Gesture based Intelligent Home AutomationSystem using CNN Algorithm and Android Application

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***Abstract*— The automatic and computerized control of household activities, features, and appliances is referred to as "home automation." It makes controlling home appliances simple. A network of hardware, communication, and electronic interfaces called home automation connects commonplace devices to one another over the Internet. It was previously implemented using Bluetooth, IR type of technologies but as its range was too limited GSM and WIFI technologies are preferred by people which are still used in existent system. Presently there are various methods like by giving instructions to Alexa we can control and monitor the appliance. We developed a system that consists of two methods to control home appliances. First is gesture based and second is by using an android application. The system focuses on real time image processing algorithm that can be used to detect, recognize gestures of hand and implement actions accordingly to control home appliances. CNN machine learning algorithm is implemented to detect gestures of hand to control home appliances and the system can also control the home appliances through virtual buttons using an android application. Through the system user can control home appliances using hand gestures and through virtual buttons using an android application.**

Keywords—Home Automation, Bluetooth, GSM, WIFI, CNN, Machine Learning

I. INTRODUCTION

Home Automation is the process of accessing appliances inside the house without any efforts. Due to this, a physical effort of humans can be reduced. Many people in the world are dependent on each other. But people don't like this, especially old aged and physically challenged people. So, this technology of home automation will help people to live their life without depending on others and without any efforts. The Internet of Things (IoT) and Machine Learning play a major role in this. By hearing the word IoT, everyone can understand some profligacy is approaching this world. Smart grids and home automation are the IOT's most widely used applications [9-10].

In the current era, there are a lot of implementations of deep learning and machine learning. As it come under artificial intelligence, so it allows software applications to predict outcomes more accurately. The proposed system- Gesture Based Automation works on the technology of Machine Learning. Convolutional Neural Network is used as an algorithm to achieve the target. It supports every human's Day-to-day life with the use of inter connected devices that are to be automated [1-2]. In short, Home Automation system is a concept that involves controlling and monitoring of multiple home appliances [3]. As technology is changing everyday so, it is very important that our system should use current technology (IOT and Machine Learning). Most of the home automation systems based on "IOT and Machine Learning" are incomplete and requires a final improvement in the field. These works are either just on paper or only targeting a small proportion of population.

The developed system uses Raspberry Pi as a microcontroller. The system works on two modes. Firstly, the appliances can be automated by giving gestures to camera. This mode used Convolutional Neural Network (CNN) for classifying the gesture. Secondly, the appliances could also be automated using an Android Application. The app have buttons to turn ON/OFF the specific appliance. The system help disabled and old age people to automate appliances without any effort of getting up or walking. The gesture-based automation help people who are not aware of technologies.

II. LITERATURE SURVEY

QToggle App is linked with QToggle Server Package. Here Qtoggle Server provides a user friendly interface named frontend, which comes in form of progressive web application (PWA).Qtoggle is an operating system ready to be used with Raspberry Pi Boards and runs Qtoggle services. This system has many outcomes like controlling, indoor temperature, controlling light, monitoring power and energy. Monitoring air humidity is yet to be added. Integration of video surveillance is also added in Toggle. [1]

Cloud database communicate with user by an android application. The system monitors real time power consumption, current room temperature and humidity. Methodology here depends on website user interface so the user could interact with system by sending commands to the server. The main disadvantage of such a system is dependency on physical PC for the server which limits flexibility of system and increases cost. [2]

In this system, it was shown that at a time multiple appliances can be turned on or off through a single switch, this reduces complexity of system by implementing customization in control switch of the system. Light gets turned on as we enter the room with help of IR sensor. If the User interface is simple controlling of the system is easier. Here, customization refers to the switches that are attached to the selected home appliances that the user wants to perform his or her acts for that specific moment. [3]

Home Automation System was developed using Raspberry Pi board and was based on Machine Learning and Deep Learning algorithms. The automation of devices/appliances was done through the emotions of the person. According to the emotions captured by facial expressions, ambient lighting was changed. This system is very costly and cannot be accurate always. This type of systems is not used by the large portion of people due to high costing, non-relevance. So, we decided to propose a general Home Automation System which can be used by the maximum number of people. [4]

In this paper, the system was designed using Bluetooth Technology and the devices/appliances were controlled through an android application based on Bluetooth communication. This system is cost-effective but has a short range. Due to short range it's not relevant to use this system in the era of Wi-Fi Technology. This system has a limitation of number of appliances too. Hence, we propose a System based on Wi-Fi Technology and provision of automation of up to 16 devices. [5]

This paper presents the Design, Prototype of a Secure Wireless Home Automation System with an OpenHAB2 Framework. They employed the use of two high-performance microcontrollers, namely, the Arduino Mega 2560, interfaced with a 16-channel relay, and Raspberry Pi Model B, running the OpenHAB software. The Raspberry Pi functioned as the server to develop a prototype of an automated smart home that is remotely controllable from both a web application and an Android mobile app. Due to use of two costly microcontrollers, the system is not much affordable to common public. [6]

This paper presents a step-by-step procedure of a smart home automation controller. The system mainly requires, Node MCU as the microcontroller (ESP8266). The system has two different operation modes. In first mode make use of mobile app interfaces with virtual switches & sliders to monitor and control appliances. In second is chat based uses text or audio commands. The proposed system is scalable in that it is able to add and remove rooms on demand. [7]

The paper briefly describes the existing work for automation system for home using IOT and based on their main contribution. The system consists of web server, web interface, database, NodeMCU and Solid State Relays. When a user installs this system in his/her house, the user will be prompted to enter the device id along with the user information so that the server can attach the device to the user and thus the device will be accessible only by the authenticated user. [8]

The classifications for sign recognition and detections are carried out automatically in the system that is proposed in [11]. Real-time images are formatted in RGB, which requires preprocessing to remove different movements from the picture. The proposed categorization system for sign language is simulated using MATLAB.

Based on the inertial motion units, this study [12] uses a deep learning strategy to classify the prediction of gestures from long short-term memory, and it produces the best results based on the inertial motion units (IMU).

The microcontroller used in [13] is Raspberry pi 2. The processing steps combine programmed logic with image processing techniques like blurring, masking, and erosion. The processing system receives the video data that the Pi camera has recorded as its input. The visual data from the image processing is mapped onto the corresponding audio.

III. METHODOLOGY

There are numerous Home Automation Systems present today which are mostly based on technologies like GSM, Bluetooth, IoT, Voice recognition. There are few systems that are based on machine learning algorithms like Support Vector Machine, Fisher Face Classifier, and Convolutional Neural Network. The systems based on Bluetooth have short range which doesn't work if we automate appliances through long distance. GSM based systems take longer time to automate appliances. The systems controlled through emotions are not much accurate and are costly. Keeping this all drawbacks in mind, we decided to develop a Home Automation system based on CNN algorithm and IoT which uses Raspberry Pi as the microcontroller. CNN algorithm is widely used for image processing and provides better results.

The system shown in fig.1 – Block Diagram is designed in such a way that it will be easy to use and helpful for disabled and aged people. By studying the literature mentioned we decided to automate devices/appliances using our developed application as well as through hand gestures. Instead of using old Technology- GSM and Bluetooth, we are using Wi-Fi technology, which has fast speed and a wide range. CNN algorithm is used for gesture based automation.

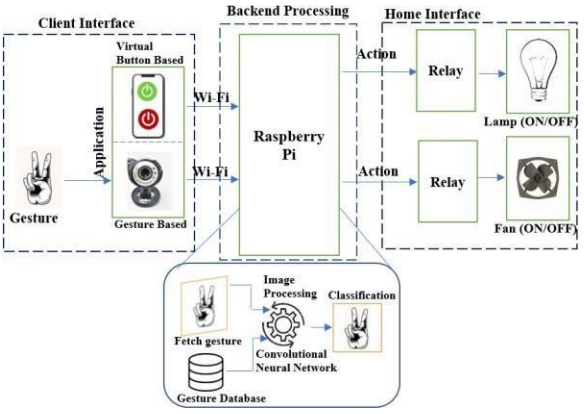


Fig. 1. Block Diagram of Proposed System

A. Elements of Block Diagram

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

- Client Interface – It is the interface on the user side where the user gives an input. The user can give input as a gesture to the camera or using virtual buttons on Android application which will be sent to Raspberry Pi.
- Backend Processing – The backend operation for gesture happens in this element. Raspberry Pi is used as a microcontroller for this process. The image of the gesture received from client interface will be pre- processed and compared with the gesture database which is trained

using Convolutional Neural Network (CNN) Algorithm and according the class of the image will be classified.

- Home Interface – This is the output interface where the appliances will turn ON/OFF according to the actions. Depending upon the action received from Raspberry Pi, the relay will turn ON or OFF. Hence the appliance will turn ON or OFF.

B. Block Diagram Explanation

The proposed system shown in fig.1 – Block Diagram works on the concept of IOT and Machine Learning-

- Virtual Button Based Automation – The system devices will be controlled through a Wi-Fi-enabled mobile device. The main hardware part consists of a microcontroller Raspberry Pi, to which several relays will be connected. The devices/appliances to be controlled are then will be connected to relays. Raspberry Pi has a Wi-Fi module. So, we can connectit to our IoT application. The developed application will be controlling the internet part. The devices/appliances can be controlled through Wi-Fi. In application, all the controls will be created for each appliance to be controlled. Through this application, we will be able to turn ON/OFF the specific applianceat any instant.
- Gesture Based Automation – The gesture based system contains three interfaces – Client interface, Backend processing, and Home interface. In the Client Interface, a camera will be used to capture the gesture input in the client interface before sending it to the raspberry pi. The Raspberry pi act as a backend server. The input images will be further pre- processed. These images will be utilised to both train and build our CNN (Convolutional Neural Network) model. Based on our trained CNN model and the input image, we will estimate the class of the image and use it as a testing image. In Home-Interface if the prediction is accurate then the respective action takes place like turning the light ON/OFF. For image classification, we employ the Convolutional Neural Network (CNN) technique. It is superior to other algorithms in a number of ways since it uses fewer parameters. Hence, training time reduces.

C. Work Flow of the System

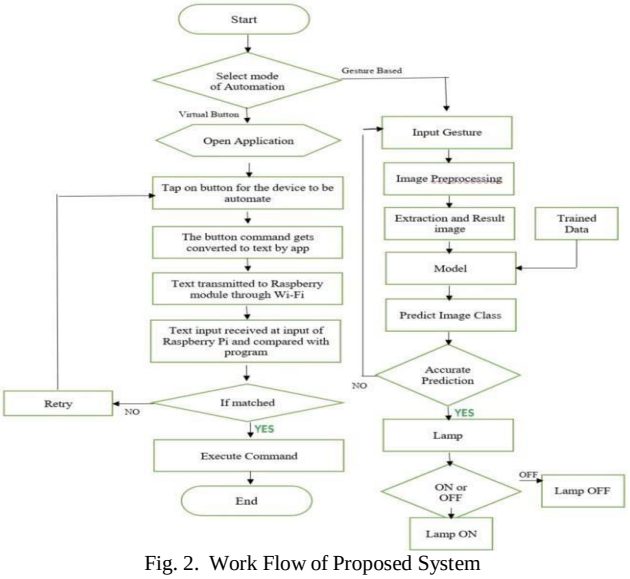


Fig. 2. Work Flow of Proposed System

D. Appliance control based on classified image

G_id	Gesture	Action
1		Light On
2		Light Off
3		Fan On
4		Fan Off

Fig. 3. Actions assigned to the gestures

E. Tools and Technologies used

In our system, the hardware includes a minimum Ram of 4 GB, Raspberry pi 4 Model B, 32 GB SD Card, some jumper wires, relay module, Bulb, and Fan. For communication and information transfer we need some hardware interfaces like Ethernet, WI-Fi, and software interface like android application.

Python libraries which include Keras, OpenCV, and NumPy. Android Studio is used to develop application.

F. Hardware Implementation

One gesture type out of the several specified gestures wasused as an input to test the system. After an image is taken using the camera on the Raspberry Pi, it is pre-processed and its class is predicted using a pre-trained CNN model. Some appliances are on or off depending on the expected image class. Each gesture has a unique action associated with it. The bulb, for instance, is turned on with the index finger. With the aid of a relay module, the appliances are connected to the Raspberry Pi.

Fig. 4. Implementation Results

IV. RESULTS

The results in terms of accuracy and loss are shownbelow.

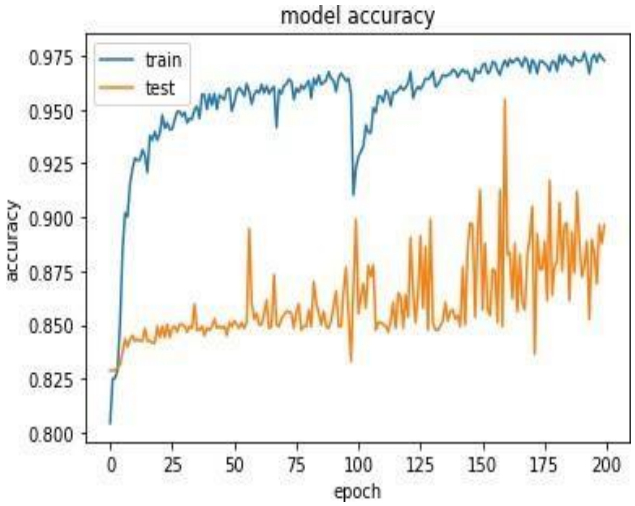
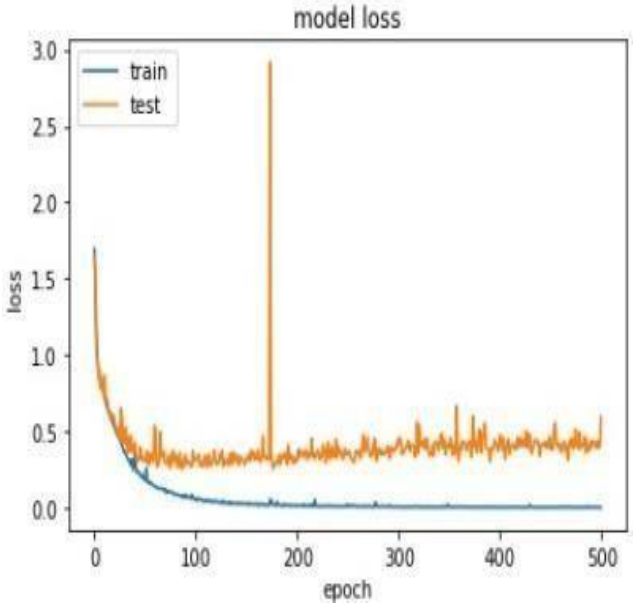


Fig. 6. Loss vs epoch



V. CONCLUSION

The prototype developed has two ways to control home appliances. First with hand gestures using machine learning algorithm and second with virtual buttons present on android applications. CNN algorithm is used for the controlling of home appliances through gestures. The concept of IoT is used for controlling appliances with virtual buttons. The accuracy obtained by CNN model is 96.5%. The system was designed to work in two ways but we succeeded in one method which is gesture-based. Android application is developed but it didn't work efficiently to control appliances.

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