From Blink to Speak: Navigating Post-Stroke Communication Challenges with Computer Vision - A Case Study

Khondokar Riaz Mahmud
Deptartment of Computer Science and Engineering
United International University, Dhaka, Bangladesh
kmahmud2310008@mscse.uiu.ac.bd

Dr. Khondaker Abdullah Al Mamun, Ph.D.
Department of Computer Science and Engineering
United International University, Dhaka, Bangladesh
mamun@cse.uiu.ac.bd

***Abstract*—In this paper, we delve into a compelling case study that navigates the intricacies of developing an alternative communication method tailored for physically disabled individuals, with a poignant focus on a bedridden patient grappling with the aftermath of a brain stroke. The exclusive reliance on voluntary eye blinks for communication becomes the canvas upon which we paint a transformative narrative. Proposing an avant-garde solution, our approach harnesses the power of computer vision, intricately analyzing facial landmarks to interpret the subtle language of voluntary right eye blinks. This innovative leap aims to transcend the conventional barriers faced by those with severe physical limitations, presenting a promising avenue to amplify the quality of life for this underserved population. As we unfold this narrative, the abstract encapsulates the essence of our exploration—a journey from silent struggles to a potential revolution in communication for those who have long been confined by the constraints of physical disability.**

***Index Terms*—Communication, physically disabled, computer vision, facial landmarks, eye blink, alternative communication, brain stroke.**

I. Introduction

Physically disabled individuals, especially those who are bedridden due to conditions like brain strokes, face significant communication challenges. This case study explores an innovative computer vision-based solution designed to improve communication for such individuals. We focus on a bedridden patient who can only communicate through voluntary eye blinks, emphasizing the potential for this technology to enhance their quality of life.

In the realm of healthcare and assistive technology, addressing the unique communication challenges faced by physically disabled individuals, particularly those bedridden due to conditions like brain strokes, remains a critical frontier. This paper delves into a groundbreaking case study, exploring the development, testing, and implications of an alternative communication method tailored for individuals with severe physical limitations. The focus centers on a bedridden patient who, in the aftermath of a debilitating brain stroke, found solace in voluntary eye blinks as their sole means of communication. Recognizing the profound impact of limited communication on the quality of life for such individuals, we present an innovative computer vision-based solution. This system harnesses the intricacies of facial landmarks and strategically leverages the patient's voluntary right eye blinks as a gateway to communication. The unfolding narrative within this case study navigates through the intricacies of patient selection, shedding light on the challenges faced by those grappling with severe physical limitations post-brain stroke. The meticulous development of a computer vision-based system takes center stage in our methodology, where facial landmarks become the canvas upon which communication is painted through the subtle art of voluntary eye blinks. The proof of concept phase becomes a testament to the viability of our solution. As the patient is adeptly trained to utilize the system, a myriad of communication options unfolds on a screen, each option seamlessly accessible through the patient's right eye blinks. The results not only showcase the effectiveness of the system but also underline its potential to revolutionize the communication landscape for bedridden patients facing similar challenges. As we delve into the discussion, the transformative power of the computer vision-based solution is elucidated. The ability of the system to transcend physical limitations, providing an accessible and intuitive medium for expression, marks a paradigm shift in the lives of physically disabled individuals. The conclusion draws together the threads of this case study, reinforcing the notion that computer vision has the capacity to redefine the quality of life for those who have long been confined by the constraints of limited communication. Looking forward, the paper suggests avenues for future research, urging a refinement of the system and its expansion to cater to a broader spectrum of physical disabilities. Additionally, the integration of this technology with other assistive technologies and its adaptability to diverse communication needs are proposed as fertile grounds for exploration. In crafting this narrative, we endeavor to present not just a case study but a narrative of hope and progress, illustrating the profound impact that cutting-edge technology can have on the lives of those who need it most.

II. Related works

Numerous studies on alternative mode of communication have been carried out throughout the years.

[2]This research paper aims to design a robust decoding algorithm for recognizing movement-related states from tongue movement ear pressure signals and deep brain local field potentials. The project has successfully developed a robust decoding technique for identifying tongue movement commands and an efficient translation algorithm for decoding deep brain local field potentials (LFPs), potentially aiding in understanding neural circuit mechanisms related to motor control.

Stroke causes aphasia, impacting communication. Speech-language therapy is complex, and Augmentative and Alternative Communication (ACC) devices are limited. [6] This study developed an ACCstive Touchpad to overcome technology barriers for aphasia treatment.

[7]In this paper a system using eye movements for bed positioning was developed and tested in patients with multiple sclerosis. The system, which used a digital-to-analog converter module, improved efficiency and task time in patients. The system was found reliable for positioning beds in patients with limited motor abilities, with seven patients expressing interest in using it for other applications.

[10]This particular paper introduces a real-time eye blink detection algorithm using standard cameras, enhancing accessibility and usability in Human-Computer Interaction, with potential applications in drowsiness detection and disability assistance. [4]This study explores the use of a hybrid brain-computer interface (BCI) for assistive technology in paralysis patients. The BCI uses auditory stimulation and speech imagination, with efficiency varying depending on background noise.

Hospital cabins often lack adequate support for bedridden and immobile patients. [5]A study using computer vision and deep learning technologies developed a multimodal control system for these patients. The system supports hand gesture, nose teeth, and voice commands, enhancing accessibility and usability. The system's effectiveness and efficiency were evaluated, providing a promising solution for the healthcare sector.

[1]This article proposes a system that allows severely ill or disabled patients in hospital cabins to control their environment using their thoughts. A BCI headset collects EEG data, and an artificial neural network processes it to predict their thoughts, providing significant benefits in developing countries.

[9]This study aims to design an eye-tracking assistive robot control system for disabled individuals, with a graphical user interface integrated into the control architecture for targeted engagement. [8]The article discusses the use of digital technologies for monitoring bedridden patients, focusing on the recognition of their position using artificial neural networks training. [3]This work presents an Internet of Things-based patient condition monitoring system using deep learning algorithms. Wearable sensor-based devices detect movement and posture, with a Mask Region Convolutional Neural Network approach extracting data from key points. The system achieves a 95

III. Methodology

A. Patient Selection:

A bedridden patient who had experienced a brain stroke, resulting in significant physical limitations was selected. This selection ensured that our study was rooted in the real-world challenges faced by individuals dealing with the aftermath of such a debilitating event.

B. Understanding Voluntary Eye Blinks:

Extensive groundwork involved a detailed exploration of the patient's communication capabilities, focusing on voluntary eye blinks as the sole expressive channel. This phase aimed to comprehend the nuances and patterns of these eye blinks, laying the foundation for our subsequent technological intervention.

C. System Development:

Leveraging the insights gained, we embarked on the development of a sophisticated computer vision-based system. Facial landmarks were meticulously integrated into the system architecture to facilitate accurate tracking and interpretation of the patient's right eye blinks. Based on Eye Aspect Ratio (EAR) the blink was detected. To as we observed that the patients voluntary and involuntary blinks we gained the insight that both type of blink have a bit of difference. The involuntary blink takes more time than the voluntary one. Taking that insight we averaged the ear for 10 frames coming from a 30fps camera feed. That created a difference between both types of blink. We instructed the patient to hold blinks longer for the voluntary one. So any blink that happened in between 10 frames, in time aspect 0.33 second, will be discarded and will be considered as an involuntary one.

The text was shown as well as audio of that text was played so the patient can both see and hear the command. And one particular text was shown for 10 seconds. The system architecture was designed to be intuitive, ensuring a seamless interaction between the patient and the technology. Calibration processes were implemented to personalize the system according to the unique characteristics of the selected patient.

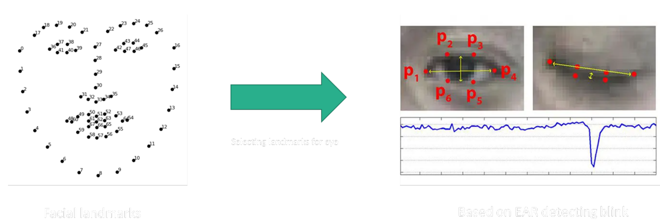

Fig. 1. Methodology

D. Calibration and Training:

A crucial aspect of our methodology involved the calibration and training of the patient to effectively use the computer vision-based system. This phase aimed to establish a symbiotic relationship between the patient's voluntary eye blinks and the system's capacity to interpret and respond.

E. Presentation of Communication Options:

Communication options were strategically presented on a screen, with the patient's right eye blinks serving as the navigational tool. The selection process was fine-tuned to ensure ease of use, allowing the patient to convey a range of messages, from basic expressions to specific requests.

F. Proof of Concept:

The developed system underwent a rigorous proof of concept phase, where the patient actively engaged with the technology to communicate. The effectiveness of the system in accurately detecting and interpreting right eye blinks to select communication options was thoroughly evaluated.

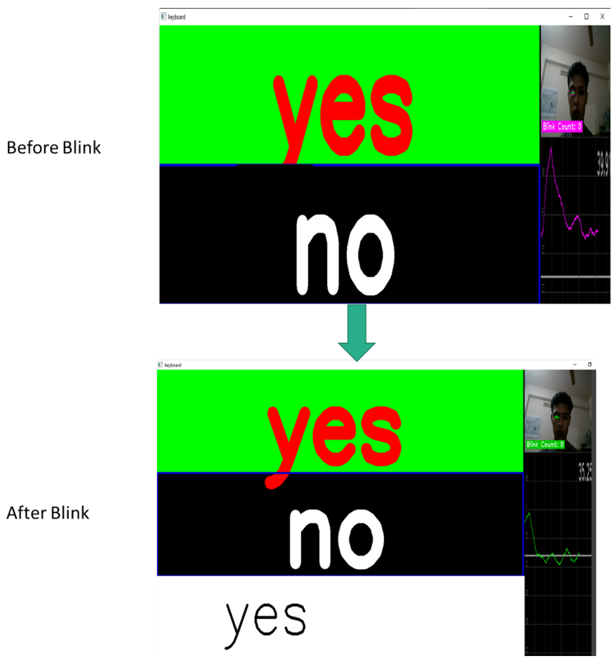

Fig. 2. Methodology

G. Iterative Refinement:

An iterative refinement process was employed based on feedback from the patient, ensuring continuous improvement in system responsiveness and adaptability. This iterative approach aimed to enhance the overall user experience and efficacy of the communication system.

H. Data Collection and Analysis:

Comprehensive data on the patient's interactions with the system were collected and analyzed. This included the accuracy of eye blink detection, response time, and the patient's ability to express themselves through the provided communication options.

This nuanced methodology ensured a comprehensive exploration of our computer vision-based solution, encompassing both the technical intricacies of system development and the human-centered aspects of patient interaction and adaptation.

IV. Conclusion

This case study provides evidence of the viability and potential of computer vision-based solutions for enhancing communication among physically disabled individuals. By leveraging facial landmarks and voluntary eye blinks, our system offers an alternate means of communication for individuals with severe physical limitations, thus improving their quality of life.

References

[1] Md Shadman Aadeeb, Md Mahadi Hassan Munna, Md Raqibur Rahman, and Muhammad Nazrul Islam. Towards developing a hospital cabin management system using brain computer interaction. In *International Conference on Intelligent Systems Design and Applications*, pages 212–224. Springer, 2020.

[2] Khondaker Abdullah-Al-Mamun. *Pattern identification of movement related states in biosignals*. PhD thesis, University of Southampton, 2013.

[3] Sarra Ayouni, Mohamed Maddeh, Shaha Al-Otaibi, Malik Bader Alazzam, Nazik M Alturki, and Fahima Hajjej. Development of a smart hospital bed based on deep learning to monitor patient conditions. *Journal of Disability Research*, 2(2):25–36, 2023.

[4] Manorot Borirakarawin and Yunyong Punsawad. Hybrid brain–computer interface system using auditory stimulation and speech imagination paradigms for assistive technology. *IEEE Access*, 2023.

[5] Muhammad Nazrul Islam, Md Shadman Aadeeb, Md Mahadi Hassan Munna, and Md Raqibur Rahman. A deep learning based multimodal interaction system for bed ridden and immobile hospital admitted patients: design, development and evaluation. *BMC Health Services Research*, 22(1):803, 2022.

[6] Kent Bryant Jimenez, Arnold Cera, Nicko Ceblano, Roxcella Reas, Argel Bandala, Ronnie Concepcion, Adrian Genevie Janairo, Mike Louie Enriquez, Andres Philip Mayol, Ryan Rhay Vicerra, et al. Aacstive touchpad: An electronic augmentative and alternative communication touchpad for post-stroke aphasic patients basic support. In *2023 17th International Conference on Ubiquitous Information Management and Communication (IMCOM)*, pages 1–6. IEEE, 2023.

[7] Martin Kopecek and Jan Kremlacek. Eye-tracking control of an adjustable electric bed: construction and validation by immobile patients with multiple sclerosis. *Journal of NeuroEngineering and Rehabilitation*, 20(1):75, 2023.

[8] Georgy Lebedev, Anna Meshcheryakova, Natalia Pestova, Sergey Kachkovskiy, Aleksandr Taksikov, Nataliya Kasimovskaya, Iliya Poleshuk, Georgiy Radzievskiy, and Herman Klimenko. Artificial neural networks to monitor bedridden patients. *procedia computer science*, 176:1923–1929, 2020.

[9] Md Samiul Haque Sunny, Md Ishrak Islam Zarif, Ivan Rulik, Javier Sanjuan, Mohammad Habibur Rahman, Sheikh Iqbal Ahamed, Inga Wang, Katie Schultz, and Brahim Brahmi. Eye-gaze control of a wheelchair mounted 6dof assistive robot for activities of daily living. *Journal of NeuroEngineering and Rehabilitation*, 18(1):1–12, 2021.

[10] Lu Youwei. Real-time eye blink detection using general cameras: a facial landmarks approach. *International Science Journal of Engineering & Agriculture*, 2(5):1–8, 2023.