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AN IMPLEMENTATION ON EYE BALL DETECTIONBASED WHEELCHAIR CONTROL USING MATLAB AND ARDUINO PLATFORM FOR A PHYSICALLY CHALLENGED PERSON

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Abstract: This result paper includes the electronic wheelchair that is implemented for the disabled person who cannot walk. Our system implemented eye ball controlled wheelchair is to eliminate the assistance required for the disabled person. In this system we are controllingthe wheelchair by eye movements and central switch. A good resolution camera is mounted on wheelchair in front of the person, for capturing the image of eye and tracking the position of eye pupil by using any image processing techniques using Matlab platform. According to eye pupil position of disabled person, motor will be moved in required direction such as left, right, backward and forward withthe help of Arduino. We are also using Ultrasonic sensor. It is mounted in front of wheelchair for safety to detect static obstacle or mobile barriers and to stop the wheelchair movement automatically. A central button switch is also mounted on wheelchair handle for emergencypurpose and to stop movement in require direction if any one call to stop and someone require attention on themselves. This is independent and cost effective wheelchair system. An Arduino board is used to control whole system.

Index Terms: Arduino, Computer vision library, Image Processing, Matlab, Eye gauge, Arduino.

I. INTRODUCTION

There are number of persons who are paralyzed or physically handicapped, therefore they depend on other people due to loss of self- mobility. This dependency is growing day by day with the population. The development of the wheelchair for paralyzed and disabled person issurprisingly increasing recently starting with the conventional manually powered wheelchairs and advancing to electrical wheelchairs. Conventional wheelchair use tends to focus exclusively on manual use, which assumes users still able to use their hands which excludes those unable to do so. Diseases or accidents injuring the nervous system also makes people to use wheelchair because people lose their ability to move their voluntary muscle. Because voluntary muscle is the main actuator enabling people to move their body. Paralysis may cause a person to not move their loco-motor organ such as arm, leg and others. Paralysis may be local, global, or may follow specific patterns. Most paralysisare constant, however there are other forms such as periodic paralysis (caused by genetic diseases), caused by various other factors. In our project the advance level of Image Processing open computer vision library is used for Face and Eye detection [1]. And several application and algorithms are used to find out accurate pupil location detection and tracking of that. One of them is Haar cascade like features detection algorithm used to detecting the exact Eye pupil and locate its center point is ultimate goal of this system. For automatically finding out eye pupil and tracking eye pupil, many computer vision library of Image processing are used like object detection, motion detection, image color conversion, edge detection, pattern matching etc. For eye pupil tracking there are several number of other techniques available [6] [15]. But they have its own limitation. One of them ECG, EEG and EOG sensor based eye pupil detection technique is available [6] [8], where voltage variation based output assumed to decide the location of pupil [9]. But for different paralyzed user, different output voltage will be generated,which will result in faulty location of the eye pupil. The head movement based system have limitation, where user cannot be able to access the system physically [11] [10].

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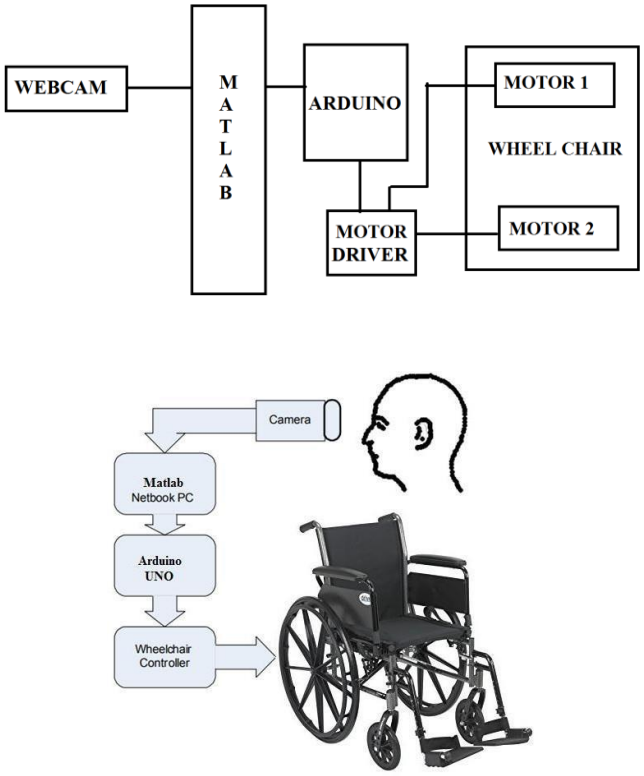

(a) (b)

Figure 1: (a) Block diagram of the Eye-Tracking System (b) System prototype architecture

The idea was to create a generalized tool that can be easily interfaced with other systems like electric wheelchair, movable patient bed, eye controlled alerting mechanisms for disabled ones etc. To validate the proposed idea, a motorized platform was interfaced with the eye-tracking system via microcontroller and specified motor drivers. The block diagram of the proposed system (figure 1) shows thesystem hardware and software integration.

Objective:

The main objective here is designing a GUI to capture or load an image and also establishing a system that can track the position of eye ball and recognize with respective movement. Thus, we can summarize our project as follows: the main objective of this project is ‑to design a vision based wheelchair system‖, using the camera to acquire disabled person's eye pupil position images and analyzing disabled person movement detection.

II. IMAGE PROCESSING BASED EYE BALL TRACKING

In this research work a pupil has been identified via image processing in 2D domain to determine various required parameters [4] [3]. For this purpose MATLAB has been used which is more précised and accurate for image processing of tracking application [12]. A graphic user interface or GUI based eye tracking environment is developed in MATLAB that is able to detect pupil of an eye following the design steps as mentioned below.

1) **Image acquisition:** The image processing starts with the frame acquisition through a webcam that transferred data serially to MATLAB. The resolution was adjusted to 320x240 to speed-up the procedure and to make data processing simpler. An infinite triggering event for the camera is initiated for continuous stream of data whereas.

2) **Plane separation:** The stored RGB frame is then separated into its respective planes i.e. red, green and blue. Among the three planes, red plane was selected for the feature extraction step because it had appropriate values of brightness, contrast and gamma presets that resulted in a clear identification of pupil.

3) **Segmentation:** Logical threshold function was applied on the red plane image. The GUI is capable of performing real time threshold of the continuous data stream. The value of threshold varies with amount of ambient light which needs to be tuned in the beginning of the GUI.

Algorithm:

We use viola-jones algorithm for detection of drowsy driver detection. It is based on machine learning approaches**,** where we can train many positive and negative images using cascade function. This algorithm is use to detect the object from the real time capture images and video. We need extract feature images from it. Each of feature [17]

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having a single value which is obtained by subtracting the sum of pixels under custom rectangle from the sum of pixels under black rectangle.

The function of this proposed system contains various stages such as skin color detection, face detection, mouth detection and eye detection etc. We will discuss all the blocks one by one to understand the complete process of detection of eye and mouth. So that the road accident dueto drowsiness **[**10] can be avoided. For the proper detection of the status of eye and mouth or the facial expression a web cam is installed with are the controlled by computer vision.

Eye tracking

The high speed processing, to eliminate the processing of each frame to detect the position of eye from the captured image, to obtain this a new function is used [20]. This function is used in such a manner that the actual position of the eye can be tracked by recognizing the area which becomes impossible to track without using this function. [8] The eye tracking is a concept which defines the area of the facial image where eye search is made as per the central coordinated of the eye. This is necessary for this tracking system is to track the data from the captured image and compare it with the reference image. To track the actual position of the eye, [19] by detecting the next frame so that actual information can be obtained. The degree of openness will decide the tracking of the eye whether it is correct or not. If the degree of openness of eye varies between the specified range. Similarly, if eye remains out of range which means it is not traced correctly. The region of eye willstart from some initial points so to detect [21], [25] this points a coordinate system is required. Once the image is captured, at specific distance from the head and mouth the position of the eye are located. Let this distance is (0.5 * height of captured image) from the top and (0.25 * width of captured image) from the left. The size of window is (0.35 * height of image) in height and (0.58 * width of image) in width. Before detectingthe eye, the conversion is done. The specified configuration represents a complete frame of the image which are capture and over which all the operations are need to be performed.

III. SYSTEM APPROACH

Viola-Jones algorithm is basically used for object detection framework and it is very first object detection framework techniques which provide competitive object detection rates in real-time. Basically this technique is developed for detecting variety of objects and further this technique gets expanded. To solve the problems in face detection. Algorithm can be developed in open-cv as well as Matlab. Basic problem is to detect the face and object, and as we know that it is very easy for human but it is very hard and difficult for a computer as computer required constraints and instruction so to make this task easy viola-Jones algorithm come to existence as Viola Jones requires full view frontalupright faces. Thus in order to detect all coordinated the entire face must be covered and pointed towards camera. Basically viola- Jones doesthe work of taking pictures of different objects and it convert them in coordinates system so that the computer can understand the data, once the coordinates are get plotted we can access the position and movement of any object and so on. Viola-Jones algorithm can applied on stilledobjects as well as moving objects.in case of face detection our different objects like nose, ears, mouth are stilled but in caseof eye the pupil moves here and there so for that viola-Jones algorithm can be applied and can detect the relative motion and position of eyes pupil. As viola- Jones algorithm face problems in detection of pupil in low lighting condition or in accurate and insufficient data. Detector used in this algorithm device are mostly effective in frontal images of faces.it can hardly cope up with 45 face rotation both around the vertical and horizontal axis. Highly sensitive to lightning conditions as pupil is black and cannot be recognize low light conditions. Feature types and evaluation:-

The characteristics of Viola–Jones algorithm which make it a good and accurate detection algorithm are: Robust – very high detection rate& very low false- positive rate always.

Real time – For practical applications at least 2 frames per second must be processed.
Face detection only (not recognition) - The goal is to distinguish faces from non-faces.

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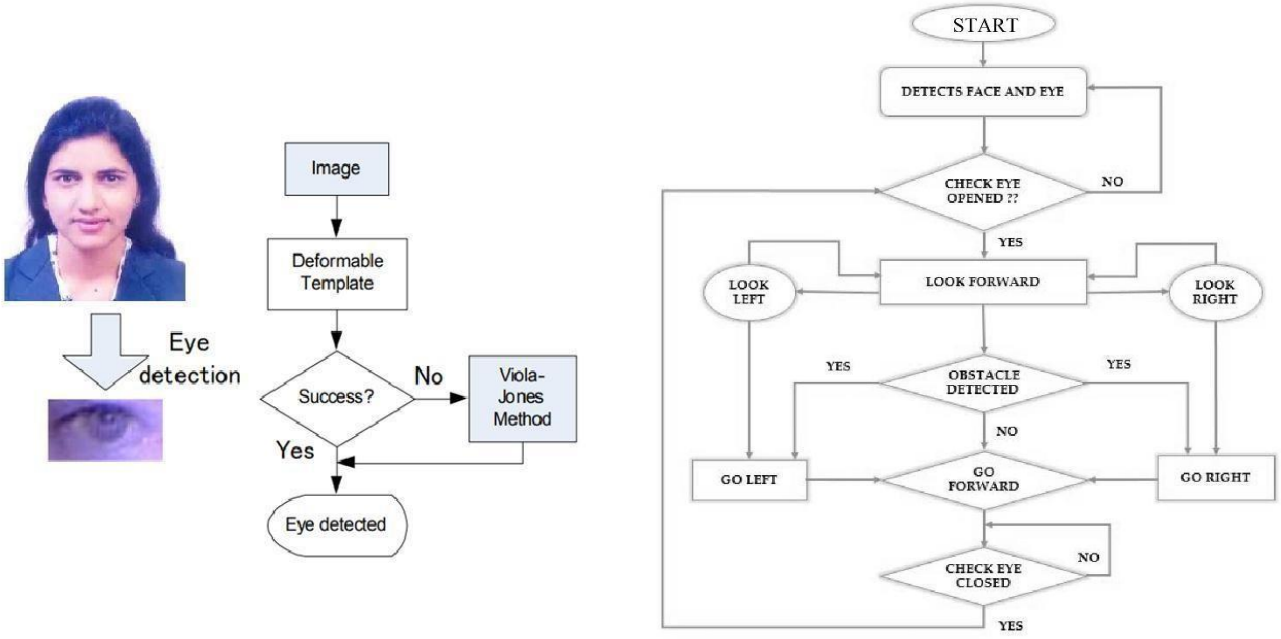
Algorithm follows some stages:-i.) Haar Feature Selection
ii.) Creating an Integral Image



(a) (b)

Figure 2: (a) Viola Jones algorithm process (b) Flowchart of system working

Initially, all we do is monitor if any eye feature points have been detected or not. If not set a flag and display it on the debug screen. To increase the detection accuracy, we wanted to neglect all other points on the screen except the actual eye of the person. The reason being, if anyone except quadriplegic person comes in front of the camera, the person should not affect the system. Also certain things seemingly lookinglike eyes should be rejected as well. The way we incorporated this is taking into account the height and length of the eye. After repeated testing, we decide a length and height of a valid eye, sets a range around the threshold and reject everything which is outside it.

The blink detection section is not compute intensive. We use a flag which is set each time no valid eyes are detected. If in corresponding frames the flag value sets, it indicates a blink. A series of 3 such blinks command the motors to freeze, halting the wheel chair. What is assumed is that the position of the camera is fixed, relative to which the left and the right eye approximate positions can be estimated. Using this, we try to distinguish and store left and right eyes in different matrices. This helps getting a clear discrimination between both the eyes, helping in easy movement detection.

The movement detection is done with a very basic principle. We take in the feature points for both left and right eyes and save it. Thereafter take the difference in pixels of the left eye position and right eye position in the current snapshot from the previous snapshot. We define the threshold for the minimum movement of the eye required to be qualified as a valid attempt. In each snapshot the difference is evaluated, and if this difference above the threshold in any direction left or right, the flags indicating left movement or right movement are set. If the difference is not above the threshold, the flag which says that no movement has occurred is set.

Sometimes due to non-linarites, both the eyes are not detected. At such instances while evaluating the difference for detecting movement, we would give a bias to the eye which was detected in the previous snapshot. After detecting the eye movements, we can proceed to determiningand sending serial signals to the Arduino. After determining which direction the wheel chair has to be moved in, the decision is transmitted tothe Arduino via the serial port. The only thing sent is a one digit decision, saying right, left or straight movement.

Today the ability to measure and analyze eye movements is increasingly important for the on-task assessment of human factors in operatingvehicles, interacting with products or in ergonomics. Since hand and eye coordination is the key issue in sports and in professional training, eye tracking can play a major role in analyzing and improving performance of the players. Eye tracking also allows market researchers to pre-test their clients' designs by measuring what the target audiences see and so improve the impact before the launch [4].

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IV. TESTING AND IMPLEMENTATION

Although the performed tests are repeatable and provide objective quantitative results, the subjective appraisal of the algorithms by a user operating wheel chair using eye controlled interaction system could be completely different. Therefore we created the Eye Tracker application using Matlab platform, which is a part of eye driven interface and allows testing eye pupil location algorithms on real time person images. The main objective of this system is to enable wheel chair movement operation based just on eye movement.The movement of eyes changes the position of wheel chair. The application settings allow for the selection of one of the described eye pupil location methods. Therefore users are given possibility to test and assess usefulness of the chosen algorithm in their own conditions.

Experimental Setup:

To evaluate the performance of the face detector and eye detector of the eye gauge system under variations in lighting conditions, viewing angle and distance to the experimenter, the experimental set-up was as follows. The experimenter was situated in front of a 15-inch laptop. Thescreen of the laptop was put in the upright (vertical) position. The top of the screen contained a webcam, built into the laptop. The eyes of theexperimenter were positioned at the same level as the webcam. The initial distance between the experimenter and the screen was 60 cm. The initial horizontal angle (α-hor) and vertical angle (α-vert) of the experimenter with respect to the screen normal were 0 degrees. Figure **6**
displays a schematic illustration of (a) a top view and (b) a lateral view of the experimental setting.

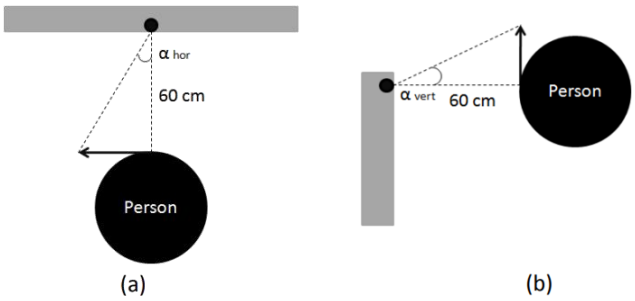

Figure 3: Schematic illustration of the experimental setting showing (a) a top view and (b) a lateral view. The black disk marked “person”represents the experimenter. The black dot in the grey rectangle represents the webcam in the laptop screen.

We design a customized GUI model which having the various function, can be detect and track the real time face and eye of the disabledperson. Our system is easy to handle and installation process.

Figure: A schematic GUI model of our implemented system

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V. RESULTS

Experiments have been carried out on different person and different time. These indicate the high correct detection rate which is indicativeof the method's superiority and high robustness. In the experimental set up two different colors of LEDs —Red and Green are used to indicateleft side condition and right side condition respectively. A buzzer is also incorporated whenever static obstacle is detected.

Experiment	Background		Left Direction	Right Direction	Straight	Overall
1	Day time Light Background		93%	91%	95%	93%
2	Night Time Dark Background		82%	83%	92%	85.7%
3	White Background		91%	94%	96%	93.7%
4	Low Brightness Background		87%	85%	94%	88.7
5	Maximum Brightness Background		94%	95%	96%	95%

Table 1: Accuracy of our system in different background

The experimental results for image sequence of eye tracking are given at table 1, and these observations show that the model can track eyeregion robustly and correctly and can avoid the accident as well. As from the table our system can work more efficient in maximum brightness and white background. Dark background and low quality camera is the limitation of our system because tracking and detection of eye on darkbackground is not be easy.

VI. DISCUSSIONS

We compared three algorithms for eye pupil location. Currently, all of them can be effectively used for gaze tracking and contactless computer operation. Although the other still lacks ergonomics, the technological progress will probably overcome that issue quickly. With better webcam images quality in terms of noise, sharpness and resolution, as well as growing computing power, operating wheel chair using eye gauge.

VII. FUTURE WORK

In future to develop an interactive software method for detection of the eye-blinks in photo sequences for automated face detection, template matching based totally eye tracking and eye-blink detection which acts as right and left click on of the mouse and head/nostril as a mouse pointer, which easily gives on hand systems for human-laptop interaction for bodily disabled persons or others. To make the system more interact with patient we need to add some additional sensors. Delay time may be further reducing to a second. Operation of systemdepends on eye movement of totally paralyze patients. Thus wheelchair moves in all required direction with good response.

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