

Home Automation Using Eye Blink Detection For Paralyzed People

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Abstract

Paralysis is a debilitating ailment that significantly restricts a person's independence and quality of life. This article outlines a research effort that attempted to build a blink sensor device for accessible home automation systems, with a special emphasis on paralysis patients. The device features advanced blink detection capabilities, allowing it to differentiate between natural and intentional blinks. This distinction enables tetraplegic patients, who are paralysed in both their upper and lower limbs, to manage home equipment more independently. Furthermore, the device features an email service module that easily integrates with home automation systems, allowing caretakers to receive real-time notifications and updates without having to remove the device from the patient's body. It also incorporates voice command control and utilizes the Sinric Pro application, further enhancing its usability for paralysis patients. The project aims to address the challenges that paralysis sufferers face and to provide solutions.

Keywords - Paralysis, blink sensor, email service, voice command control.

I. INTRODUCTION

Home automation technology has made significant advancements in recent years, aiming to enhance the comfort, convenience, and accessibility of our living spaces. However, for individuals with paralysis, the benefits of home automation have often been limited due to their physical limitations. This project addresses this issue by introducing a novel approach to home automation using eye blink detection specifically designed for paralyzed individuals, with a special focus on tetraplegic patients, aiming to enhance their independence and quality of life. By harnessing the power of eye movements, particularly eye blinks, this technology provides an intuitive and accessible means for paralyzed individuals to control various household appliances and devices.

This project focuses on developing a home automation system specifically designed for paralyzed patients, utilizing eye blink detection as a means of control. Previous research [1] has explored the potential of eye movements as communication tools for paralyzed individuals. The eye, being a modifiable component of their body, offers a powerful means of connecting with the world. Controlling home appliances plays a crucial role in enhancing the independence of paralyzed individuals.

To address the limitations of existing systems, a novel solution proposed in Paper [2] utilizes an eye blink sensor for appliance control. The sensor detects eye blinks and generates an output voltage, which is processed in real time using signal processing techniques. A micro controller analyses the input data and determines how to control the appliances accordingly. In addition to eye blink detection, our project also incorporates other functionalities. For instance, it includes a real-time mailbox alert system via SMS or email [2][4], ensuring that caretakers are promptly notified when a emergency new mail arrives.

Furthermore, our project integrates voice control through Google Assistant, allowing users to control the appliances using voice commands. Additionally, the Sinric Pro application is employed to provide control over home appliances through a user-friendly interface.

By combining these features, including eye blink detection, mailbox alerts, voice control, and application-based control, the project aims to create a comprehensive and accessible home automation system for paralyzed individuals. The system enhances their independence, convenience, and overall quality of life by providing intuitive control over household appliances and facilitating communication with caregivers.

The paper is structured as follows: Section II provides an in-depth overview of related work, Section III describes the proposed model, Section IV presents the experimental results, Section V provides information on Challenges and Limitations followed by Future work and Conclusion in Section VI and VII of the paper.

II. BACKGROUND AND RELATED WORK

Recent years have seen a surge in interest in clever and efficient home automation systems that improve comfort, convenience, and accessibility in residential settings. These technologies are particularly beneficial for individuals with disabilities, especially those with mobility issues or physical limitations. Home automation systems offer practical and useful solutions for controlling electrical appliances and equipment autonomously. One such system, described in the work “Multiple Method Switching System for Electrical Appliances using Programmable Logic Controller,” provides manual, pre-programmed, and remote-control methods to meet the growing demand for flexible and secure access to devices [1].

In the article “Real-time mailbox alert system via SMS or e-mail,” the authors propose a solution to the problem of users not being notified of new mail arrivals. By utilizing programmable logic controllers, interface modules, and GSM modems, the system generates SMS or email notifications when a new letter arrives, enhancing user convenience and efficiency [2].

To address driver fatigue, the paper “Drowsy driver detection system using eye blink patterns” presents a real-time system that analyses eye blink patterns as an indicator of drowsiness. By monitoring changes in blink duration and eye position, the system aims to improve driver safety and prevent potential accidents [5].

Another innovative system, described in “Design of a Novel Efficient Human–Computer Interface: An Electrooculogram Based Virtual Keyboard,” utilizes electrooculogram (EOG) signals to design a virtual keyboard. This EOG-based human-computer interface allows individuals with limited speech or hand movement to communicate effectively using only eye movements [7].

In the realm of remote health monitoring, the article “Remote Health Monitoring using Wireless Body Area Network” discusses the use of a wireless body area network (WBAN) for continuous health monitoring. WBAN involves attaching biomedical sensors to the body to collect data, which is then transmitted wirelessly to a mobile phone. This enables real-time remote monitoring by doctors, highlighting the convenience and efficiency of this technology for remote medical monitoring [4].

Furthermore, the paper “Eye Controlled Home-Automation for Disabled” focuses on developing an eye-controlled home automation system for people with disabilities. By utilizing eye movements, this system enables individuals to perform daily tasks through the activation of home devices using flashes and a simple signal processing circuit [3].

Lastly, the research presented in the article “Design and prototype implementation of SMS based home automation system” focuses on a cost-effective and versatile home automation system that utilizes SMS technology. The system includes a GSM modem for user communication and a microcontroller to connect the GSM network with system sensors and actuators. It supports user authentication and configuration of system settings, prioritizing security and ease of use [6].

III. PROPOSED METHOD

Our framework, as shown in Fig.3, is mostly made up of two parts. The first portion depicts a glass frame that allows an IR sensor and a photodiode to capture information from eye blinks. The IR sensor works in conjunction with a photodiode, which plays a vital role in converting light energy into electrical energy. The photodiode, situated within the wearable device, accurately measures the ambient light levels surrounding the user’s eyes and converts light energy into electrical energy. This information is then transmitted through an RF transmitter, allowing for wireless communication of the electrical signals containing the captured data. The primary purpose of the first section is to distinguish between intentional and unintended flickering. On the receiving end, an RF receiver receives the transmitted data from the RF transmitter. The receiver module serves as the interface between the wearable device and the rest of the system, facilitating the seamless transfer of data. The framework’s second segment can be divided into two parts: receiver and processing. Once the data is received, it is processed by an ESP-32 microcontroller, which serves as the brain of the system. The ESP-32 microcontroller analyses the received signals, specifically the number and duration of blinks, to determine the user’s intent. Based on predefined patterns or user-defined settings, the microcontroller triggers the appliances connected to the relay board accordingly. This is shown in Fig.1 and Fig.2. A Relay board is linked to the ESP-32 to display the system output. For instance, a specific number of intentional blinks within a set timeframe may trigger the microcontroller to turn on or off the respective appliances, providing control over various household devices.

The interaction process with the system involves a defined sequence of steps. Initially, the user is required to close their eyes for a period of 3 seconds, which serves as an entry point into the system’s loop. This duration allows the algorithm to differentiate between intentional blinks and false signals, ensuring accurate detection. After the initial 3-second period, the user can proceed to blink their eyes. The system monitors and records the number of blinks performed by the user. This information is then processed by the ESP-32 microcontroller, which serves as the decision-making unit. Based on the recorded number of blinks, the microcontroller triggers the relay connected to the desired appliance. For example, if the user blinks once, the microcontroller is programmed to turn on/off a specific appliance. This mechanism provides control over the home appliances, allowing users to operate them through their eye blinks.

To exit the loop and finalize the command, the user is required to close their eyes once again for a duration of 3 seconds. This closing of the eyes acts as a signal for the system to conclude the interaction and execute the command. The procedure for turning on and off the home appliances remains the same. The user follows the prescribed steps of closing their eyes for 3 seconds, blinking the desired number of times, and closing their eyes for 3 seconds again to confirm the command. The system, in response to the user's blinking patterns, triggers the relay to either turn on or turn off the respective appliance, providing seamless control over the home automation process.

Our project includes the use of Google Home and Assistant as shown in Fig.6 to enable voice-activated control over home automation Patients can effortlessly provide voice commands to turn lights on and off using this In addition, we have included Sinric Pro, an application that allows customers to operate household appliances with their mobile devices which is shown in Fig.4 This feature allows you to manage and alter household appliances from any room in the house in a seamless and effective manner. In the event of an emergency, our system is designed to promptly notify the designated caregiver by sending an immediate email notification. This proactive feature ensures that the caregiver remains informed and can swiftly respond to any critical situation concerning the patient's well-being as shown in Fig.5. Our project intends to empower individuals to simply interact with their home automation systems by harnessing the power of voice commands and mobile control, boosting accessibility and promoting a more connected and intelligent living area.



Fig. 1: An insight of the prototype



Fig. 2: Lights turned on in accordance with user's eyeblinks

IV. EXPERIMENTAL RESULTS

Based on our comprehensive experiments and evaluations, we conclude that our suggested paradigm improves the user experiences significantly. We have evaluated the precision of the proof-of-concept model in three distinct lighting scenarios by conducting 10 tests for each environment. We discovered that the model has an accuracy of 84% when tested in room light, 73% when tested in day light, and 86% when no light is present as shown in Fig.7.

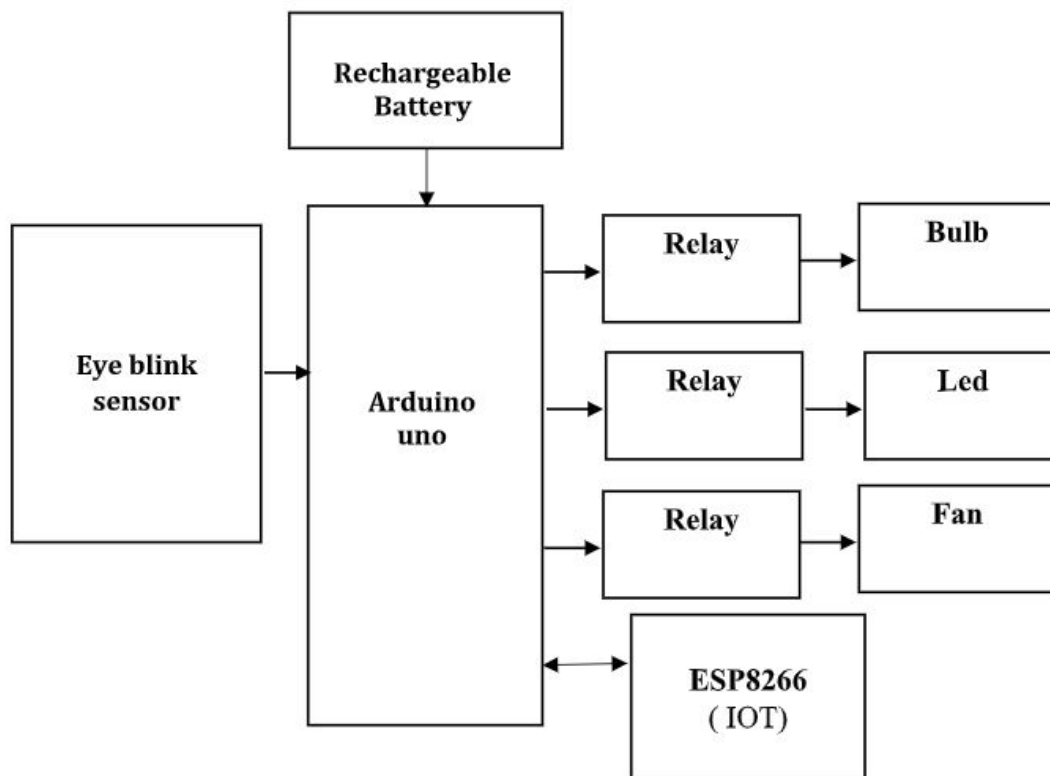


Fig. 3: Block diagram of the proposed system



Fig. 4: Sinric pro application interface to control home appliances.

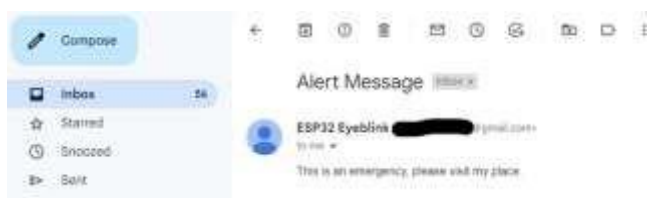


Fig. 5: Email notifications to the caretaker of the patient

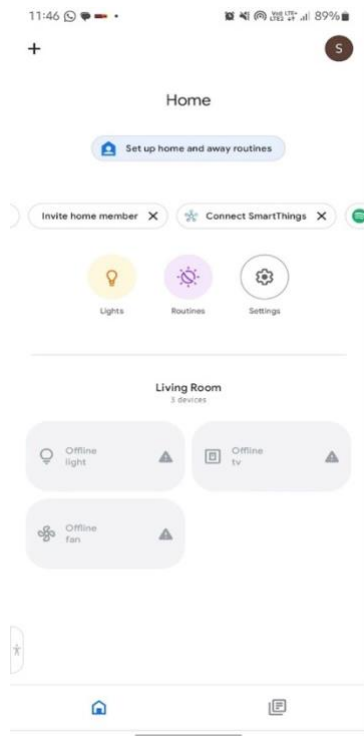


Fig. 6: Google home application page.

$$\text{Accuracy} = \frac{\text{No. of tests passed}}{\text{Total number of tests conducted}} \times 100$$

These tests were performed to evaluate the reliability and performance of our project in various lighting environments. Our proposed paradigm has the potential to significantly benefit paralysis patients, the elderly, and the general public. An advantage of this system is that the user can operate all the appliances using the same procedure, providing a consistent and straightforward method of control. Regardless of the specific appliance, the user follows the prescribed steps of closing their eyes for 3 seconds, blinking the desired number of times, and closing their eyes for 3 seconds again to confirm the command. This uniformity simplifies the user experience and reduces the need for learning different procedures for controlling different appliances. While the current prototype is limited to controlling lights and fans, the potential applications of this technology extend beyond these specific devices. In real-life scenarios, the system can be adapted to control a wide range of appliances, including televisions, speakers, or any other electronic devices.

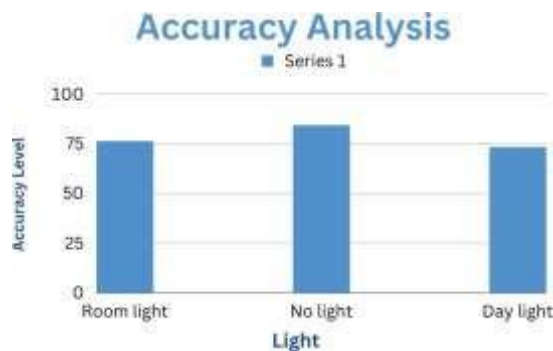


Fig. 7: Accuracy analysis under different lighting environment.

V. CHALLENGES AND LIMITATIONS

Our goal is to develop a device for usage in real-time blink detection systems. Low flash speed and varying light brightness generate problems for the user, who flashes more frequently. When the head is oriented directly at the IR sensor, the algorithm is mostly

successful. However, this method has limitations because eye blink detection goes swiftly up and down. Instead of usual flow optical input, eyelid motions are evaluated. It is the optical flow component that is perpendicular to the image gradient. Different distances indicate whether the eye is closed or open. Simultaneously, the challenge of removing the bow emerges as the person looks down. Some of the most significant problems regarding hardware performance and compatibility are described here.

- 1) Signal disturbances: This project's two modules (the wearable device and the microcontroller) communicate wirelessly via RF-LINK. Although the RF-LINK frequency is roughly 485 MHz, it has a wide channel and so matches the surrounding frequencies. Radio, mobile devices, and electric devices use foreign frequencies. In that case, the signal going between our transmitter and receiver becomes distorted. As a result, the cause of signal loss and accuracy mistake.
- 2) Difficult to wear: Rather of focusing on device compatibility, we created a prototype using our concept. Further- more, because this project is still in its early stages, we needed to be cost-effective. So, in our prototype, there are a lot of odd wires that make it difficult to wear. Because batteries are used as a power source, the overall weight of the glass has increased. As a result, the device is first unfriendly and uncomfortable to use.
- 3) Only one appliance can be turned on/off at a time: The current model allows users to control home appliances by blinking their eyes. However, due to technical limitations, the system can only handle one appliance at a time. This means that users need to focus on a specific appliance they want to control, and their blinking action will only affect that particular appliance. While this limitation may not be an issue for some users who have a limited number of appliances to control, it can be restrictive for those who desire simultaneous control over multiple devices.
- 4) A rechargeable battery is used which needs to be replaced every time because of its shorter lifespan - The current implementation is a protype to demonstrate our idea relies on a rechargeable battery to power the device that facilitates eyeblink control. The battery has a relatively shorter lifespan before it needs to be replaced. This presents an inconvenience for users as they must frequently replace the battery, which can be costly and time-consuming.
- 5) The home automation process through eye blinks can be controlled by the user only while wearing the glasses: Currently, the system requires users to wear specialized glasses or eyewear in order to control their home appliances through eye blinks. While this provides a tangible and convenient interface for interaction, it also means that users need to wear the glasses consistently to have control over their surroundings. This dependency on wearing glasses can be limiting, especially if users prefer not to wear them all the time or if the glasses become damaged or misplaced.

VI. FUTURE WORK

- 1) Future iterations of the system could aim to incorporate advanced algorithms and hardware configurations that enable simultaneous control of multiple appliances. This could involve developing more sophisticated eye- tracking techniques or integrating additional sensors to accurately interpret user intentions for multiple devices.
- 2) Researchers and developers could explore alternative methods for capturing eye movements without the need for specialized glasses. For example, advancements in computer vision technology or wearable sensors could enable eye-tracking capabilities without the need for dedicated eyewear. By removing the dependency on glasses, the system could provide more flexibility and convenience to users, allowing them to control home appliances through eye blinks in a variety of situations and environments.
- 3) One potential improvement for future work is the ability to control the speed of fans and AC using eye blinks. Currently, the system enables users to turn the fan on or off based on their blinking patterns. However, incorporating the functionality to adjust the fan speed would provide users with finer control over their comfort levels. By correlating specific blink patterns or durations with different speed settings, users could intuitively regulate the fan's airflow to suit their preferences. This enhancement would require additional research and development to establish a mapping between blink patterns and corresponding fan speeds, as well as implementing the necessary algorithms and adjustments within the microcontroller.

VII. CONCLUSION

In conclusion, our project has focused on addressing the challenges faced by paralysis patients, aiming to provide them with greater independence in managing their daily lives, particularly in controlling home electronics. The implementation of an eye-blink control system holds significant potential in improving the quality of life for these individuals. By detecting eye blinks and generating corresponding signals, the system enables patients to control various household devices, such as lights and fans, with ease.

The primary advantage of this technology lies in its ability to empower paralysis patients to independently operate their environment. With limited mobility, the ability to control lights and fan speeds through eye blinks can have a profound impact on their daily routines, offering a newfound level of autonomy. Additionally, the scalability of this technology allows for its integration

with other appliances, including televisions, air conditioners, and more, further enhancing its usefulness and relevance for paralysis patients.

One significant implication of this innovation is the potential to reduce the reliance on caretakers for completing these tasks. By enabling patients to manage their own devices, the system frees up valuable time for caretakers to focus on other essential care activities, ultimately improving overall caregiving efficiency.

The success of this idea in the real world will depend on its widespread adoption and utilization in enhancing the lives of paralysis patients. Further research, development, and refinement of the technology will be necessary to optimize its functionality and ensure its seamless integration into the daily lives of the target user group.

Ultimately, our project strives to contribute to the well-being and independence of paralysis patients by providing them with a practical and accessible means of controlling their environment. Through ongoing advancements and the support of the healthcare community, we hope to see this technology make a positive difference in the lives of those who need it most.

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