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IoT Based Smart Home for Paralyzed Patients through Eye Blink

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ABSTRACT

Newly designed high-tech devices are implanted in the patient's body to help him or her resume daily activities. Especially paralysis patients, such as tetraplegics, who suffer greatly due to their physical limitations. It is now critical to create a device that can assist paralysis patients such as tetraplegics. Furthermore, people are eager to digitize their everyday lives in order to reduce physical activity. To meet these criteria, it's past time to create a framework that can assist Tetraplegic patients as well as those who want to live a more productive and relaxed life. After much research in the lab and on the internet, we came up with the idea of creating a device that would allow an individual to control any appliance they use in their daily lives with less physical effort. We came up with an idea for creating such a device that we can use to automate our home electrical appliances by blinking our eyes. While several prototypes have been developed in the past, the majority of them are not user-friendly or provide creative solutions. The project's goal is to create a home automation device based on an eye blink sensor that is small in size and easy to use to power home electricity appliances. This will also help to minimize energy waste and enable a paralyzed patient to regulate light and fans without the need for assistance from others. The constant demand to enhance the everyday living conditions of paralyzed patients and people in general serves as a catalyst for newer technology growth. Smaller smart devices are now able to perform functions that were previously done by large conventional computers. The creation of the flickering sensor, which is used in robotic home designs for people with disabilities, is discussed in this article. This sensor can distinguish between intentional and accidental blinking, which allows paralyzed patients, especially quadriplegics, to organize their home devices without assistance. Furthermore, this system is equipped with a Bluetooth module, allowing the patient to receive alerts and updates without having to remove the device from his or her body. This saves a lot of energy and is simple to install in household appliances. Our system is a solution for paralysis patients who choose to use their eye blinks to control different electric devices and peripherals. Our system will detect the patient's deliberate blinks, decode the signal using a predefined algorithm, and then operate the specified device according to the instructions. To summarize, working with the Arduino Nano and various sensors was a fantastic experience that taught us a lot of useful information. Our initiative will primarily benefit paralysis patients and the elderly. Though we are considering a prototype for the project, our concept has been implemented and tested, but in order to implement it in the real world, many more modifications and equipment are needed. One of the main goals of our project was to assist patients in making their lives simpler, and our system will be complete until we can put it to use in real life and support people.

Key words: IoT, Smart Home, Paralyzed Patients Sensors

1. INTRODUCTION

Automation is pervasive in today's world of digital technology. From the home to the workplace, automated systems have significantly increased productivity [1]. Home Automation [11] is an excellent example of an Automation System. Some of the world's most powerful tech companies, such as Google and Amazon, have already saturated the market with the most advanced home automation systems [8]. Despite the fact that automation is supposed to make our lives easier, a certain category of people has always been ignored by these businesses. As a result, we concentrate our efforts on individuals who are physically challenged or paralyzed. Since this group of people is physically disabled, they depend heavily on the help of others. They must depend on others even for day-to-day tasks. As a result, any creative and efficient home automation systems can be of great assistance to senior citizens, the disabled, and paralysis patients. Since most of these patients have physical disabilities, they are unable to lift their hands or even talk. Furthermore, no major medical advancement has been made to address this form of impairment. In certain cases, physical exercises and proper treatment can help the patient, but writing a thesis is a time-consuming process with a low success rate. Are physically disabled for the rest of one's life. Their pupils, on the other hand, are their only means of power. As a result, we agreed to work on an automation technology that they can easily monitor with their eyes.

Current home automation systems are primarily designed and built for ordinary people who have physical access to any computer [10], [11]. With a paralyzed patient, this is ineffective. As a result, it was agreed to develop a home automation system for patients that could be used to power home appliances such as lights, fans, air conditioners, and other communication devices for emergency SMS and calls with little or no effort [4]. In this paper, we worked on a Home Automation Project primarily for paralyzed people in order to create an IR-based eye blink sensor that will be used to monitor electronic devices as previously stated. Our sole goal is to provide a long-term and successful solution for people with physical disabilities.

Our system is a solution for paralysis patients that allows them to use their eye blinks to operate various electric devices and peripherals. Our system will detect patient‘s intentional blinks and understand the signal by a predefined algorithm and operate the specified device as per instruction. We also have developed an android based mobile application through which the patient can send emergency SMS Notification for assistance. Our goal was to build a system with high accuracy with minimum development costs so that anyone could afford the technology and use it. To keep the cost low yet a scalable and efficient system, we used the open source Arduino platform for the hardware and Android for the controller application.

2. RELATED WORK

An eye blink sensor is a transducer that senses an eye blink and outputs a yield voltage when the eye is closed. This project is about eye blinking, which is used in devices that track a paralyzed person so that they can control home appliances such as lights, fans, and air conditioning. This is also linked to an Android Smartphone Bluetooth radio, allowing patients to communicate with others in an emergency by sending text SMS by simply blinking their eyes. [2],[5] look at the ongoing need to enhance the quality of life for paralyzed patients and the need to implement innovative technologies. Smaller smart devices have overcome a mission that was traditionally performed by big conventional computers. The total loss of muscle control in any part of the body is known as paralysis. It happens when there is an issue with the brain's ability to send signals to the muscles. The main aim is to create a real-time interactive system that can assist patients with paralysis in controlling devices such as lights and fans. You may also send an urgent flash message to help notify the doctor or individual by playing pre-recorded voice messages with a preset number of gifts. The intermittent sensor can detect deliberate flashes of normal flashes, allowing paralyzed patients, especially quadriplegics, to control devices without assistance. [11] According to a recent study co-authored by the World Health Organization and the World Bank, 15% of the world's population is disabled for various reasons. This device makes it simple to monitor your room's atmosphere without requiring assistance from others. It is the simplest way to monitor smart devices, such as turning them on and off, while the patient is alone, since it is based on eye movement control. This approach investigates the efficacy of EOG signals in the activation of smart devices. He proposed a new EOG-based automatic switch framework that includes a visual trigger mechanism that regulates user flashes and aids in the detection of eye flickers through a GUI that includes a flickering switch button for each time period, as well as an emergency alert system when patients are in danger. [2] looks at how eye movements like blinking and eyeball movements can be used as a module in assisted living systems to enable a community of visually disabled people to communicate – through their eyes. The aim of this project is to create a real-time personalized keyboard that can be used by a physically disabled person to communicate with the outside world, for example, to allow a computer to read a story or a text, play games, and exercise nerves, etc. The right-left, up-down eyeball motions work like a scroll in a paralyzed person's world, and the eyes twitch as a nod. Support Vector Machines are used to track the eye features (SVMs). A prototype keyboard was created and tested in a typical paralyzed person's environment under various lighting conditions to work with eye-blink detection and eyeball movement tracking using Support Vector Machines (SVMs). Tests on male and female subjects of various ages yielded findings with a 92 percent success rate. Real-time usage is not needed because the device takes around 2 seconds to process one instruction. A depth sensor camera, a faster processor setting, or motion estimation can all help to improve performance. According to [3,] 10% of the world's population is physically challenged, with 1.9 percent of the population paralyzed. Physically disabled people, such as the elderly and paralyzed, have issues with their bodies that make it impossible for them to do things that others take for granted. Disabilities can impair a person's ability to communicate, connect with others, and be self-sufficient, as well as cause them to lack self-confidence. As a result, some technologies, such as voice-controlled and hand gesture-controlled wheelchairs, have been introduced in the past to address these issues. However, current schemes are insufficiently applicable to individuals who are paralyzed or physically challenged. As a result, a device based on brain wave sensors is being proposed. Our proposed framework enables people to function independently and to act in a normal manner in terms of meeting their basic needs, as well as to live a healthy life. These commands are used in our project to monitor the various modes. The aim of the project is to create a device that can help physically ill, elderly, and paralyzed people do some work independently in their everyday lives by using the Brain Computer Interface (BCI) system. [nine] The overall goal of the project is to get a large number of people to read, write, listen to, and do something so their bodies can communicate through their brains. On a fundamental level, the brain is the body's trainer, and the mind is in control of each snapshot of the body. In any case, due to their handicap, a few people have difficulty managing their bodies to communicate with the mind and receive and transmit messages and driving forces. As a result, the cerebrum is complex, while the body is not. This makes the day-to-day and daily life increasingly difficult. One of them is correspondence, which is the body's unavoidable task of communicating with others verbally or by other means. Those individuals may think yet don't understand their contemplations. We designed and built "Eye Writer," a device that allows people with disabilities or plants to communicate through their eyes. By utilizing the onlooker, they can complete their musings and transmit them to other people. [3] The cerebrum PC interface (BCI) connects the human neuronal world to the outside physical world by deciphering people's mind signals and directing them in directions that PC devices can perceive. Profound learning has fundamentally recorded cerebrum execution and PC interface frameworks as of late. In this article, we methodically explore the kinds of BCI cerebrum flagging and related profound learning ideas for mind signal investigation. At that point, we will show a thorough investigation of BCI profound learning methods, outlining the in excess of 230 examinations distributed over the most recent five years. Finally, we discuss application areas, emerging challenges, and future prospects for BCI based on deep learning. [1] He made promising options for deadened individuals to collaborate with the machine, that is, PCs, cell phones and workstations. Some business arrangements, for example, Google Glasses, are costly and not every single deadened individual can communicate with the machine. To this end, the article proposes a gadget constrained by the retina called EyeCom. The proposed gadget depends on minimal effort, savvy yet solid IoT gadgets (i.e., Arduino microcontrollers, Xbee remote sensors, infrared radiating diodes and accelerometer). EyeCom can be effectively mounted on glass. An individual incapacitated by the gadget can collaborate with the machine utilizing straightforward head developments and eye flashes. An infrared indicator is before EyeCom to enlighten the eye territory. Because of enlightenment, the eye mirrors the IR light, which contains electrical signs. As the eyelids close, the considered light on the whole surface of the eye is adjusted and an adjustment in the reflected worth is recorded. Then again, a gadget called an accelerometer is utilized to move the cursor on the PC screen for the benefit of an incapacitated individual. The microcontroller forms the contributions of the infrared sensors and the accelerometer and transmits them remotely through a remote Xbee remote microcontroller (for example radio) to another PC. With the proposed calculation, a microcontroller associated with a PC, when it gets a sign, moves the cursor to the PC screen and encourages word-to-discourse programming activities, as straightforward as opening a record.

[6] Facial loss of motion is an infection brought about by nerve harm that can make patients lose facial development. In patients with facial loss of motion, the muscles are normally recognizably hanging on the opposite side of the face, which genuinely influences the personal satisfaction of the individual as appears in the picture (skull). More terrible, the influenced eye can't squint, dry and stick to soil, which can cause eye harm, including visual impairment. To the best of the analysts' information, the loss of motion is because of weight from a disease in the passage, which contains the primary body of the facial nerve, where the passage is inside the head of individuals called facial waterways. During this visit, we will be introducing another iBlink framework that will help stroke patients squint. Loss of motion generally happens just on one side of the face, and clinical investigations show that electrical incitement can trigger blazing. In light of these discoveries, iBlink's fundamental thought is to follow the typical side of the face with the camera and animate the deadened side so the two sides of the eye become even. [1-5],[7] researched that paralysis is one of the most important nervous disorders that causes loss of muscle movement in one or more bodies, which, depending on the cause, may affect a particular muscle group or area of the body or involve a larger area. When looking for rehabilitation, the eye can be considered as one body that can help a paralyzed person to communicate properly. Paralyzed patients and people without arms can use eye movement to perform simple tasks. This article describes acquiring and analyzing eye movements to activate home appliances in patients with paralysis. This proposed method employs a flickering sensor to obtain eye movement, which reduces the occurrence of objects, including monitoring a simple circuit for performing signal processing, which is also cost effective and useful to the user. And this processed signal can be used as an input to the microcontroller to control the devices. [8], [9-12] Investigate and record eye movement, as well as an infrared detector with a chord detector, which is used to control appliances. Who can help a paralyzer, some of whom can even move their hands and other parts of the body and can only move their eyes or eyelids? The proposed system is dominated by human eyes. Therefore, the disabled person can control the domestic equipment by himself. Often, this type of system operates in a specific condition rather than in real time. But our system is a real-time system through a predetermined number of eye movements. In addition, we have added sensors to monitor some health parameters. and if the parameter suddenly changes to the danger level, an SMS is sent to the doctor, to the patient's relative by SMS.

3. RESEARCH METHODOLOGY

The system consists of four major embedded electronics: TCRT 5000 as the Eye Blink sensor, Arduino compatible Micro-controllers, RF LINK Pair modules and Bluetooth. Additionally, a rechargeable lithium-ION battery is attached with both the Transmitter Glass Frame Module and the Receiver Module. It meets our requirements due to its low cost and availability. The reflection value is lower when the eyes are closed than when the lids are open [8]. As a result, we can easily detect when the user closes his eyes for a certain period of time. Blinks of the eyes can also be seen. We defined a pattern to trigger the device since eye blinking is a normal function of the human body. When the consumer closes his eyes for four seconds, the machine recognizes this as a signal to take action and prepares. Otherwise, the eye will blink unintentionally as is human nature, and the machine will do nothing. After the IR sensor is activated, the input will be taken when the device is ready to operate, and the system will function as instructed.

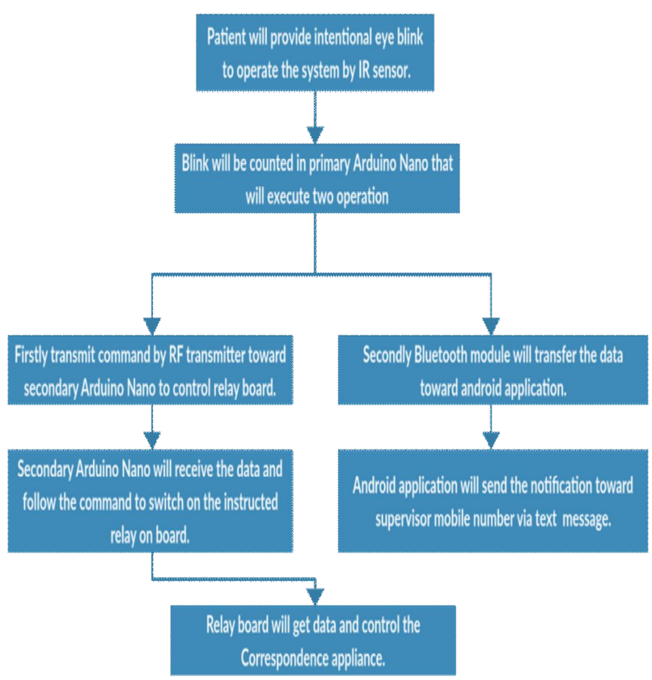

Figure 3.1: Work Flow of the System

As the entire system is developed for physically disabled people, we have prepared the system and the interaction is easy enough that it takes minimum to no effort to adopt and operate for a new user. As there are two major parts of the system, one is the wearable glass frame module, which is also actually a transmission device. And the second one is the electrical peripheral control unit, which is actually a receiver module. Furthermore, we have also developed an Android Application for configuring the device itself.

To configure the Glass module, we have also developed a very easy to use and intuitive Android Application. Using the Android application, users can configure the S.O.S emergency number, on which the message will be sent and all the command sequences and their specific actions.

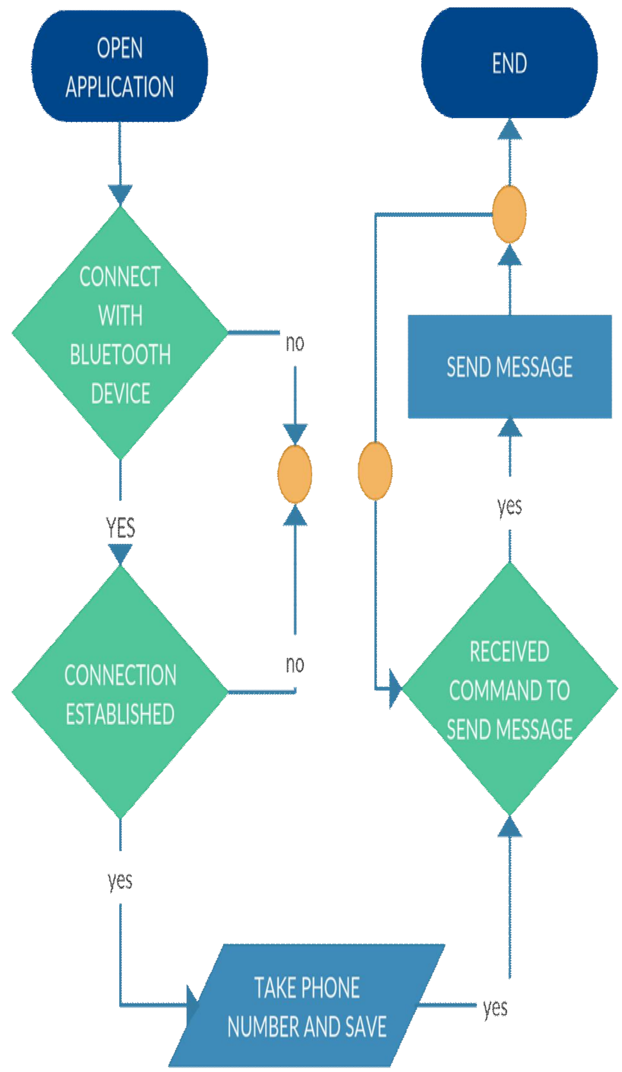

Figure 3.2: Android Application Flowchart

The Android application working process is very simple, which is described above in the flowchart. There will be a dedicated android mobile phone for patients that will be in the range of the device's Bluetooth so that patients can send the signal through the device and the mobile detects the signal and the installed application will send the text message to the predefined number for supervisor's attention for emergency.

3.1 SYSTEM MODEL

Our framework predominantly comprises of two separate parts. The initial segment conveys a glass outline which is an IR sensor associated with the Bluetooth module and Micro controller to gather information from eye blink. The IR sensor comprises a transmitter and a receiver to measure the intensity of light to decide flickering, both deliberate and regular.

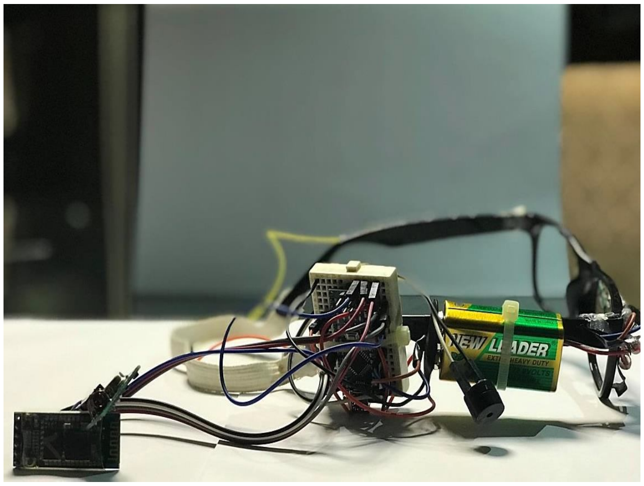

Figure 3.3: IR Sensor Associated Primary Segment

The Micro controller unit is associated with an RF-Link to exchange the gathered information to other bits of the framework.

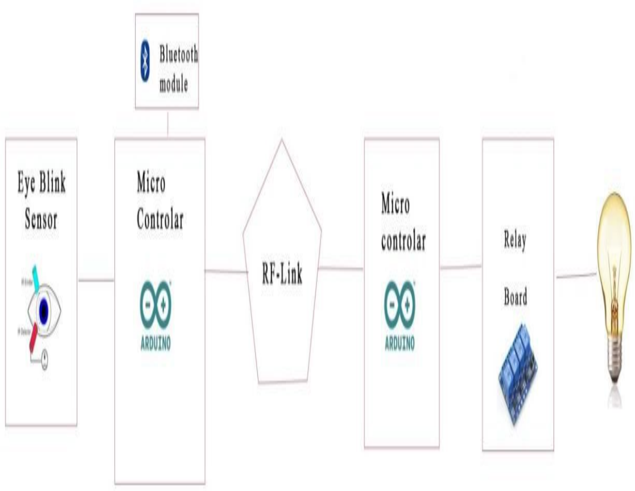

Figure 3.4: System Model

The second segment of the framework can be characterized as the recipient and processing part. It comprises another RF-Link module which gets information sent from the initial segment of the system. In this part, a relay board is associated with another Micro Controller to show the system's output.

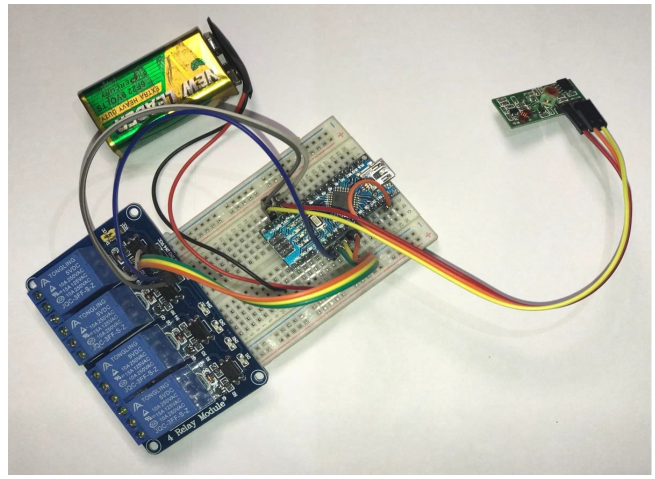

Figure 3.5: Relay Board Associated Secondary Segment

This structure is also equipped with Bluetooth, allowing the patient to send messages. This Bluetooth will be related to neighboring android devices that work with android applications. The android application will save one emergency contact. The patient can send messages to the saved contact in case of an emergency. The Bluetooth associated with the primary micro controller goes about as the functional unit of our android application by conveying SMS to the paired phone by measuring the instruction from the Relay board.

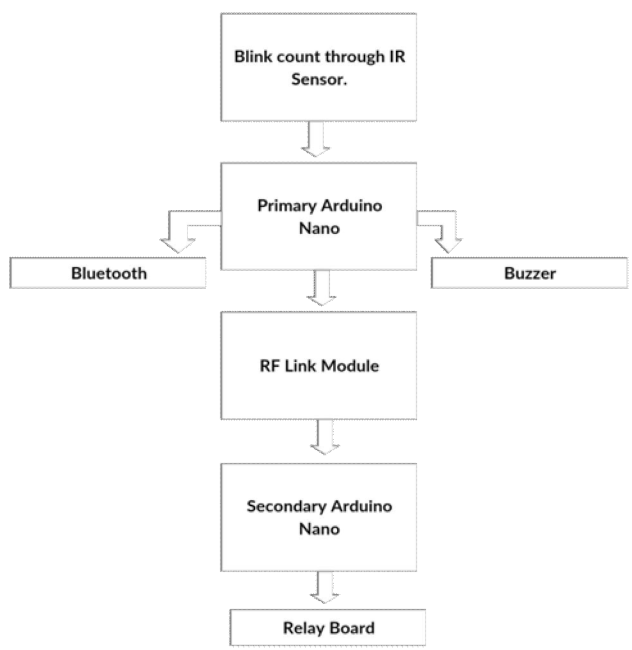

Figure 3.6: Block Diagram of the System

4. ANALYSIS RESULTS

To verify whether our IR sensor is working or not, we check the Serial Monitor output value for Average Flux. As we will detect the intentional blink, we need appropriate light for flux value. IR takes some continuous value of light by counting the lux (intensity of light), then it sets an average value for a scenario described below:

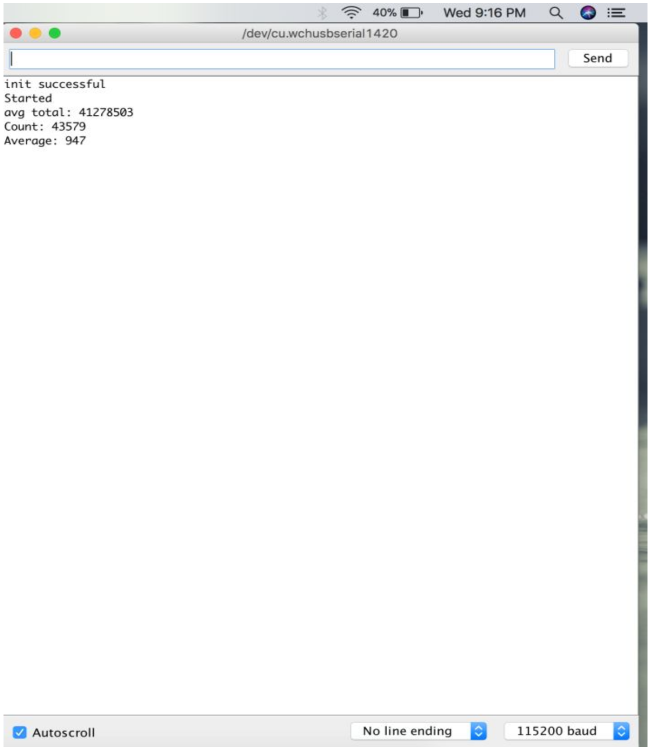

Figure 4.1: Flux Average Value and Trigger Status

Average Value (Flux): 805then, it works as follows:

STATE	CONDITION
Average Value < Flux Received	Eyes Closed
Average Value > Flux Received	Eyes Open

Table 4.1: Flux Average Value and Trigger Condition

This system will take action for 5 seconds after the action taken mode is ON. In this period of time, patients have to give instruction as they want to operate. Patients have to give valid eye blinks.

The microcontroller inputs are classified in Table 4.2, and the corresponding appliances will be switched ON/OFF or will send a message.

Table 4.2: Eye Blink Interactive Appliance

TIMES	BINARY VALUE	APPLIANCES NUMBER	BLINK LENGTH
1x	0001	#1 (Sending Message)	Short
2x	0011	2nd Appliances ON/OFF	Short
3x	0111	3rd Appliances ON/OFF	Short
4x	1111	4th Appliances ON/OFF	Short

4.2 RESULT DISPLAY

It takes around four seconds to get ready to take data, and then the sensor sends data to the Micro Controller. output is perfect as its detects eye blink. It shows the status. Finally, we get confirmation by getting a message of data received.

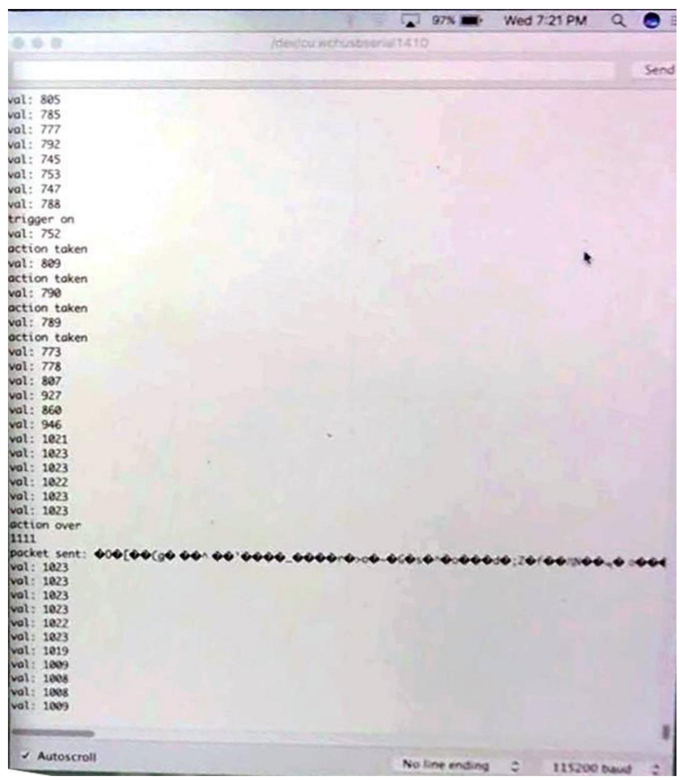

Figure 4.2: Flux Value and Sensor Data

4.3 ANDROID APPLICATION

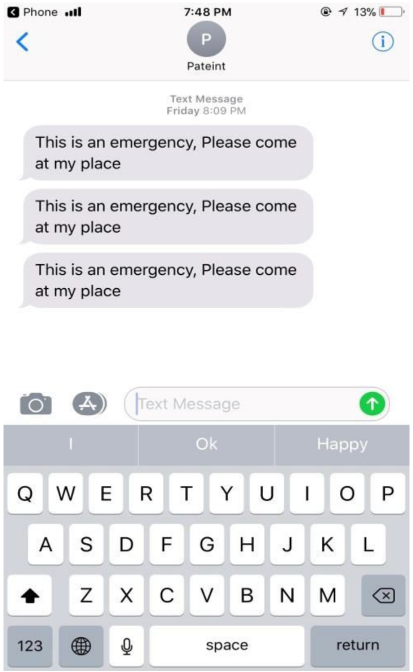

Figure 4.3: SMS Screenshot

If the patient blinks once after the trigger is turned on, the action is transferred to Bluetooth rather than the relay board.The Bluetooth will send SMS to a paired device of the given number. The supervisor will get this text message from that connected device.

Device Range: A device has two parts, primary and secondary. Both are wirelessly connected via RF link. This link will work up to 100 meters without any other foreign signal interference such as mobile, radio frequency etc.

Bluetooth Range: The device is Bluetooth-connected to an Android mobile phone for emergency text messaging service**.**In test trials, this device's Bluetooth module can work within 15-20 meters without any interruption.

4.4 ACCURACY RATE ANALYSIS

Our system is currently providing above 70 percent accuracy on the test trial with minimal foreign signal interface depending on various light environments. We discuss the accuracy of analytical data on three light environments below.

1. Day Light.
2. Room Light.
3. No Light (Dark).

Table 4.4: Test Analysis for Binary Sequence 0001 Day Light

Environment Condition	Sample Data	Success	Fail	Comments
Day Light (Test 01)	Action 1	☑	☒	Among 7 Actions 3 failed and 4 succeeded. Accuracy: $(\frac{4}{7} \times 100)$ = 57.14 %
	Action 2	☒	☑	
	Action 3	☒	☑	
	Action 4	☑	☒	
	Action 5	☑	☒	
	Action 6	☑	☒	
	Action 7	☒	☑	
Day Light (Test 02)	Action 1	☑	☒	Among 7 Actions 2 failed and 5 succeeded. Accuracy: $(\frac{5}{7} \times 100)$ = 71.42 %
	Action 2	☒	☑	
	Action 3	☒	☑	
	Action 4	☑	☒	
	Action 5	☑	☒	
	Action 6	☑	☒	
	Action 7	☑	☒	
Day Light (Test 03)	Action 1	☑	☒	Among 7 Actions 4 failed and 3 succeeded. Accuracy: $(\frac{3}{7} \times 100)$ = 42.85 %
	Action 2	☒	☑	
	Action 3	☒	☑	
	Action 4	☑	☒	
	Action 5	☒	☑	
	Action 6	☑	☒	
	Action 7	☒	☑	
Average Accuracy in Daylight:	$\frac{57.14+71.42+42.85}{3}$ = 57.14% ≈			58%

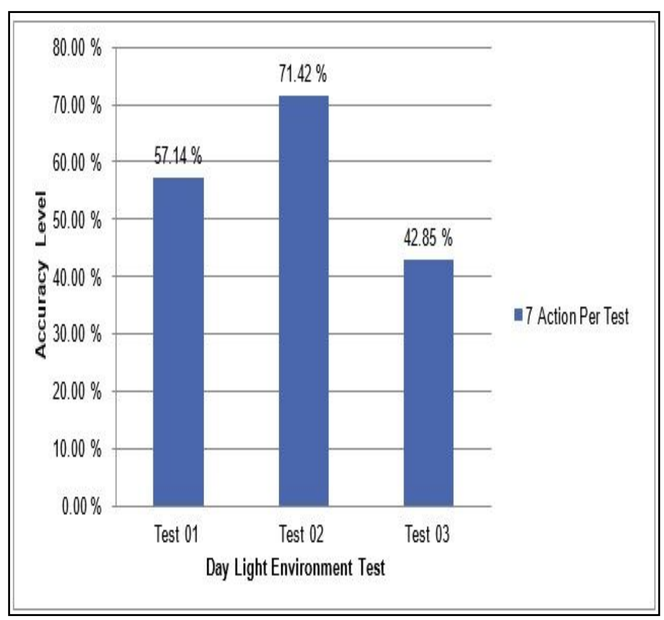

Figure 4.5: Day Light Accuracy Test for Sequence 0001

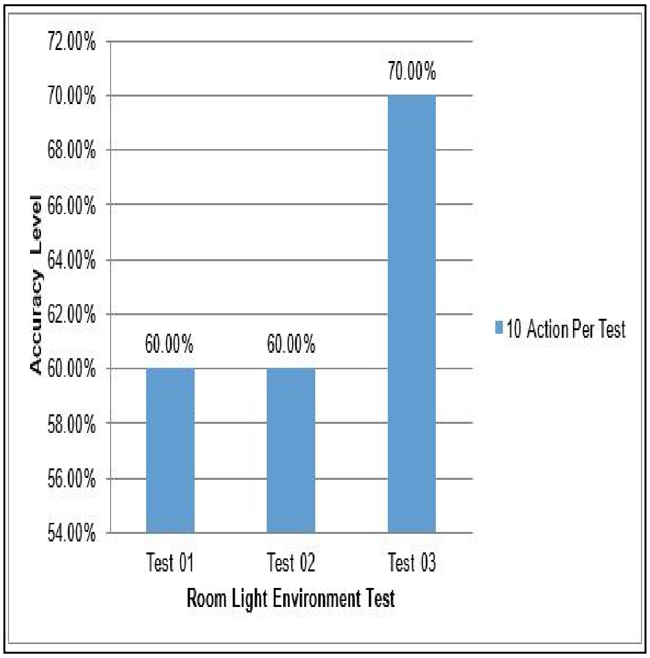

Figure 4.6: Room Light Accuracy Test for Sequence 0001

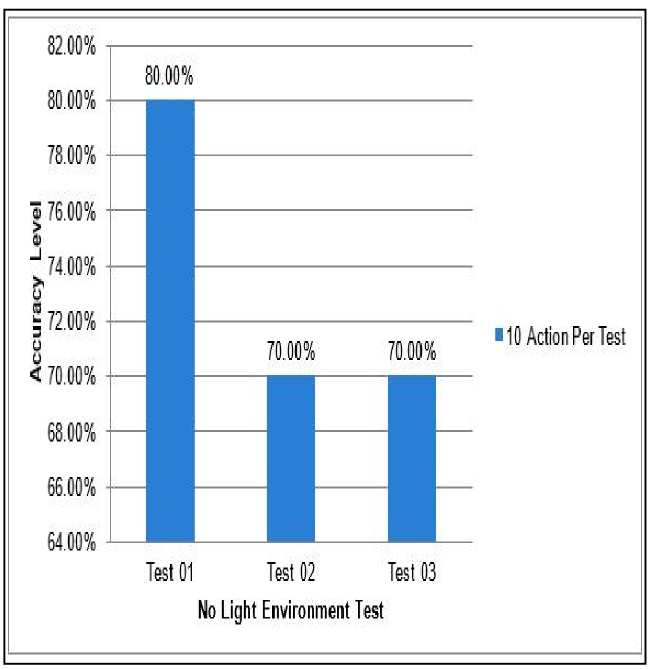

Figure 4.7: NO Light Accuracy test for Sequence 0001

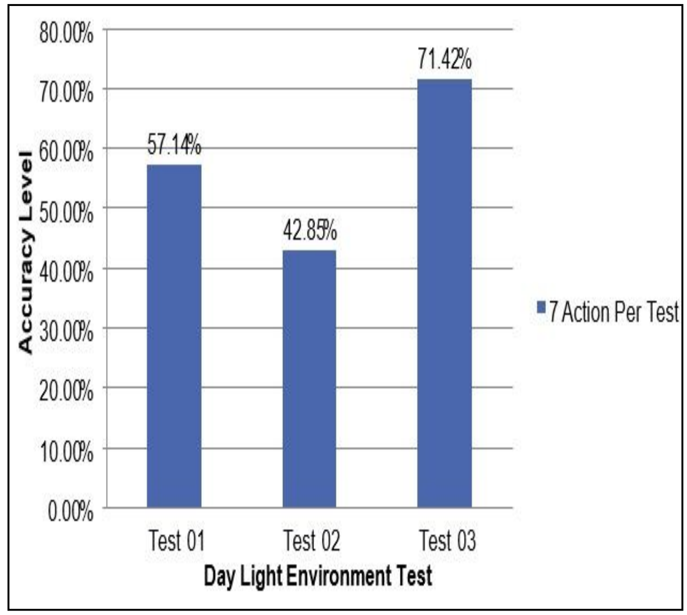

Figure 4.8: Day Light Accuracy test for Sequence 0011

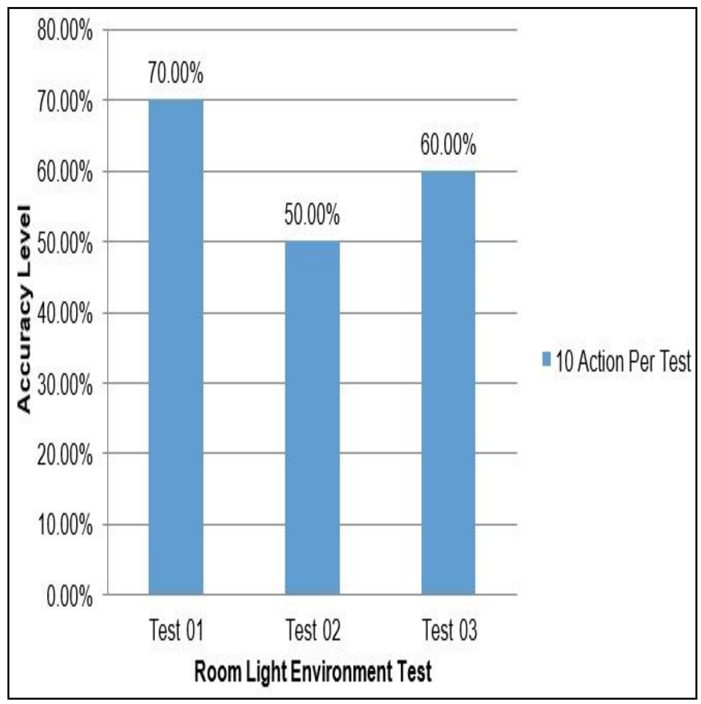

Figure 4.9: Room Light Accuracy Test for Sequence 0011

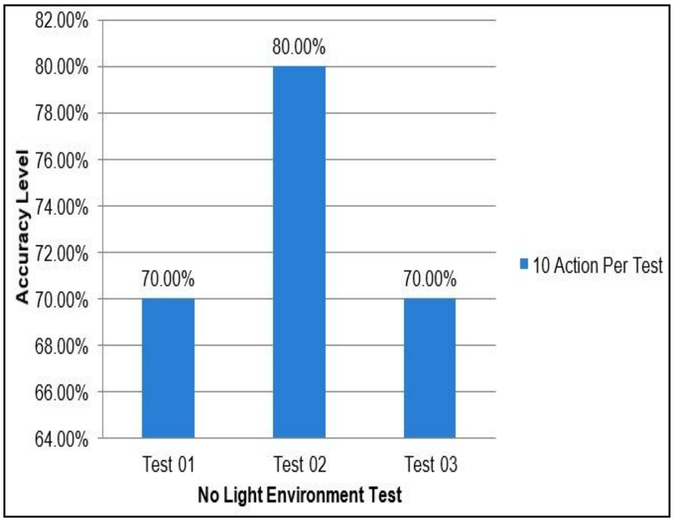

Figure 4.10: No Light Accuracy Test for Sequence 0011

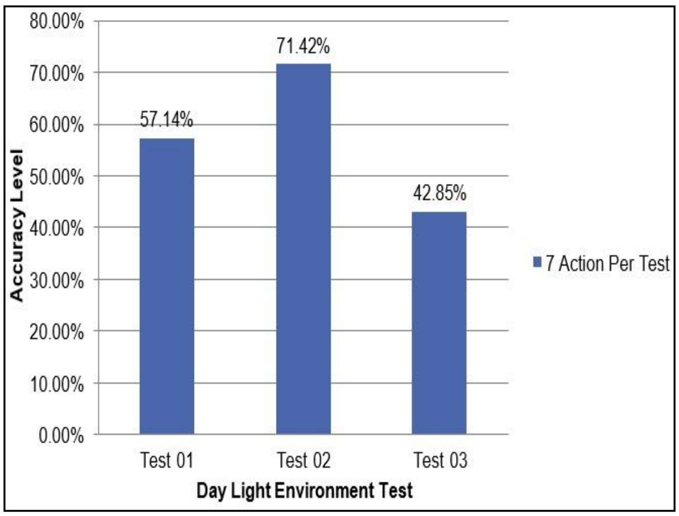

Figure 4.11: Day Light Accuracy test for Sequence 0111

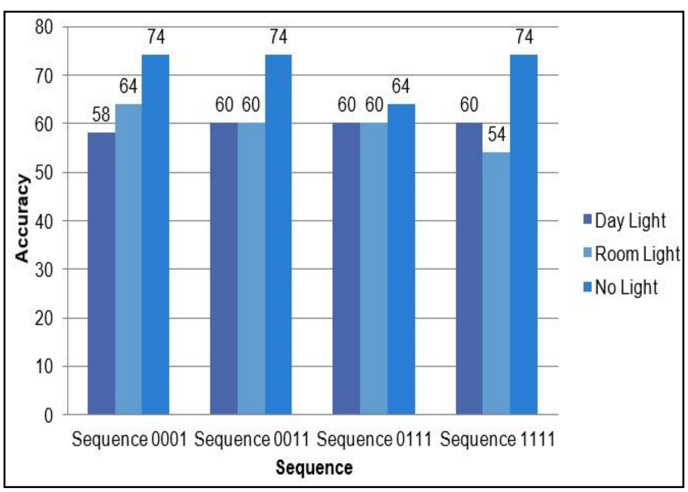

Figure 4.12: Average Accuracy Comparison

According to our test results, our device performs best in no light conditions, with an accuracy of more than 70%, because there is less foreign reflection rather than reflection from the eyes in no light. Secondly, it works better in a room light environment with an accuracy of 64 percent. Finally, it has a 60 percent accuracy in day light situations.

5. CONCLUSION

This project is mostly for paralysis patients who have been through a lot. We're attempting to do a little bit with this venture so that they can, at the very least, monitor the household appliances. We also have additional plans to improve this venture by providing better benefits. An eye blink sensor is a transducer that detects an eye blink and provides a yield voltage at any point the eye is closed, enabling the patient to monitor the home equipment and others, such as turning on and off lights, monitoring fan speed, and calling for help. To summarize, working with the Arduino Nano and various sensors was a fantastic experience in which we learned a lot of useful information. Our initiative will primarily benefit paralysis patients and the elderly. Though we are thinking about the project's prototype, our concept has been implemented and tested, but it still needs a lot of changes and equipment to be implemented in real life. One of the key goals of our project was to assist patients in making their lives simpler, and our system will be completed when we can put it to use in the real world and support people. The aim of this project is to develop a flicker detector that can be used in a real-time flicker detection system. The consumer would find it difficult to blink more often if the light has a low flicker rate and several brightness levels. When the head is directly directed towards the infrared sensor, the algorithm works best. When the eyes move rapidly up and down, however, this method has difficulty detecting flicker. The natural flow, rather than the visual flow, is used to estimate the movements of the eyelids. It's the optical flux part that's perpendicular to the image gradient. A different distance shows whether the eye is closed or open. When an individual looks down, the issue of bow elimination occurs. Below are some of the major obstacles we must tackle in order to achieve hardware reliability and compatibility.

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