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BlinkSync Wheelchair: Navigating Independence through Eyeball Movement Control

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ABSTRACT: The BlinkSync Wheelchair features an innovative eyeball-movement control system, empowering quadriplegic individuals by addressing the limitations of traditional speech and gesture-controlled wheelchairs. Its adaptive threshold modification ensures reliable eye tracking even in dim lighting, while eye detection and image processing facilitate intelligent guidance. Despite high accuracy, the system faces challenges in comfort and economic viability, and infrared light poses potential risks. Integrated with Raspberry Pi and ultrasound sensors for smooth control and obstacle detection, the wheelchair promotes user independence. Utilizing convolutional neural networks and an extensive eye-tracking dataset, this deep learning-based system exemplifies AI's potential in enhancing healthcare and quality of life.

KEYWORDS: BlinkSync Wheelchair, Eyeball-movement control, Quadraplegic, Assistive Technology, Eye tracking, Intelligent guidance, Convolutional Neural Networks, Ultrasound safety, Adaptive Threshold Modification.

I. INTRODUCTION

A. Description:

With its ground-breaking eyeball-movement control system, the BlinkSync Wheelchair allows people who are quadriplegic to regain their freedom. It is a groundbreaking advancement in assistive technology. In a world where speech and gesture-controlled wheelchairs, which show restrictions for individuals unable to use their hands, or wheelchairs functioning in noisy situations may provide limitations for those with significant motor impairments. Because of this method's adaptive threshold modification, eye tracking is possible even under dim or unstable lighting. While eye-tracking recognition technology has a high accuracy rate, in terms of comfort and economic viability, it is significantly less than the camera recognition option. Additionally, the infrared light it produces can cause irreversible damage to human eyes. With the use of eye detection and image processing, this system tracks users' eye blinks and provides them with intelligent wheelchair guidance. Smooth control is ensured by the Raspberry Pi's connection with motor drivers, and the use of ultrasound improves safety by identifying obstructions from numerous angles. The goal of the BlinkSync Wheelchair is to improve users' quality of life overall by encouraging a sense of empowerment and independence that goes beyond the physical act of movement. In summary, convolutional neural networks and attention processes are used in the eye-tracking identification scheme of this human eye-gaze model to create an intelligent eye-tracking wheelchair with minimal financial and operational constraints. In order to enhance the model's accuracy and generalizability, a multidimensional, wide-ranging eye-tracking dataset is constructed. In order to have exact control over the wheelchair, a structure that moves the wheelchair by adjusting the rocker using a tiller has been designed. The deep learning-based intelligent eye-tracking wheelchair created in this research is an illustration of how artificial intelligence is being applied in the healthcare, senior care, and other domains. It can be used as a model for the application of new technologies to enhance the quality of human life.

B. Problem Statement

Create and build an ocular movement control system wheelchair movement to give people with severe mobility disabilities a dependable and natural way to move about. Using eye movements as input, the system should enable users to operate the wheelchair securely and effectively, providing precise control and adaptability to a range of real-world circumstances.

C. Objectives

- To provide functional wheelchair movement using eyeball control system prototype.
- To record user documentation and guidelines for setup and customization.
- To ensure demonstration of the system's effectiveness in various real-world scenarios.

D. Significance of study

The BlinkSync Wheelchair stands as a groundbreaking advancement in assistive technology, particularly benefiting quadriplegic individuals, offering newfound freedom and independence. Its innovative eyeball-movement control system, coupled with adaptive threshold modification for eye tracking, addresses critical limitations in existing systems, ensuring usability even in challenging lighting conditions. This study emphasizes safety and precision through the integration of ultrasound sensors and Raspberry Pi for obstacle detection and motor control, respectively. Furthermore, the utilization of convolutional neural networks and attention mechanisms showcases the application of advanced AI techniques, contributing to the broader field of healthcare and senior care. By focusing on economic efficiency and operational viability, this study aims to broaden accessibility to assistive technology solutions. The creation of a comprehensive eye-tracking dataset enhances the model's accuracy and generalizability, catering to diverse user needs. The innovative rocker and tiller mechanism for wheelchair control exemplify user-centric design and pave the way for future mobility solutions. Overall, the BlinkSync Wheelchair serves as a pioneering model for the integration of new technologies to enhance the quality of life for individuals with significant motor impairments.

II. LITERATURE REVIEW

"Eye-controlled wheelchair" by M. Abreu and A. Lobato:

This paper presents a system for controlling a wheelchair using eye movements. The authors discuss the design and implementation of the system, including the use of eye-tracking technology and the development of a user-friendly interface.

"Development of a novel eye-controlled wheelchair system" by J. Zhang et al.:

This study introduces a novel approach to eye-controlled wheelchair navigation. The researchers propose a hybrid control system that combines eye gaze tracking with head movement detection for improved accuracy and reliability.

"Evaluation of a gaze-controlled wheelchair system for individuals with severe disabilities" by S. Kim et al.:

This research evaluates the usability and effectiveness of a gaze-controlled wheelchair system in real-world settings. The study assesses user satisfaction, task performance, and user experience to identify strengths and limitations of the technology.

"Design and evaluation of an eye-controlled wheelchair" by P. Svensson et al.:

This paper describes the design process and user testing of an eye-controlled wheelchair prototype. The authors discuss technical challenges, such as calibration and accuracy, as well as user feedback and suggestions for improvement.

"Eye-controlled wheelchair with multimodal interface" by H. Wang et al.:

This study proposes a multimodal interface for controlling a wheelchair using both eye movements and speech commands. The researchers explore the integration of different input modalities to enhance usability and accessibility for individuals with disabilities.

"Real-time eye gaze tracking for human-computer interaction" by K. Santini et al.:

While not specifically focused on wheelchairs, this paper discusses real-time eye gaze tracking technology and its applications in human-computer interaction. Understanding the underlying technology can provide insights into the challenges and opportunities of implementing eye-controlled interfaces for wheelchairs.

"Evaluation of eye-controlled computer pointing devices for users with severe disabilities" by A. Hyrskykari et al.:

Although this paper focuses on computer pointing devices, it discusses relevant aspects of eye-tracking technology and user interaction that are applicable to wheelchair control systems. The study evaluates different eye-controlled pointing devices and their usability for individuals with severe disabilities.

"A survey on eye tracking technologies' applications, methodologies, and systems" by P. Bakshi et al.:

This survey paper provides a comprehensive overview of eye-tracking technologies, including various applications, methodologies, and systems. It covers topics such as hardware sensors, data processing techniques, and applications in fields like healthcare, psychology, and human-computer interaction, offering valuable insights for researchers working on eye-controlled wheelchairs.

"Wheelchair control interface using eye movements for disabled people" by J. Kim et al.:

This paper presents a wheelchair control interface based on eye movements specifically designed for people with disabilities. The authors discuss the development process, including hardware and software components, as well as user testing to evaluate the system's performance and usability in real-world scenarios.

III. METHODOLOGY

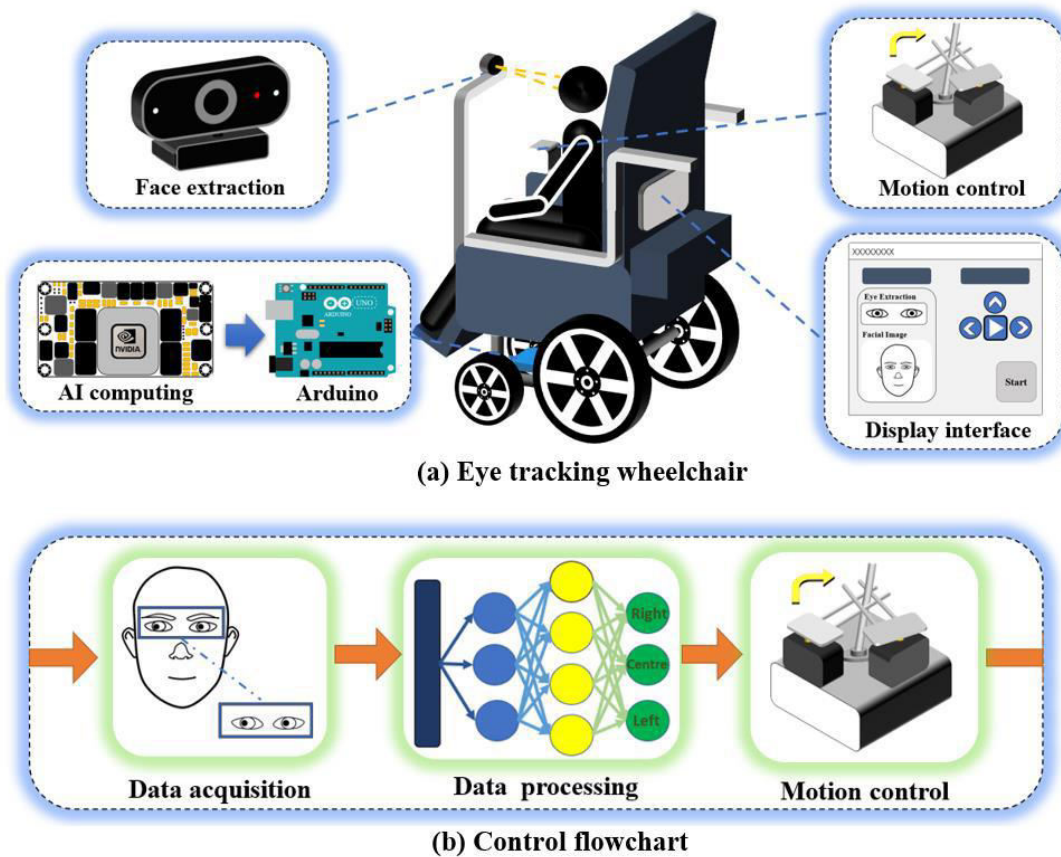


Fig 1. System Architecture

The eye-tracking wheelchair system consists of eye-tracking data acquisition, data preprocessing, eye-tracking direction estimation, and wheelchair motion control. The camera in front of the wheelchair transmits the face images collected in real time to the embedded AI computing module. The latter inputs the processed image into the neural network model to obtain the estimated direction of eye-tracking and transmits the signal to the Arduino then, the Arduino controls the 2D servo to adjust the wheelchair rocker and change the motion state of the wheelchair. The user's eye state and the estimated direction of eye-tracking are updated in real time on the display.

IV. RESULTS

The following section provide the result snapshots of proposed system Fig 2 illustrate the integration of IoT technology with Wheelchair prototype. Fig 3 presents the front page of a website designed to display real-time data fetched from the Eye ball movement. The user-friendly interface prominently features data visualization related to Eye Tracking. Fig 4 illustrates a website interface showcasing the eye tracking and direction of movement of the wheel chair.



Fig 2: IOT-enabled Wheelchair navigating through eyeball movement

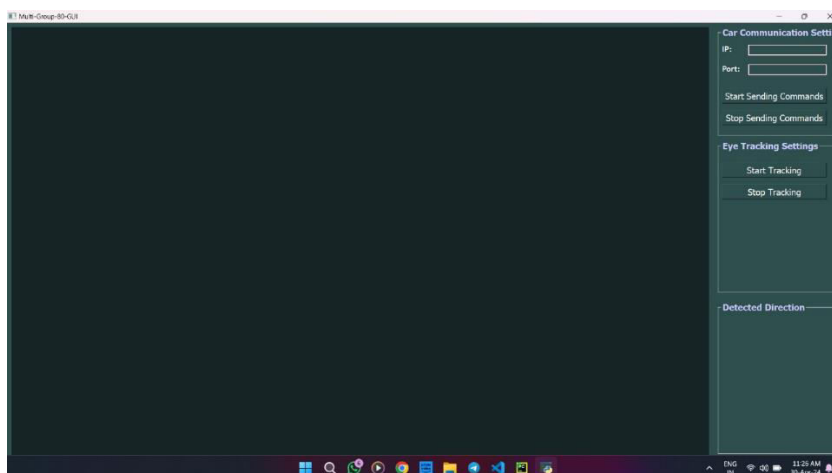


Fig 3: A Screenshot of aEye Tracking Application interface

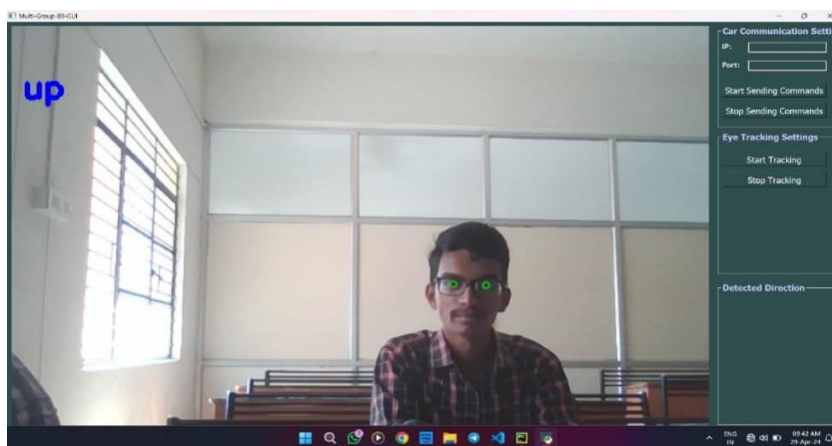


Fig 4: Eye Tracking interface Data Display

V. CONCLUSION

In our study, we developed a GazeNet neural network model using an eye-movement dataset of 135,000 annotated images from virtual and real scenes. The model outperformed existing models with faster convergence and higher accuracy in eye-tracking tasks. For wheelchair control, we used a 2D steering gear to optimize joystick control signals, achieving smooth and gentle steering based on Arduino output experiments. The model accurately classified eye-movement categories without erratic outputs. Our reliability analysis revealed high accuracy in motion control and eye-tracking, yet highlighted complexities in current motion control methods. Simplifying controls with direct Jeston Tx2 output could enhance reliability. Our eye-movement dataset, while comprehensive, lacked real-life scenarios like crossing roads and rainy conditions. User feedback indicated that continuous eye-movement control burdens users, reducing accuracy and posing risks. To address these issues, future work will incorporate visual SLAM and path planning for autonomous navigation. Additionally, we plan to integrate a positioning system for remote user monitoring via mobile apps. The study demonstrated the effectiveness of the GazeNet model for eye-tracking tasks and optimized wheelchair control using a 2D steering gear. This identified areas for improvement in simplifying motion control and expanding the eye-movement dataset to encompass real-life scenarios. Future work will focus on enhancing adaptability through visual SLAM and path planning, aiming to create a safer and more user-friendly autonomous wheelchair system with integrated remote monitoring capabilities.

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