# HOME AUTOMATION SYSTEM USING GESTURE PATTERN & VOICE RECOGNITION FOR PARALYZED PEOPLE

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*Abstract*—**Paralyzed people face a lot of challenges and difficulties in their regular activities. Even a simple task such as controlling electrical devices also very difficult for them. This study's primary purpose is to develop a cost-effective home automation system based on the human-centered design (HCD) that could reduce some people's difficulties. The proposed approach takes voice or gesture as input and performs necessary actions according to the information. The proposed system helps all paralyzed people except quadriplegia operate the room appliances without regular attention from a caretaker or nurse.**

***Keywords—Home Automation, Voice Recognition, Gesture Pattern, Smart House, Paralyzed People, Monoplegia, Hemiplegia, Diplegia, Paraplegia***

## I. INTRODUCTION

Paralyzed people are a part of society. There is no reason to neglect themselves. Although some body-parts are disabled for paralyzed people, they can think like an average person. Modern scientist Stephen Hawking had motor neuron disease. But his brain was ruled the world by various modern innovations. So, we have a great responsibility to help disabled people. A recent study by Christopher and Dana Reeve foundation shows that around 11,000 new cases of paralyzed issues arise every year caused by accidents, disease, or acts of violence [1].

Nowadays, due to modern globalization, the joint family is divided into several single families. In a single-family, most of the members are younger. Younger members contain less experience and low patience compare to older adults. If a family includes any paralyzed member, sometimes it is not always possible for the other members to assist them 24 hours. Since a paralyzed person cannot perform their daily activities like ordinary people, they need support from a third party for doing so. Due to the rapid change of technological innovations, paralyzed people can easily be benefited, e.g., scientist Stephen 'Hawking's neck was downwards, and he was immobilized. His eyes and eyebrows were functional, and the only way to communicate with the world. He performed various researches with the help of a device called an equalizer. The equalizer was a speech synthesizer. It is clear that how technology plays a crucial role in every sector of life. Human-centered design (HCD) is a technique to develop interactive systems. HCD makes useful and usable designs based on 'user's needs and requirements. It applies human factors, ergonomics, and usability knowledge with techniques. Nowadays, different types of pattern recognition systems are being used in the IoT sector [2]. This research aims to build an HCD based home automation system that can be usable for the paralyzed people.

Physically paralyzed people are suffering from monoplegia, hemiplegia, diplegia, paraplegia, etc.[3]. Monoplegia affects one limb (one arm or one leg), hemiplegia affects only one side of the body (arm, leg, trunk), diplegia affects both legs or hands, whereas quadriplegia affects both legs and hands. Moreover, the rest of the types of paralysis affects different minor parts of the body. There are several types of paralyzed people in this world. This home automation system's primary objective is to enhance the leading life system for paralyzed people by providing the control power in their hegemony. Patients can use this system very effortlessly, such as using gesture patterns or voice commands or using the switch buttons to control household chores. It is a very user-friendly, cost-effective, and safe system. This device can also enhance the self-confidence of paralyzed and older people by allowing them to be self-dependent.

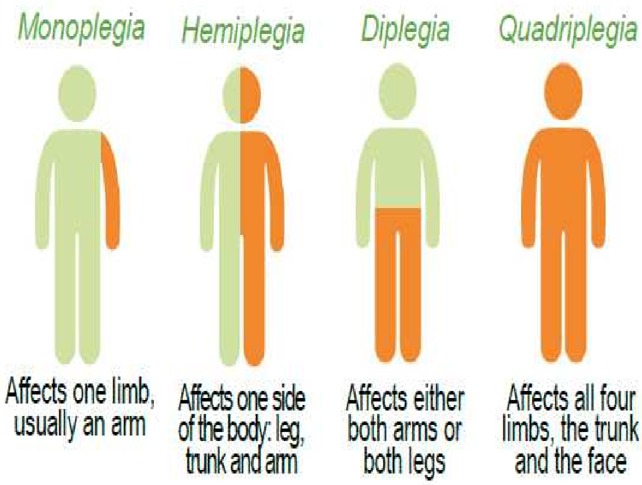


Fig. 1. Types of Paralysis occurred in humans [4].

## II. RELATED WORK

Numerous studies have been conducted by various researchers about the home automation system. A recent study by Prathima et al. proposed a voice recognition-based home automation system using a voice recognition module, gsm module, and robotic wheelchair. This system is costly and cannot use in patients with hemiplegia as they only use voice recognition [5]. In another similar study by Kumar et al. used only the voice recognition module [6]. Although the 'authors' claimed that their proposed system is cost-effective, it is not

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usable for hemiplegia paralyzed people. Another recent study by Islam et al. presented a smart home system for disabled people that can improve their lives, focusing on the key features, major challenges, and potentials [7]. However, their study's limitation is that if any patient has difficulties in touching any screen touch device, the system will not work. Habiba et al. proposed a device using voice recognition, wireless communication, GPS, GSM, location tracking, etc. This device cannot work for those patients who have disabilities with hand illness. It will be quite challenging for them to control devices [8]. Dubey et al. proposed a voice control system facilitated by a voice-controlled based device and not focused on all kinds of paralyzed people. The proposed device is not cost-effective [9]. In another recent study, Qushem et al. proposed a conceptual device, but this concept not covered all types of disabled people [10]. J. Saha et al. offered advanced IOT based home automation control and medical monitoring using a Gesture Pendant, a personal computer, and a controller. However, this system is not suitable for diplegia and quadriplegia. In addition to that, it is also not cost-effective [11]. Another study by Redrován et al. proposed a robot-based automation system for paralyzed people, which is costly. This device/robot is not for all kinds of people in this society. Many people cannot afford it [12]. Author Linner et al. proposed robotic micro-rooms, which is also very costly [13]. According to the short literature review, we can postulate that an automated system is required for varieties of paralyzing conditions.

So, we proposed a system that can reduce the devices' complexity and functionality so that paralyzed people with single or multiple conditions could easily operate their daily household chores like switching on/off fan, light, air condition, television, etc.

## III. SYSTEM DESIGN

In this system, a developed hand gesture device has been used to detect four types of hand gesture patterns. Similarly, voice module v3 has been used to detect voice commands. Detected hand gestures and voice commands are inputs of this system. A user can use this system in three different ways: Hand Gesture, Voice Command, or Pressing Buttons. Fig 2 shows the flow chart of our system.

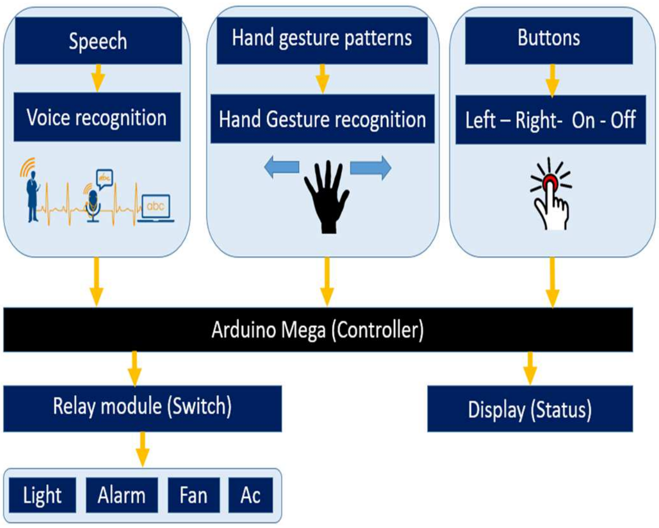


Fig. 2. Flow chart of the proposed design

The Voice module takes speech as input, and the microcontroller executes the command with instruction. Patients need to use different voice commands to use this module. For example, using voice command to turn on anything, the patient must say "On"; similarly, to turn off anything patient must say "OFF"; in the same way, to switch the left menu patient must say "LEFT" and to change the right menu patient must say "RIGHT."

The hand gesture takes hand patterns as input and executes instructions from the microcontroller. For example, to turn on anything, patients must hold their hand over the left ultrasonic sensor for five seconds. Similarly, to turn off anything, patients need to hold their hand over the right ultrasonic sensor for five seconds. The patient can swipe right to left to change the left menu, similarly to change the right menus patient must swipe left to right. The patient can also use switches to operate the device.

## IV. SYSTEM DESCRIPTION

We have used Arduino Mega 2560, Voice module v3 as our system's core component. We developed gestures with a hc-sr04 ultrasonic sensor, liquid crystal display (LCD), and the relay used in this system. The overall circuit diagram of this system is illustrated in Fig 3. Left-sided HC-SR04 ultrasonic sensor's trigger, echo, GND, VCC pins are connected with Arduino's digital pin 30, 32, GND, 5V.

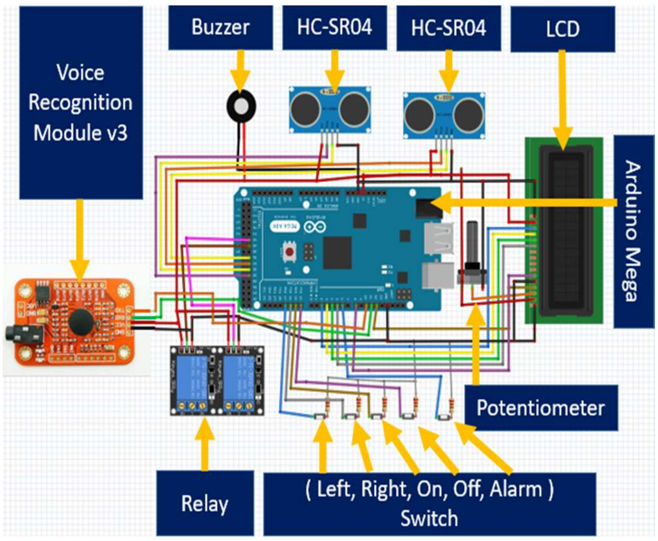


Fig. 3. The circuit design of proposed system

Right-sided HC-SR04 ultrasonic sensors trigger, echo, GND, and VCC pins are connected with digital pin 34, 36, GND, and 5V of Arduino microcontroller, respectively. Buzzer's GND and VCC are connected with the GND and 5V pin of Arduino, respectively. Voice module v3's RSX, TXD, GND, and VCC are connected with Arduino's digital pin 11, 10, GND, and 5V. Relay's pin number In1, In2, GND, and VCC are connected with Arduino's digital pin 40, 42, GND, and 5V. Switches are connected with Arduino's digital pin 6,14,15,16, and 17. Moreover, all switches are connected with a 10K ohm register and shorted to GND. The LCD display panel's pin number K, A, D7, D6, D4, D3, E, RW, RS, V0, VDD, VSS are connected with Arduino's GND, 5V, 2, 3, 4, 5, 8, GND, 12, potentiometer output, 5V, and GND respectively.

Another component potentiometer's GND and VCC pins are connected with Arduino's GND, 5V pin, respectively.

Arduino Mega 2560 has been used in this system because it has sufficient pins to support the proposed system. Arduino mega stored the program. The code has been uploaded with Arduino software in the microcontroller. The Arduino mega needs a 12v-2amp as an external power source in this system. Voice module version v3 has been used. Three persons' vocal data were trained in this voice module. -Liquid Crystal Display (LCD) has been used to visualize status. For example, light status – ON, fan status – OFF, etc. A two-channel 5V (DC) relay has been used in this system to turn on / off 220v ac devices.

After giving the 12v-2amp power source, the Arduino mega will be powered on. Then the hand gesture, voice module, and relay will be initialized. After ten seconds, the later device will pop up with menus. To initialize the whole system, it takes 30 – 45 seconds. In that running state, patients can easily operate the functions to turn on a light bulb, fan, air-condition, etc. The patient can use several input options in real-time. For example, if anyone turns on the light by voice module, he can turn off the light using gesture or switch.

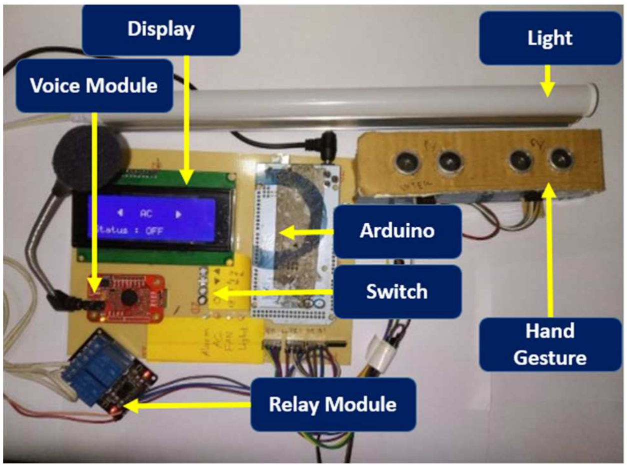


Fig. 4. The physical structure of the proposed system

## V. RESULT & ANALYSIS

Our proposed device's primary goal is to assist the different types of paralyzed people to control the home appliances without any help of another person. This system has been tested with the clinical trial. Some students act like various paralysis patients, and we have performed our test on them. There are lots of accidental trauma, monoplegia patients we have collected, and part of our test. Since quadriplegia patients are rare in our society, we have imitated trials as some of our students act like quadriplegia patients. The overall result is illustrated in the Table I.

We tested our system on 53 datasets, where 38 were paralyzed patients and 15 were average persons pretending to be paralyzed. This device has been tested over ten monoplegia patients. Eight patients passed in the voice module among this cohort, ten patients passed in the gesture module, and ten patients passed the pressing switch.

Twelve hemiplegia patients have been tested with this device. Only five patients passed the voice module test, twelve patients successfully passed the gesture test, and ten patients passed the switch pressing test.

Eight diplegia patients (both hand) has been tested. From them, seven patients easily passed the voice module test; no patients passed the gesture module and switched pressing tests.

Two quadriplegia patients have been tested. From them, no one passed the voice, gesture, and switch pressing test. Twenty-one other trauma (injured by accident) patients have also been tested with this device. Among them, 17 patients successfully passed the voice module test, 19 patients passed the hand gesture module test, and 15 patients successfully passed the switch pressing test. Fig. 5 shows the graphical representation of the result analysis.

Our tests have shown that the proposed approach has the potential to become an integral part of the monoplegia, hemiplegia, diplegia, and other trauma patients' daily life.. This result shows that the gesture module is more useful than the voice and switch module for different types of paralyzed people.

TABLE I. DEVICE RESULT OVER DIFFERENT PATIENTS

| Patient type | Number of Patients examined | Voice | Gesture | Switch |
|---|---|---|---|---|
| MONOPLEGIA | 10 | 8 | 10 | 10 |
| HEMIPLEGIA | 12 | 5 | 12 | 10 |
| DIPLEGIA(BOTH HANDS) | 8 | 7 | 0 | 0 |
| QUADRIPLEGIA | 2 | 0 | 0 | 0 |
| OTHER TRAUMA (INJURED BY ACCIDENT) | 21 | 17 | 19 | 15 |

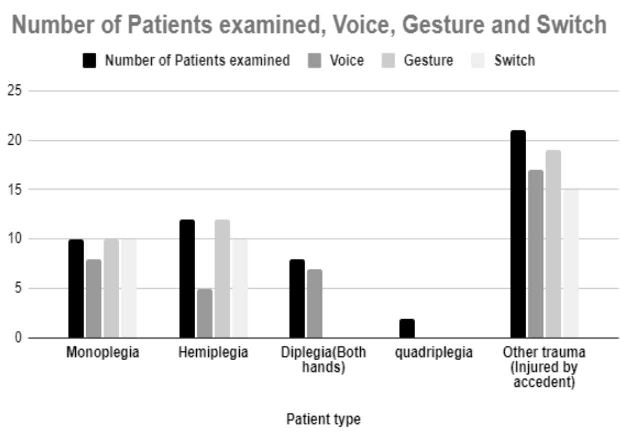


Fig. 5. Graphical representation of the result

## VI. FUTURE WORK & CONCLUSION

The proposed device is shown in Fig 4. There are many costly devices available in this modern technology, but this device is cost-effective. Various types of paralyzed people, except quadriplegia patients, can use it. In the future, we will develop a cost-effective brain signal input system so that quadriplegia patients can use it. The device will be essential for paralyzed people if we make it available for them. In society, various types of people can easily afford it, as it is inexpensive. We could also modify the proposed to make it more human-centered, analyzing the patterns from the reflexes considering the conscious and subconscious retinal responses and brain signals [14][15]. However, it is worth mentioning that incorporating the retinal subconscious responses and brain signals are quite challenging in real-time systems.

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