A Survey on Visual based Wheelchair Control System for ALS Impaired Patients

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ABSTRACT

Thanks to advancements in the construction of electric wheelchairs, people with motor limitations brought on by conditions like the amyotrophic lateral sclerosis (ALS) are now given the ability to become more independent and mobile. But operating and utilising an electric wheelchair often calls for a high level of ability. Additionally, certain individuals with mobility impairments are mechanically unable to regulate the movements of their hands, making it impossible for them to use a joystick to manually adjust an electric wheelchair (as in people with ALS). In this article, we suggest a system that would permit continuous real-time tracking in uncharted terrain and allow someone with a severe disabilities to regulate a wheelchair with eye gaze. The system is made up of a Raspberry Pi board with all the sensors wired up to it, a camera, and an IR sensor to detect objects, an accelerometer to move the wheelchair across all directions, a motor to move forward and backward, and a GPS module to locate the patient. The OpenCV method is presented to enable continuous real-time target detection, route planning, and navigation in uncharted territory. Interesting findings from a case study that involved an ALS patient are presented and examined. The participant performed better in terms of calibration time, task execution time, and maneuvering speed for trips in between office, dining room, and bedroom. Positive outcomes from listening to the carer included the participant driving the wheelchair with more assurance and avoiding mishaps throughout the experiment.

***Keywords**: Amyotrophic lateral sclerosis, OpenCV, internet of things, raspberry Pi*

INTRODUCTION

Motor impairments brought on by illnesses like amyotrophic lateral sclerosis have a profound influence on people's quality of life (ALS). Thanks to advancements in the design of electric wheelchairs, people with motor disabilities have long learned to live with certain degree of independence. But using and controlling such electric wheelchair often requires a high degree of skill. Furthermore, some individuals with motor disabilities are physically unable to control the movement of the hands, making it difficult for them to manually operate an electric wheelchair using a joystick (such as people with ALS). Researchers have studied a variety of interface technologies that allow wheelchair users to easily and safely operate the device, including sip-and-puff (SnP) switches, head arrays, eye tracking, and brain-computer interfaces (BCIs) based on electroencephalography (EEG), electrooculography (EOG), as well as the speech recognition [1]. However, every technology has flaws that prevent it from being used on a regular basis. For those with severe paralysis, BCIs may be helpful [2], although they are difficult to incorporate into daily life [3] and are prone to interference and motion anomalies. Voice recognition software is worthless when used with wheelchair or a cursor, despite the fact that it speeds up texting [4]. SnP switches (sip-and-puff) [1]. However, every technology has flaws that prevent it from being used on a regular basis. Patients with severe paralysis may benefit from BCIs [2], although they are difficult to use in daily life [3] and are prone to interference and motion abnormalities. Voice recognition technology may speed up typing [4], but it is worthless when used with a mouse or wheelchair, unreliable in noisy environments [6], and unsuitable for navigation [5]. Tetraplegics employ head arrays and SnP switches because they are inexpensive and easy to use, despite the fact that they only support a small number of instructions and require some physical skill from the user [7]. People with ALS gradually lose their ability to walk, and if they don't have the right mobility aids, they risk becoming bedridden or totally dependent on carers [8]. As their muscle strength gradually deteriorates, they typically have reach and grip difficulties that make it difficult for them to use control devices like joysticks. They also have a very limited vocabulary. Due to these physical limitations, people with ALS are only able to utilise voice, head movements, and the conventional hand- or chin-operated joysticks which are presently used to interface with electric wheelchairs. People with ALS gradually lose their ability to walk, and if they don't have the right mobility aids, they risk becoming bedridden or totally dependent on carers [8]. As their physical strength gradually deteriorates, they often have range and grip limitations that make it difficult for them to use control devices like joysticks. They also have a very limited vocabulary. People with ALS are not able to talk, move the heads, or utilise the joysticks which are currently used to operate electric wheelchairs due to these physiological limitations. When using eye sensors to move a mouse cursor on a computer display, no physical touch is required [9]. The bulk of ALS patients even have normal visual control and effortless eye movement [10]. It could be possible to turn or move the wheelchair in a particular direction using a control system that can detect the user's eyes. Since then, a unique kind of machine interaction known as activated, or eye monitoring and gazing, has arisen where the user's gaze (pupil movements) is collected and converted into actions without the user having to do any physical action [11]. People with motor disabilities may become more autonomous, mobile, and communicative with the use of eye-tracking technology. The user's gaze (pupil movements) is captured and translated into actions using recognition technologies that have emerged as a paradigm shift in human-machine interaction [11]. People with motor disabilities may benefit from using eye-tracking technology to increase their independence, movement, and communication. [10] The wheelchair may well be spun or pushed to a certain spot with the help of a control system that can detect where the user is looking. Following this, eye tracking and gaze recognition technologies have arisen as a unique kind of machine interaction where the user's gaze (pupil movements) is collected and transformed into actions without the user having to make any physical motion [11]. The user's gaze (i.e., pupil movements) are gathered and converted into actions without the need for any physical movement in a novel kind of interaction with machines known as recognition technologies [11]. Eye tracking technology seems to be a potential option for those with movement restrictions that will improve their autonomy, mobility, and communication. People with motor limitations may benefit from using eye-tracking technology to communicate, maneuver, and be more autonomous. When using an eye tracker to move a mouse cursor on a laptop screen, no physical touch is required [9]. The bulk of ALS patients even have normal visual control and effortless eye movement [10]. It could be possible to turn or move the wheelchair in a certain direction using a control system that can detect the user's eyes. Eye tracking and gaze recognition technologies have evolved as a new kind of machine interaction because the user's gaze (pupil movements) may be captured and translated into actions without the need for physical effort [11]. For those with movement limitations, eye tracking technology appears to be a viable way to increase their independence, mobility, and communication skills. In order to capture the user's face and transmit a video stream to a computer, a normal web camera is connected to a Head-Mounted-Display (HMD) in the first eye movement control method for such an electric wheelchair, that was published in 2007 [11]. After analyzing the video footage from the cameras and determining the user's visibility position in respect to the target area, the computer activates the electric wheelchair. The efficiency of Eye-Gaze detection and tracking, the impact of ambient circumstances, and the rigorous calibration required for appropriate detection or tracking performance are a few of the major issues that have prevented widespread implementation of this technology [12,13]. The proposed study has three objectives: (1) Continuous real-time target detection and route planning for target navigation in uncharted territory. The system makes use of a depth camera (Microsoft Kinect), which collects 3D geometry of the immediate environment. It then alters the visual user interface (2) to meet the needs of the input/output system, generating the necessary path of travel while dodging obstacles. The screen is divided into an N-cell grid depending on the eye-resolution tracker's and accuracy, the screen's clarity, and (3) a simple and rapid calibration method for the eye-tracker which is also resilient to head movements. It should be stressed that a variety of people with disabilities, such as those with tremors, limited hand movement, or undeveloped upper limbs, may benefit from the recommended strategy.

LITERATURE REVIEW

Eye-Tracking Methods

Eye tracking tools, which may be divided into two categories: electrooculography and video, are often used to determine a person's eyeball location and gaze direction. Electrooculography (EOG) signals were proposed by Al-Haddad et al. to control a wheelchair. Based on the patient's current angle of view, the navigation method determines the direction and distance to the target location. In a following study, an algorithm dubbed Bug-2 for hands-free wheelchair control was developed [14], allowing the user to freely scan their surroundings as they move. To evaluate the polarity of the corneal-retinal potential arising from depolarization and hyperpolarization between the retina and cornea, EOG employs five electrodes. After focused on the target location, all the user has to do is blink to tell the navigation system to start. The controller can calculate the desired point location, distance from, and direction from the target by positioning the wheelchair user's point of view. [15] Compares the Tangent-Bug and Bug2 algorithms. Even with a precision of around 10, it may not be possible to develop a reliable control system. The disadvantage of EOG technology is the need to surround the eyes with surface electrodes. To address these problems and others, the researchers experimented utilizing image-based eye gaze tracking. Position of the destination, travel time, and distance to the destination. Video-based surveillance systems come in a variety of configurations; some are head-mounted and may need a steady head, while others work remotely and automatically track head motions. Active infrared methods, like those in [16] and [17], and passive image-based methods, like those in, may also be further categorized. The identification of the regions housing the eyes is made possible by the use of infrared light, which is used to record the physical characteristics of the pupil in additional to its dynamics and appearance. Arai and Mardiyanto [17] used an IR camera mounted on the user's glasses to eliminate ambiguities caused by changes in illumination, user movement, and human head movement. A gadget that employs the associated ground-breaking image processing method. The user's eye movements are shown on. The process is not activated whenever the eye is directed straight forward. The wheelchair will start to move left, right, or forward depending on whether the user raises their eyes up, down, left, or right. Users are restricted to just navigation using this method, which generates cognitive overload and requires constant eye contact for effective control. The disadvantage of camera-based gaze tracking that it requires continuous eye contact from the user. Nguyen and Jo revealed a wheelchair control system that uses posture-free eye gaze estimates as well as a 3D orientation sensor that takes the location of the head into account. The equipment also includes an electric wheelchair and eye tracking. The glasses' frames, an infrared camera with two LEDs on each side, and a 3D orientation sensor coupled to one of the frames were used to create a vision tracker. The proposed method requires complex calibration. Additionally, attempts have been made to leverage gaze movements and facial alignments as a hands-free wheelchair control interface. After a web camera was used to transmit the image of the face in real time to the computer, the orientation of the face was determined by altering the brightness of the nostrils. Instead of using a joystick interface to drive the automated wheelchair, the gaze motion recognition system works by mirroring the alignments of the operator's face as they look at the control computer. Jia and Hu proposed using head motions to steer a wheelchair with intelligence. The head gesture is used to control the wheelchair after Adaboost facial recognition pinpoints the position of the nose and the front of the face. Because individuals are still unable to move their heads, ALS patients are utilizable to utilise these gadgets. Mobile eye tracking devices are available; SMI, 1ASL2, and Tobii3 are the main manufacturers. The three main alternatives for buyers to choose while implementing the system were SMI (Senso Motoric Instruments) Glasses 2.0, Tobii Glasses 2, and ASLXG Eye. The ALS XG Eye was discontinued because it contained a huge head-mounted device that the ALS sufferer found uncomfortable to wear. The SMI Glasses 2.0 are a pair of eyeglasses that track the wearer's gaze thanks to two small cameras attached on the edge. The following variables affected how SMI devices were deployed: First off, using the device is fun and comfortable (just like normal glasses). Second, it makes precise use of two cameras that are mounted on the edge of the eyewear to record eye movements and track the point of view (accuracy of 0.2). The glasses also don't obstruct eyesight, and they can withstand changes in the environment (such as lighting conditions). However, we are mindful that maintaining SMI glasses costs money and that a lower costly alternative is offered.

Wheelchair Control System via Eye Gaze

Even while common electric wheelchairs have aided millions of handicapped people, many of them cannot help those who have severe disabilities. Since ALS patients are paralyzed from the waist down, many existing systems need the use of a joystick as a control input to operate the motors of electric wheelchairs that is not an option for them. Since devices do not require any physical contact, eye gaze interfaces are advantageous in these situations. All of the studies examined optical vision tracking. For instance, the research in measured the direction of the gaze and the calibre of the blink by placing a camera in front of a wheelchair user. Eye blinks and gaze direction reveal the wheelchair's movement direction and timing. Commands for direction, timing, and speed were used to regulate the wheelchair's pace. The gadget demands the user to have a steady, uninterrupted vision while navigating. Target navigation has been used for wheelchair control by several researchers. They offered both manual and automatic wheelchair control options. Human users gaze up to go straight forward, right to turn right, left to turn left, and bottom to stop. The user just has to stare in the direction of the desired objective and blink to begin steering the wheelchair to the intended location automatically (right to start and left to stop). This method reduces cognitive stress, but since it operates in a specified and well-known setting, it has certain limits. Furthermore, the extensive calibration procedure makes the whole system useless in real-world applications. The researchers also considered how to maintain the wheelchair programme in uncharted areas. For barrier-free navigation, a wheelchair user travelling new area requires real-time map creation and course planning. A real-time map is commonly produced by adding sensors that scan the local physical area. These have been extensively investigated and include some well-known examples like, SENA, Rolland, Hephaestus [35], and Navchair. A cozy environment is necessary for all of these systems. A vision-based wheelchair navigation system that makes use of a landmark ceiling light is described in [37]. Two cameras on the cart are used for self-localization and obstacle avoidance. Because they are easy to install and can be seen from a distance, ceiling fluorescent lights are often employed as markers. This method only works in partly recognized locations and requires ceiling lights as reference points. The main goal of this article is to create and evaluate a unique gaze wheelchair system for traversing unfamiliar regions with the least amount of cognitive load and calibration labour. We describe a unique method that locates adjacent objectives and develops routing pathways from the centre of gravity of obstacles for autonomous real-time navigation in uncharted areas. In order to address the calibration problem, we have devised a fast and simple calibration process that looks to take just 30 seconds to complete. We provide a graphical user interface built on an adaptive N-cellgrid input/output interface. Finally, we describe the case study we conducted in which an ALS participant tried the recommended approach.

LIMITATIONS OF EXISTING WORKS

Individuals who find it challenging to move from one place to another in modern life. Today's market offers joystick controlled wheelchairs that range in price from Rs 80,000 to Rs 150,000. This type of wheelchair, which is only able to move, will not be able to detect obstacles that are present in front. We can't find the location of the wheelchair.

- Help is needed to move from one place to another.
- Individuals need some strength to use this joystick controlled wheelchair.
- Repeated use of this device leads to pain in the shoulder.
- When driving long distances or uphill, this device will not work well.

Table 1: *Comparison Chart.*

TITLE	YEAR	AUTHOR	PROPOSED METHODOLOGY	OUTCOME
Human Machine interface Wheel Chair by Using Wi-Fi Communication for Disabled Person	2020	P. Sasikala	Bluetooth module with the help of servo engines.	Scalability constraints . The android module did not work efficiently.
Gesture Controlled Wheel Chair and Convertible Wheel Chair into Stretcher	2020	Prasanna Vernekar; Basavaraj Chougula; Manjiri Pawar; Anirudha Patil; Keerthi Hooli	Gesture and Convertible wheelchair into Stretcher.	Useful to people who have adequate upper body movement i.e; they are paralysed below the waist .
A Hand Gesture-Based Wheelchair for Physically Handicapped Persons with Emergency Alert System	2020	P. Upendar ; P.A. Harsha Vardhini	Accelerometer sensor and atmega328p controller.	Not efficient and consistent with the controller's movement . Use of Arduino , makes it less connective in terms of USB .

PROPOSED SOLUTIONS

The suggested method increases the amount of space provided to people with physical impairments while simultaneously lowering the number of restrictions they must contend with on a daily basis. The system's long-term objective is to make it possible for persons with physical disabilities to conduct their everyday lives on their own. The three essential facets of daily living are driving, communicating, and having fun. A general architecture that allows features including communication on social media, interactivity with entertainment tools, and environmental functions.

Here, we'll steer the wheelchair using hand motions and visual cues. The ability to detect motion in any one of the tri - axial directions is provided by a sensor known as an accelerometer. The X and Y axes were taken into consideration for the direction of this project. An encoder receives the data from the sensor and encrypts it before sending it wirelessly via the transmitter. The sensor data is then encoded and collected at the receiver end before being sent to the microcontroller. According on the data from the accelerometer, the microprocessor generates a relay signal that moves the wheelchair left, right, forward, and backward. An IR sensor that can identify a roadblock is seen here. While the camera is utilized for visual instructions, GPS is used to determine the position. The camera records a person's eye movements and transmits them to the microcontroller as instructions. Here, the eye picture and instructions are captured using the OpenCV method. Project management on the Raspberry Pi uses Python programming.

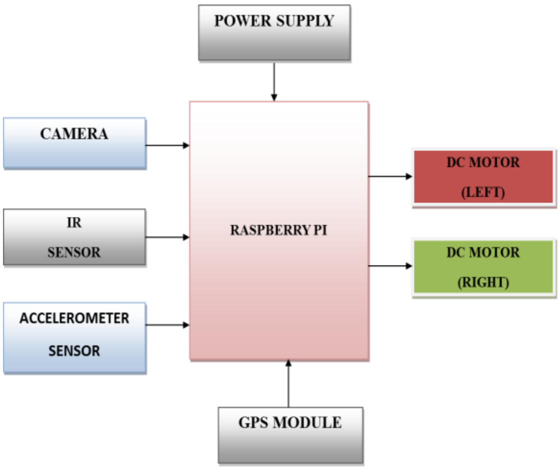

Fig. 1: *Block diagram of proposed system.*

CONCLUSION

This paper provides a thorough review of the various approaches and models. This system uses advanced gesture technology built from wearable, affordable and portable components. Acceleration data is used to identify hand movement. Motion commands are given to move the cart forward and backward. Natural interaction between the elderly, disabled and disabled people. User independence and also the psychological benefits of independence. The wheelchair user has the freedom and ability to turn in the desired direction with just a slight twist of the hand. The accelerometer is very sensitive, so training is required before using it. Voice commands for controlling the wheelchair Improvements can be achieved by using speech sensors and various body movements, such as leg or head movement. In order to develop and further validate this process in the future, they will focus on addressing the shortcomings of their work and conducting additional trials.

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