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Implementation of HOG algorithm on eye controlled wheelchair using Python language

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ABSTRACT

The eye-controlled wheelchair is a flexible device for persons with restrained or severe locomotor disabilities, ameliorating movement further for the aged. There are numerous interfaces for wheelchair obtainable within the market, but still, they continue to be under-utilized because they require the presence of mind, ability and power to control them. The proposed model is an alternative that tries to form the lives of those individuals easy by helping them move around as they wish and not a burden on others. An individual littered with paralysis will move his eyes and may tilt his head partially. Thus, A wheelchair that is totally controlled with eye movements and blinks has been designed in which python software is used & processing of eyeball movement is done which employs the Histogram of Oriented Gradients (HOG) algorithm. The Arduino drives the motor driver circuit. The motors connected to the wheelchair support differential steering that avoids clumsy motion. The wheelchair has been supplied with a joystick to make sure safe movement just in case of tired vision and with a security stop button, which is able to prevent the wheelchair movement at his own case.

Keywords— *Locomotor disabilities, Ameliorating movement, Wheelchair, Python, HOG algorithm, Joystick*

1. INTRODUCTION

Victims littered with severe paralysis, amputees and physically challenged should lead an acceptable standard of life. Progressive Motor Neuron Diseases (PMND) and Spinal Cord Injuries (SCI) might cause a condition referred to as Quadriplegia that results in loss of muscle functionality. According to the world health organization report on 2 December 2013, as several as 500,000 individuals suffer from spinal cord injuries and 60,000 cases with Motor Neuron Diseases (MND) every year & many of those end in partial or total loss of all four limbs [1].

In order to solve these problems, powered wheelchairs are used than conventional wheelchairs. Powered wheelchairs have high direction flexibility to move with the surroundings. Presently there are numerous input devices used for interaction with wheelchairs like a joystick, keyboard, mouse and alternative devices which needs hand movements, not all the individuals littered with locomotor disabilities are able to navigate using the above mentioned.

2. LITERATURE REVIEW

Usually, hand movements are required by the input devices like keyboard, joystick, mouse and other devices. The disabled people suffering from complete paralysis cannot use the above mentioned. The existing devices with the use of voice, finger, gesture and their disadvantages for the paralysis individuals are classified as

(a) Voice-based technique [2], utilizes the user's voice as supply input. Voice analysis is employed to convert voice into digital data. This method is vulnerable to noise. Voices that come back from surroundings could have an effect on the system. Limitations of this technique are background noise, less accurate, speaker variability, channel variability, speed of speech etc.

(b) Motion-based technique [3], that uses the alternative normal movement of organs like head, foot etc. to control the input of laptop. Limitation of this technique isn't helpful for the organs failed individuals and needs human effort to navigate like joystick etc.

(c) Bio-potential based technique uses potential from user's body actions obtained by usage of a special instrument like Electromyography (EMG) [4], electrooculography (EOG), and Electroencephalograph (EEG) [5]. For a paralyzed individual, the search coil is used as sources of laptop input. EOG technique [6], [7] uses voltage variations between aft and fore surfaces of eyes. Limitations of this technique are accuracy is less compared to video tracker, poor gaze direction, comparatively expensive.

(d) Search coil technique [8] utilizes the induced voltage along with coil and contact lenses attached to the user's eyes. Limitation of this technique is its lifetime which is limited, the burden to the individual, measuring time is 30 to 60 seconds approximately.

(e) Image analysis technique, employ a camera to know the desire of the user and convert into digital data. Many image processing techniques are there like face-based user's desire from face expression and similarly other methods.

3. PROPOSED METHODOLOGY

The image is captured by the camera in real time based on eye and face detection with less time delay and the image is analyzed as input to interface the set of commands on the motor driver IC through passing the command to General Purpose Input/ Output (GPIO) pins, to perform the different operation such as left, right, forward and stop.

For face and eye detection, Image processing open computer vision (open CV) library is used. For detecting multiple or single face and detection of both the Eyes, is the ultimate goal of the system. Image processing techniques include face & eye detections, color images to gray conversions, edge detection, pattern matching, blurring, noise reduction, filtering etc. HOG algorithm is used to detect the blinks of the eye.

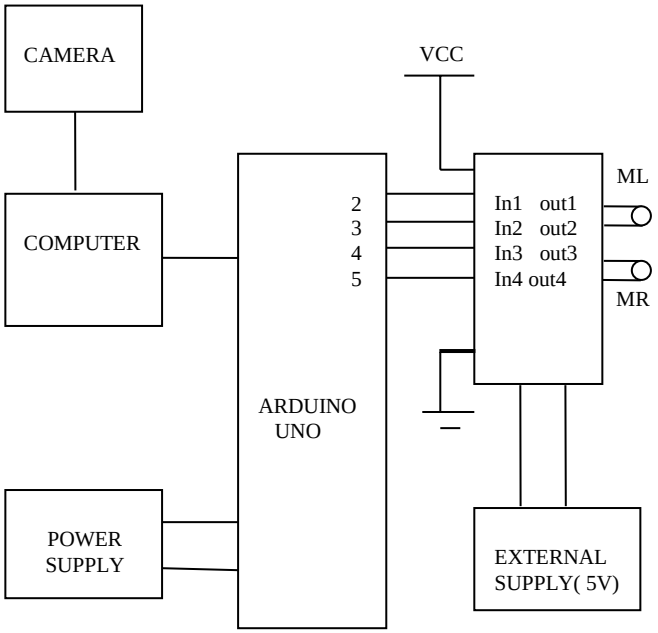

Fig. 1: System architecture diagram

Arduino board is the soul of the system, which controls the complete system operation. Image processing based data signal sent to the Arduino & received the data and analyze it and send the control signal to the motor driving circuit, based on the location of the eye pupil. This will decide motor run either in the desired direction or stop. Two individual motors are fixed on each wheel.

3.1 Hardware description

3.1.1 Arduino board: The Arduino UNO is a microcontroller board based on the ATmega328.it has 14 digital input/output pins. It is programmed as a USB to serial converter. The Arduino software (IDE) allows to write programs & upload them on the board.it has 32kb 0f flash memory for storing code. It also has 2kb of SRAM and 1kb of EEPROM.

3.1.2 Web camera: For capturing the image web camera is used. HD (high definition) camera can also be used but it increases the memory size, it will increase the processing time and the system can't able to read the image.

3.1.3 Motor 12 V: To demonstrate running of wheelchair DC motor is used for forward, reverse, left and right direction movement. L293D motor driver is used to interface with Arduino which is TTL compatible. From L293D two H bridges can be connected in parallel for increasing its current capacity up to 2 Amp.

3.2 Software description

3.2.1 Open CV image library: Under a Berkeley Software Distribution (BSD) license Open CV is released and is free for both the academic and commercial use. It supports various interfaces like C, C++, Java and Python and also supports Linux, Windows, IOS, Mac OS & Android. It was designed for more efficiency and for real-time applications.

3.2.2 Python language: Python is an object-oriented, high-level programming language.it is an interpreter with dynamics semantics. It has a high level built-in data structures which comprises of dynamic binding and dynamic typing. These make it very suitable for rapid application developments. Python syntaxes are easy to learn & emphasizes readability. The cost of program maintenance is therefore reduced. The fast debug cycle & edit test makes this language very effective.

3.2.3 Embedded C language: When a particular hardware architecture is associated for which programming language is written in C then it is defined with a generic term Embedded C, which is an extension for C language with additional header files. The programming depends on the hardware architecture that may be microcontroller or other devices. It is useful for only limited sources like ROM, RAM and I/O peripherals on the embedded controller.

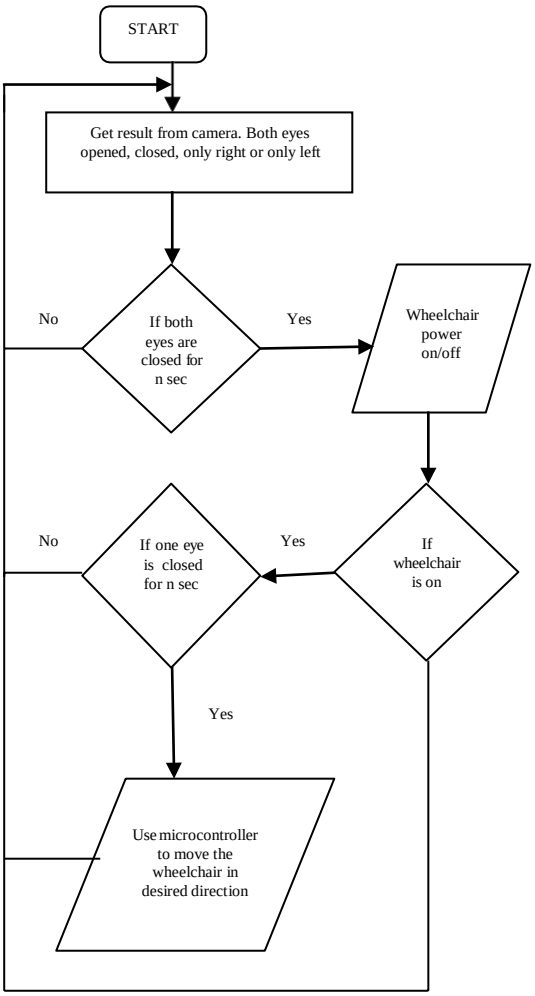

Fig. 2: Flowchart of the Entire Process

The camera is placed such that it captures the image of one eye allowing the other eye for clear vision. The captured image of the eye is sent to the computer. Four frames of images are captured per second by the web camera. These are sent to the classifier and the eye direction is obtained. The eye images are classified by image processing techniques.

In this model, a computer vision application is developed that is capable of detecting and counting blinks using facial landmarks and open CV. To build the blink detector, eye aspect ratio (EAR) is computed. For computing blinks, the traditional image processing methods involve some combination of:

(a) To find the whites of the eyes thresholding is done
(b) Eye localization.
(c) To determine if the "white" region of eye disappears for a period of time (indicating a blink).

Instead of these, the Eye Aspect Ratio (EAR) is a much more elegant solution which involves simple calculations like to find the ratio of distances between the facial landmarks of eyes. This method of eye blink detection is very efficient and easy to implement.

3.3 Classification Method (EAR)

By using facial landmark detection to localize important regions of the face, includes eyes, eyebrows, nose, ears & mouth. So by knowing the indexes of the particular face parts, the facial structures can be extracted. an eye is represented by 6(x,y) coordinates, starting at the left/right corner of an eye(as if you were looking at the person).

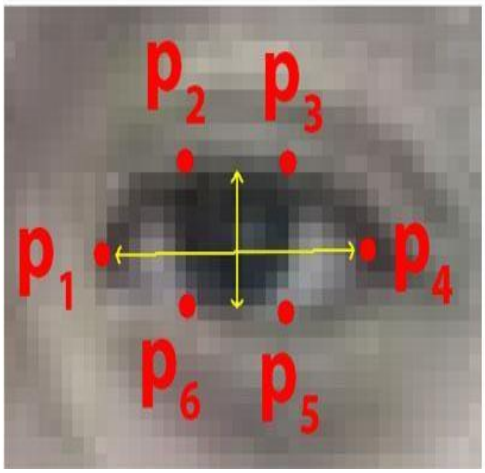

Fig 3: The 6 Facial Landmarks of Eye

Based on this image, there is a relation between the width and the height of these coordinates. This relation is called the eye aspect ratio (EAR) which is derived by the eye aspect ratio equation

$$\text{EAR} = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|}$$

Where p1,..., p6 are 2D facial landmark locations.

The numerator of this equation computes the distance between the vertical eye landmarks while the denominator computes the distance between horizontal eye landmarks, weighting the denominator approximately as it has two sets of vertical points but only set of horizontal points.

The eye aspect ratio is approximately constant while the eyes are open, but will rapidly fall to zero when a blink is taking place. Using the above equation, the image processing technique is avoided and determines whether a person is blinking or not based on the ratio of eye landmark distances. For clear assumption, consider the following figure

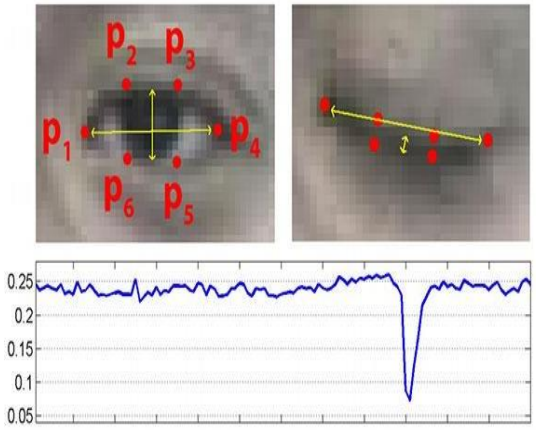

Fig. 5: Visualization of Eye Landmarks

On the top left an eye is fully open-the eye aspect ratio here would be larger® and relatively constant over time. Once the person blinks (top-right) then the eye aspect ratio decreases dramatically & approaching zero. A graph is plotted at the bottom that shows the variation of the eye aspect ratio overtime which is constant, then drops to zero and increased again, indicating a single blink has taken place.

If the eye aspect ratio falls below a certain threshold and then rises above the threshold, then it is registered as a "blink". The dlib library uses a pre-trained face detector which is based on a modification to the "histogram of oriented gradients + linear SVM" method for object detection. The dlib library has predefined facial landmarks they are:

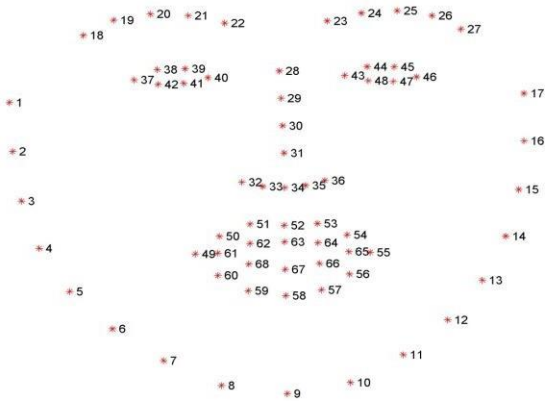

Fig. 6: Entire set of facial landmarks in dlib

Hence by determining the starting and ending array slice index values for extracting (x,y) coordinates for both the left & right eye. Using these index values the eye regions are extracted easily.

The classified result is then sent to microcontroller for the automatic control of the wheelchair. If the same direction is given by the classifier for 8 consecutive frames, that is if a person looks in a particular direction for two seconds, the wheelchair moves in that particular direction or stops, if closed for two seconds. This allows the user to have free eye movements and blinks under two seconds. Closing eyes for 16 consecutive frames or four seconds will switch on & off the wheelchair.

4. HARDWARE PROTOTYPE

The designed system contains four parts:

(a) A web camera & personal computer, to track the user's eye movement.

(b) Arduino board that receives the output from laptop & convert it to digital & then to electric signals.

(c) A dual H-bridge L293D motor driver IC used to control two motors at a time. It uses the Arduino signals to control the set of motors.

(d) Chassis for which wheels are attached to DC motor.

The real-time system implementation will be similar to the designed prototype. Instead of chassis wheelchair is kept.

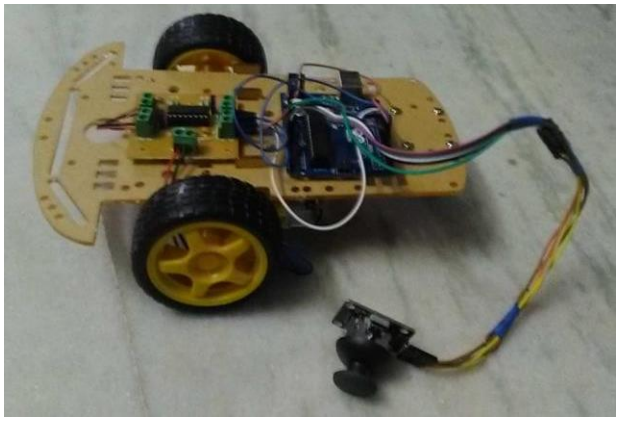

Fig 7: Eye controlled wheelchair prototype

5. RESULTS AND DISCUSSIONS

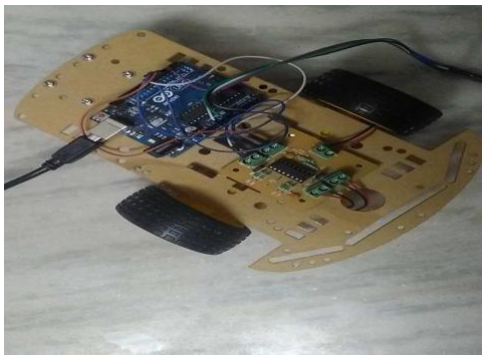

Fig 8: Wheelchair moves in the left direction

When the right eye is closed or consider giving a blink then the wheelchair moves towards the right side where the left side eye is open and the motor present at left side works.

Fig 9: Wheelchair moves in the right direction

When the left eye is closed or consider giving a blink then the wheelchair moves towards the left side where the right side eye is open and the motor present at right side works.

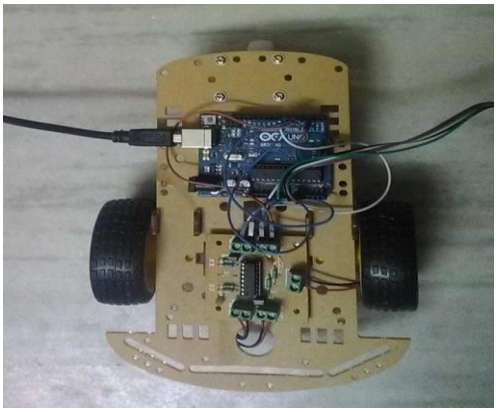

Fig 10: Wheelchair moves in the forward direction

When both the left eye and right eye are closed then the wheelchair moves towards forwarding direction i.e. straight left and the motor present at both sides works.

6. CONCLUSION

In the proposed design a wheelchair is developed which is based on eye blinking for physically disabled patients to move their wheelchair independently using the coding language (python) and an Arduino board (embedded C) with the test accuracy of 80%. The code employs the HOG algorithm to detect the eye features. The overall prototype was excellently built with the cheaper cost and done with an effective coding technique. It can be integrated into a wheelchair.

7. FUTURE SCOPE

It can be implemented for the people who are having spectacles. A voice command IC can be used to interface the voice signal with a microcontroller. The project can be extended in such a way that it may send SMS to the person during an emergency. Delay time can be reduced further. A hybrid microcontroller can be designed in which it consists of an alcohol detector. So if the person is in a drunken state the wheelchair will not start or it will be stopped immediately. Its accuracy can be increased more. Even in poor lightning conditions, the wheelchair must move in the desired direction.

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