home and works close Controller. It is placed at home/building which needs to be automated. Act as a server (assigned an IP address e.g., 210.111.64.32) using Apache Tomcat server for this research. It is connected with Home Automation using Smart Home Controller. It translates action to the appropriate commands that can be listened to by the Hardware installed at home. It is connected with a centralized control panel (Automation Controller) using a Smart Home Controller of the house which controls the house activities from a hardware perspective Connected to a Data Store which stores information. It listens to the User's Cell Phone GPS Data over http protocol. Authentication and authorization are done by using Device Id which is already registered through Smart Home Mobile and using its Device ID. Smart Home Computer is connected to the internet with a unique IP address through which the mobile phone detects the controller. After the connection has been set controller starts working. Smart Home Computer receives the location; matches the criteria against the rule set defined by the users and give signals to hardware-based Automation Controller for performing the desired action.

Data Store. This module of the proposed system is used to store all the required data by the applications also the user account information, the database is developed in MySQL. These are the major tables in the database user login, user rules, and rules description.

The database provides the facility for user management. User can create their user account by giving their personal information, username, and password, and device id using the interface provided by the application. Users can also update any of their statuses; can delete any of non required features. The whole liberty is given to the user. The database stores all the user-defined rules in the table. Rules Management is the key feature of the Smart Home server where three entities work together

Rule: a user-defined rule

Scenario: a situation defined by the user according to his convenience

Action: an action is taken according to the defied rule and scenario

RULE: SCENERIO = > ACTION

Users can create a new rule using scenarios and actions.

Condition (Scenario) is the case where some Action needs to be performed like "Move North from Current Location", "Move 2 KM to East from Current Location", "Move West from Current Location when time is 3 AM". So, condition can be added up with Metrics' like "Time, Distance, Direction, etc". There can be multiple conditions using operator AND/OR. Action is the capability of the Home Automation System as to what things it can perform like Lights Turn On/Off. AC turns Off/On. See Action Importers.

Actions Importer. This is the service that runs to communication with home automation system and fetches all the possible "Actions" and stored them in Data Base. (Communication protocol between Smart Home Server and Home Automation Controller varies as per home automation installation and this is out of the scope of current research. All this complexity is wrapped in the "Smart Home Controller").

User Registration and Security. Using the application interface user can register to the application. Every cell phone device has an id. Enter that id against the username, password and it is registered and stored in some data source table. This device id sends along with GPS data through the user smart phone and it is then authenticated.

Smart Home Manager. The manager is the server component that is interacting with three components data Listener, rule matcher, and action executor.

Smartphone Data Listener. Once the server is up Manager start this service. It listens to GPS Data send through the user cell phone. Data is sent to the Rule Matcher.

Rule Matcher. This component matches the user location data with the user-defined rule. Algorithms are used to quickly match the rule. If the rule matches with user location, it fetches defined "Actions" and send it to the action executor.

Action Executor. The action executor eventually communicates with "Smart Home Controller" to execute given actions.

Smart Home Mobile Application (User Location Sender). Smart Home Mobile Application is installed on the user's cellular phone and acts as a GPS data sender. The focus of the application is to retrieve the calculated GPS, which is the embedded feature of Smart phones today, and send it to the Home controller through GPRS or WiFi. The GPS data need to send the home user's current location. Application installed on User's Smart Phone by using GPRS/WIFI for Internet and GPS for calculating user current location. Send User GPS data to the Smart Home Server at home. The mobile application facilitates users by providing multiple GUIs.

This application sends GPS data to Smart Home Computer Application along with device id using the internet

which further control the home equipment using centralized control. User can view the status of his/her home like what equipment are OFF or ON. Users can view the customization set by him/her. Users can perform critical functions like turning ON/OFF equipment at home. Add Smart Home Server using IP address along with Name/Password to configure Smart Home Mobile with the server. If the server is up it verifies and allows the application to login to the Smart Home Mobile otherwise it returns an Error. Smart Home load necessary data into the application as User Profile, Rules Defined by User and Allowed "Actions" etc. Users can see already defined Rules, update/delete them, and can define new rules now. Add condition (scenarios) and metrics to it Map "Action" with it. Smart phone Data Sender service always runs on Smart Phone which sends user data to the location. Using Remote Control user can trigger "Action" manually by already fetched actions.

We can set the trend by hand gesture if we want that this peripheral is kept turning on at the same time in the future. The sensor observes the hand gesture and the timer record the starting and ending time of the appliance working. Those appliances which have a recorded gesture have to be turned on at a specific time without GPS. In this way, we can make our home automation more intelligent. After getting the basic idea of the proposed system, now we understand how the system works.

4. WORKING OF SYSTEM

Automation Controller is a hardware setup that receives commands from Smart Home Computer Application and physically controls complete household activities from a centralized location. The level of automation needed by a user is hardware-based. Smart Home software only provides options that are designed to be physically performed by Automation Controller.

Smart Home Mobile and Computer Application are covered in detail from HCI Perspective. An automation Controller is a typical Home Automation hardware setup. It can vary from basic home automation to complicated design. It is being already designed and details are beyond the scope of this study, hence, is not focused on.

Act as a bridge between home automation and Smart Home server. Convert Smart Home Server Commands to Home Automation understandable commands. Return the data in Smart Home Server understandable format.

Returns "Actions" list inquired by Action Importers of Smart Home server. Perform actual "Action". Hardware Implementation is out of scope.

Process Flow. A simple process flow consists of the following steps performed by a user.

Configure the Smart Home Computer Application by adding actions that can be performed by home automation system e.g., Action1: "Turn OFF Air Conditioner (AC)". Define a scenario e.g., Scernrio1: "Reach Away from Home by 2KM"

Define a rule by mapping actions against scenarios

e.g., Rule1: Scenerio1 → Action1

Launch Smart Home Mobile Application and connects with internet. Trigger the scenario e.g. reach far beyond 2KM radius from home. Smart Home Mobile sends coordinates to Smart Home Computer and it checks the rule set and matches the scenario. Smart Home Computer triggers the Automation Controller with the proper signal and performs the desired operation. Smart Home Computer placed at home is listening on some port for using GPS location over the internet. However, not any mobile can send data to this application. Smart Home Mobilefirst needs to be registered to this application using its device ID. Smart Home computer then only facilitates users with authenticated device IDs.
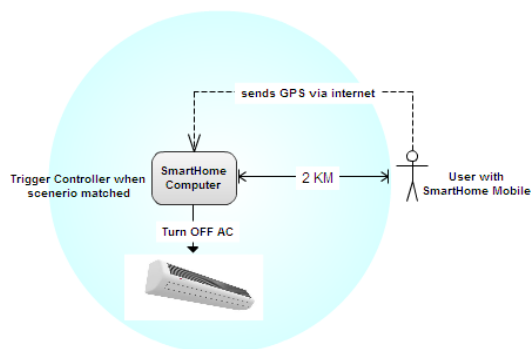
FIGURE 2. Process flow on the user-defined scenario

There is support for configuring multiple cell phones in Smart Home Application and the system works on logical or user-defined prioritization for automating home activities.

5. CONCLUSION

In this paper, we have a workout on breakthrough technology for home automation using a mobile global position system. Home automation makes our life easier, comfort and safe our money and time. Mostly home automation system consists of sensors which make it expensive. This paper identifies GPS based Home Automation which is more effective and efficient in its working. Our research provides the solution to the following problems How to automate daily life activities with already used technologies with no extra installation. Sensors and Motion Detectors usually make the Home Automation system quite expensive. And for automating multiple rooms in a home, multiple sensors are required. So, this solution saves this cost. Disable or elder people are unable to use switches; remote control or Control Panel installed outside the room as in a typical Home Automation system. This solution automates their daily life activities with ease and comfort. As GPS Precision is improving day by day then there will be a need for an application design for GPS based home automation system. There is a need for a centralized way of handling building automation in the future. The same cell phone can work not only in the house but in the offices and other places as well. In the future, this system will support a customization level according to the hardware setup installed as per the desires of a user. Some of them are Alarm water leaks detection, gas leaks detection, fire detection, intruder detection, and light control.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHOR'S CONTRIBUTIONS

All authors equally contributed to this work. All authors read and approved the final manuscript.

REFERENCES

[1] Delgado, A. R., Picking, R., & Grout, V. (2006). Remote-controlled home automation systems with different network technologies. *International journal of advances in computer science and technology (ijacst)*, **4**(1), 08 -14.

[2] Obaid, T., Rashed, H., El Nour, A. A., Rehan, M., Saleh, M. M., & Tarique, M. (2014). ZigBee based voice controlled wireless smart home system. *International Journal of Wireless Mobile Networks*, **6**(1), 47.

[3] Parameshachari, B. D., Gopy, S. K., Hurry, G., & Gopaul, T. T. (2013). A Study on smart home control system through speech. *International Journal of Computer Applications*, **69**(19).

[4] Thakur, D. S., & Sharma, A. (2013). Voice recognition wireless home automation system based on Zigbee. *IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)*, **6**(1), 65-75.

[5] Dutta, K. P., Rai, P., & Shekher, V. (2012). Microcontroller based voice activated wireless automation system. *VSRD Internationl Journal of Electrocal, Electronics and Communication Engineering*, **2**, 642-649.

[6] Kato, S., Lakshmanan, K., Ishikawa, Y., & Rajkumar, R. (2011). Resource sharing in GPU-accelerated windowing systems. *17th IEEE Real-Time and Embedded Technology and Applications Symposium* (pp. 191-200). IEEE.

[7] Malche, T., & Maheshwary, P. (2017). Internet of Things (IoT) for building smart home system. *International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC)* (pp. 65-70). IEEE.

[8] Gupta, V., Schwan, K., Tolia, N., Talwar, V., & Ranganathan, P. (2011). Pegasus: Coordinated scheduling for virtualized accelerator-based systems. *USENIX Annual Technical Conference (USENIX ATC'11)* (31).

[9] Robles, R. J., Kim, T. H., Cook, D., & Das, S. (2010). A review on security in smart home development. *International Journal of Advanced Science and Technology*, **15**.

[10] Jawarkar, N. P., Ahmed, V., Ladhake, S. A., & Thakare, R. D. (2008). Micro-controller based Remote Monitoring using Mobile through Spoken Commands. *J. Networks*, **3**(2), 58-63.

[11] Ciubotaru-Petrescu, B., Chiciudean, D., Cioarga, R., & Stanescu, D. (2006). Wireless solutions for telemetry in civil equipment and infrastructure monitoring. *3rd Romanian-Hungarian Joint Symposium on Applied Computational Intelligence (SACI)* (pp. 25-26).

[12] Asadullah, M., & Ullah, K. (2017). Smart home automation system using Bluetooth technology. *International Conference on Innovations in Electrical Engineering and Computational Technologies (ICIEECT)* (pp. 1-6). IEEE.

[13] Tariq, M., Zhou, Z., Wu, J., Macuha, M., & Sato, T. (2012). Smart grid standards for home and building automation. *IEEE International Conference on Power System Technology (POWERCON)* (pp. 1-6). IEEE.

[14] Scaradozzi, D., & Conte, G. (2003). Viewing home automation systems as multiple agents systems. RoboCUP2003, Padova, Italy. Retrieved from $http : //www.robosiri.it/robocup_2003/robocupsitosiri/articles/pdf/conte.pdf$.

[15] Potamitis, I., Georgila, K., Fakotakis, N., & Kokkinakis, G. (2003). An integrated system for smart-home control of appliances based on remote speech interaction. *In Eighth European Conference on Speech Communication and Technology.*