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IMouse: Cursor Movement Using Eyeball Motion

Prof. T. V. Deshmukh[1], Chhaya Wanare[2], Pallavi Gawande[2], Shraddha Sanjore[2], Poonam Kale[2]

[1]*Assistant Professor, CSE, STC [SERT], Shegaon, Maharashtra, India*

[2]*Student CSE, STC [SERT], Shegaon, Maharashtra, India*

Abstract-Some people are not able to operate computers because of illness. The idea of eye controls of great use not only to the future of natural input but more importantly the handicapped and disabled. Moreover, implementing a controlling system in it enables them to operate computer without the help of another person. Those who need to operate computers without hand this one is most useful those can operate cursor by movement of eye. In this system camera is capturing the image of eye movement. First detect pupil center position of eye. Then the different variation on pupil position gets different movement of cursor. What all these applications have in common is that the use of personal computers is mostly based on the input method via keyboard and mouse. While this is not a problem for a healthy individual, this may be an insurmountable bound for people with limited freedom of movement of their limbs. In these cases it would be preferable to use input methods which are based on more abilities of the region such as eye movements. To enable such substitute input methods a system was made which follows a low-price approach to control a mouse cursor on a computer system. The eye tracker is based on images recorded by a mutated webcam to acquire the eye movements. These eye movements are then graphed to a computer screen to position a mouse cursor accordingly. The movement of mouse by automatically adjusting the position of eyesight. Camera is used to capture the image of eye movement.

Keywords: Mouse movement, Image processing, Eye tracker, Eyesight

1. Introduction

As the use of computer is increasing day by day, we cannot consider our life without computer. The internet technology plays a very important role to update our knowledge so it is very crucial part of our career. Unfortunately, the use of computer is limited to only those who can handle the input devices such as keyboard and mouse. Though the technologies are changing very rapidly the human computer interaction methodology does provide a solution for those peoples who are suffering from the motor disability So the physically challenged peoples are away from the use of computers. Therefore it is very necessary to take part in the research in the human computer interaction field and found solution how it would become possible to interact the user with computer in another way. In a human eye-computer interaction system, we need to understand eye movement to detect an eye accurately; we focus a pupil of an eye. Eye tracking using computer vision techniques has the potential to become an important component in future computer interfaces. Jacob describes several ways of using eye movements for human-computer interaction. Robust techniques for eye detection in images are of particular importance to eye-gaze tracking systems[1].

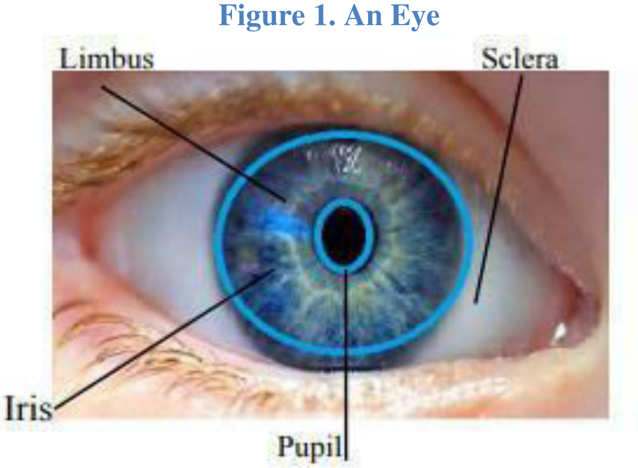
Information about the eyes can also be used to detect and track human faces and bodies, for applications in face recognition, monitoring human activity, multi-modal interfaces, etc.To develop a human eye-computer interaction system, we examine pupil detection and tracking by image processing techniques. In the image processing techniques, the illumination directly influences the image quality in general. If influence of the illumination is little, we can obtain an image of good image quality. The subsequent image processing techniques are expected almost to succeed. By a specific device using active infrared (IR) illumination, an effective eye tracking method is proposed. The specific device can get 2 types of images: dark and bright images. We want to use not a specific device but a more general device. In order to avoid the influences of illumination, we have tried to combine the hardware constitution of an infrared light-emitting diode (LED) light, a sensitive infrared camera, and an IR filter. In the experiment with this hardware constitution, we investigate the effects of the pupil detection and tracking by image processing techniques for a human eye computer interaction system [1].

2. Literature Review

The literature was studied to address the aims, understanding of the research area, focus on the research questions, planning of the data collection approach, clarification of the meaning of the terms and proper identification of the framework. The most important task was to understand the research domain in which eyes detection and cursor movement of a mouse is involved. Going through the literature, the focus was on how to develop a system which can fulfill the needs of physically impaired individuals and the system should be very easy to understand. A group over at MIT has created a system titled "The sixth sense", the system aims to enhance human-computer interaction by using gestures from the hands and eyes. The entire system is mountable on the user"s head, so that it can be projected on to smooth surfaces (like walls) and used anywhere in the world. The problem is that, it doesn"t provide enhanced assistance and accessibility to the disabled nor does it produce a system that can interact with other compatible devices. Though Drewes, Heiko (2009), presents a comprehensive overview, it was noted that most algorithms needed further refinement as they took tedious and longwinded approaches to calibration. A no-nonsense, agile approach was defined Schmidt, Jochen , in using structure from motion algorithm for human-computer interaction. This was exploited by Kassner, Moritz Philipp, and William Rhoades Patera , in using the same sfm (structure from motion) algorithm, optimizing it and extending its use as an efficient algorithm for pupil tracking. In order to achieve this goal, they developed a framework by the name of PUPIL, to critically inquire the relationship between a human subject and space to visualize this unique spatial experience and to enable its use for gaze gesture tracking. In 2018 [6], an eye tracking algorithm based on Hough transform was developed. This system detects the face and eyes of a person. It uses a webcam to detect user's face and eyes. The system is based on]MATLAB. The issue in this system is of real-time tracking and time-speed issue. The system is quite slow and it needs a high-quality computer system to work properly which is costly. In 2017 a better system was introduced by the authors. This system is developed for the paralytic patients. This system uses webcam through MATLAB and moves the mouse cursor by using the pupil of a person [5]. The issue in this system is that it takes a lot of time in detecting the pupil of a person. It uses a lot of algorithms and techniques to detect the pupil. In 2016 [4] a Vision-based wearable eye-gaze tracking system was introduced. This system works using a high infrared camera. It detects the eyes of the person through the infrared cam. The issue in this system was that it is slow and costly [4]. In 2015 [3], a Pupil center coordinate detection using the circular Hough transform technique was introduced.

In this system, the webcam uses Hough Transform Techniques to detect the pupil of a person . The issue in this system was that it takes a lot of time and is not a real-time system. It first captures the body after that, it move to face then eyes and finally to the pupil taking a lot of time. In 2014, a face and eye-controlled system were developed which were based on MATLAB . It uses a webcam to control the mouse by eye and face movement. The issue in this system is that this system only works in a few centimeter radius. In 2013 [2], a system was developed which used eye tracking system, this system is based on the pictogram selection. It uses different eye-tracking techniques to make the system reliable. The issue in this system is that if any liquid is found in eyes, it will not work. Like female use eyeliner or mascara in their eyes, so the system stops working in those situations. A. The Human Eye The eye of a human, works on a two-lens system in a fluid called the vitreous humor, to project the waves of light from different objects in the world onto the retina exterior. Fig. 1 gives the structure of the human eye with the various aspects labeled.

Figure 1. An Eye



There is an area on the retinal surface of the eye that is thickly pressed with cones in the extent to poles. Once the rays pass through the lens, they cast on the retinal surface after traveling through the vitreous humor. The fovea is measured as 1/4000th of the retinal surface area or a rawboned distance of between 0.3 degrees and 2 degrees. This zone is called fovea and appears as a minor yellow segment on the retinal outside.

The retinal surface contains two sorts of photoreceptors, bars and cones . The fovea is thickly stuffed with cones, roughly 161,900 for each square millimeter, taking into account high-determination shading vision. The composition of a retinal exterior demonstrates to us that around is just a little portion of our visual field that we can resolve in high resolution . The rest of the retina isn't visually impaired as the separation increments, the fovea thickness of pinecones and visual sharpness are enormously decreased. The first optical element is the Cornea, to be precise, a thin layer of tear fluid that covers the curved corneal surface. The encompassing zone is populated by bars, thickly pressed around the fovea. One function of the aperture is to control how much light can pass into the lens or camera. This gap can revolute in the estimate, becoming bigger – expansion in little light circumstances to permit all the further.

The eye focal point can change, fit as a fiddle or distort keeping in mind the end goal to center around light originating from various depths [6]. The retinal surface is secured with photoreceptor cells, so that the density of the light should be such that it is not too high that it affects the eye and cause the eye lens to contract and also it should not be too low that the camera becomes unable to track the movements of the pupil.

2.1 Goal of the system

1. Hands-free mouse controlling
2. To establish vision based system
3. Controlling mouse motions using facial gesture and voice
4. To eliminating the limitations of stationary head
5. To provide real time eye tracking

2.2 Eye Tracking Techniques

There is no universal technique to track the movement of the eyes. In any study, the selection of the technique rests with the actual demands of the application. During the analysis phase of this research, three techniques were analyzed; the Limbus tracking, Pupil tracking, and Electrooculography. Every technique has its own robust points and disadvantages. [7]

A. Limbus Tracking

Limbus Tracking explains a way of tracking the eye using the limbus. The limbus is the boundary between the white sclera of the eye and the darker iris. As the sclera is white and the iris is darker, this boundary can easily be visually detected as well as tracked. This technique is based on the position and shape of the limbus relative to the head, therefore the head must be kept quite still or the apparatus must be fixed to the user's head. This technique is negatively affected by the eyelid often concealing all or part of the limbus. This makes its uses limited to horizontal tracking. Usually this technique does not involve the use of infra red light[7].

B. Pupil tracking

Pupil tracking is a technique of gaze detection that is commonly used often in conjunction with different forms of tracking. There are several reasons for this; however the main advantage is the notion of the “bright spot”. Like the situation associated with red eye when taking flash photographs at night, infrared can used in pupil detection to form a high intensity bright spot that is easy to find with image processing. This bright spot occurs when infrared is reflected off the back of the pupil and magnified by the lens. The main advantage of pupil tracking is that as the border of the pupil is sharper than the limbus, a higher resolution is achievable. Also, as the pupil is never really covered by the eyelid, x-y tracking is more feasible as compared to Limbus tracking. The disadvantage is that the difference in contrast is lower between the pupil and iris than between the iris and sclera-thus making the border detection more difficult [7].

C. Electrooculography

The third category uses electric potentials measured with electrodes placed around the eyes. The eyes are the origin of a steady electric potential field, which can also be detected in total darkness and if the eyes are closed. It can be modeled to be generated by a dipole with its positive pole at the cornea and its negative pole at the retina. The electric signal that can be derived using two pairs of contact electrodes placed on the skin around one eye is called Electrooculogram. If the eyes move from the centre position towards the periphery, the retina approaches one electrode while the cornea approaches the opposing one. This change in the orientation of the dipole and consequently the electric potential field results in a change in the measured EOG signal. Inversely, by analyzing these changes in eye movement can be tracked. Due to the discretisation

given by the common electrode setup two separate movement components – a horizontal and a vertical – can be identified. A third EOG component is the radial EOG channel, which is the average of the EOG channels referenced to some posterior scalp electrode. This radial EOG channel is sensitive to the saccadic spike potentials stemming from the extra-ocular muscles at the onset of saccades. Due to potential drifts and variable relations between the EOG signal amplitudes and the saccade sizes make it challenging to use EOG for measuring slow eye movement and detecting gaze direction. EOG is, however, a very robust technique for measuring saccadic eye movement associated with gaze shifts and detecting blinks. Contrary to video-based eye-trackers, EOG allows recording of eye movements even with eyes closed, and can thus be used in sleep research. It is a very light-weight approach that, in contrast to current videobased eye trackers, only requires very low computational power, works under different lighting conditions and can be implemented as an embedded, self-contained wearable system. It is thus the method of choice for measuring eye movement in mobile daily-life situations and REM phases during sleep. The major disadvantage of EOG is its relatively poor gaze direction accuracy compared to a video tracker [8].

3. Proposed system

To detect and track a pupil of an eye by image processing techniques , we want to reduce the illumination influence as much as possible. It is known that a pupil has a characteristic which does not reflect an infrared light. Thus, we focus this characteristic and consider using an infrared light. In general, in the case of the use of a digital camera

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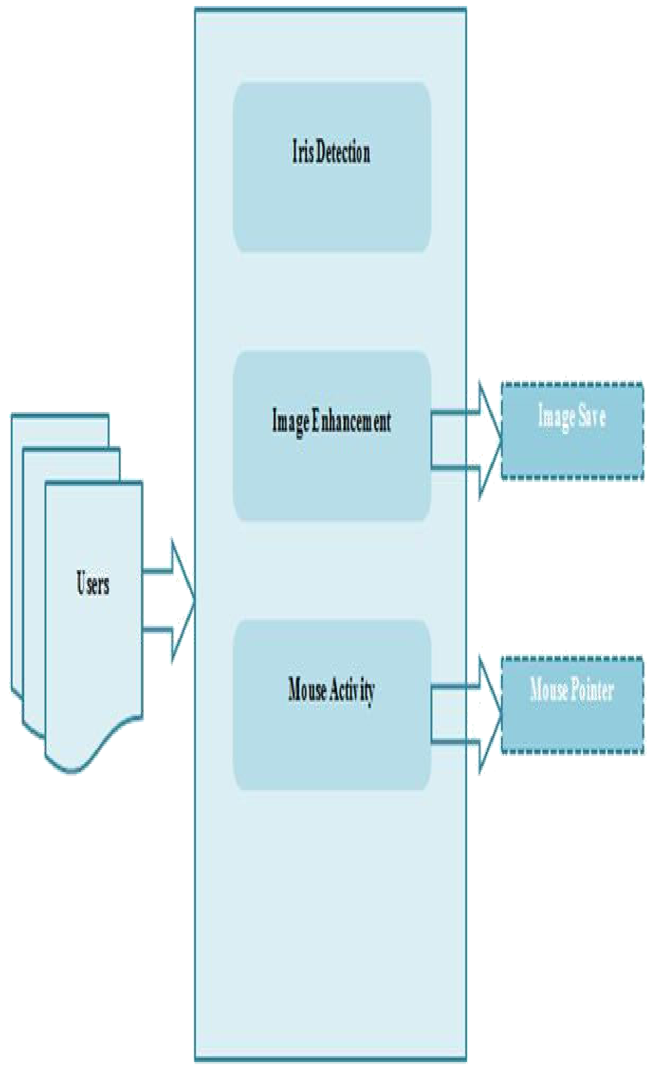
oriented for a visible light such as a web camera, these cameras may cut an infrared light. This leads to difficulty that we cannot use reflection of an infrared light. we use a sensitive infrared camera. The images obtained by a sensitive infrared camera still include many noises. Therefore, we use an infrared (IR) filter and expected to reduce the influence of noises. We use an IR filter which cuts the wavelength of light under 800 *nm*. With the IR filter, the camera is taken into an infrared light only. It effects to reduce influences of the illumination or noises. A part of an eye such as an iris except a pupil has a higher reflection rate of an infrared light. On the other hand, a pupil does not reflect an infrared light at all. Thus, a pupil in the video is comparatively easily detected. By an image processing technique: thresholding, a pupil part is detected. That is, by setting a comparatively small threshold value for thresholding, we can detect the pupil part.

4. Methodology

The goal of the eye-tracking algorithm is first to locate the eyes of the user from an image and then use the location information to perform certain functions. Static images are retrieved from an image library and are used to initiate the system. In the first stage, an efficient image enhancement sharpening filter is employed. This is followed by a simple method to segment the eyes. Following this, an iris detection method is used to find the direction of the user's gaze and

Figure 2. Proposed Architecture



finally the computed direction information of eye movements is used to drive the computer interface. Each step will be explained in detail in the following sections.

A. Image Enhancement

The first step after retrieving the input image is to enhance it. This increases the image definition by improving contrast. In the presence of noise, the sharpening and smoothing of the image are important pre-processing steps. These are usually the precursors in many operations such as object recognition, edge detection, feature extraction and pattern recognition (Liu et. al., 2002). Smoothing removes noise but typically also blurs edges. To facilitate edge detection and other similar processes, deblurring (sharpening) of the image is required.

B. Binarization

The first step to localize the eyes is through binarization. The segmented RGB image was first converted to grayscale by eliminating the hue and saturation information while retaining the luminance. The grayscale image is binarized using a global threshold value that is automatically calculated.

C. Iris Position Detection

Several calculations were performed on both cropped images in order to detect the actual position of the iris. This in turn indicates which direction the user is looking in. There were 8 parameters calculated, namely: (min_x, y_min_x, max_x, y_max_x, min_y, x_min_y, max_y, x_max_y). min_x is the value of the x-coordinate calculated on the left corner point of both eyes and y_min_x is the value of the y-coordinate at the same point. min_x was calculated by performing a raster scan and finding a white pixel whose x-coordinate value is minimum among all white pixels. Similarly at this point the value of y was also calculated. max_x is the value of x calculated on the right corner point of both eyes and y_max_x is the value of y at the same point. max_x was calculated by performing a raster scan and finding a white pixel whose x value is maximum among all white pixels. Similarly at this point value of y was also calculated. The value of min_y was initially set to 1. It was changed after scanning the image left to right and finding the first white pixel. At this point value of x was also calculated. max_y was also calculated after scanning the image from left to right until a white pixel whose y value is greater than all white pixels is encountered. At this point value of x was also calculated.

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5. System Setup

Figure 3. System Flowchart

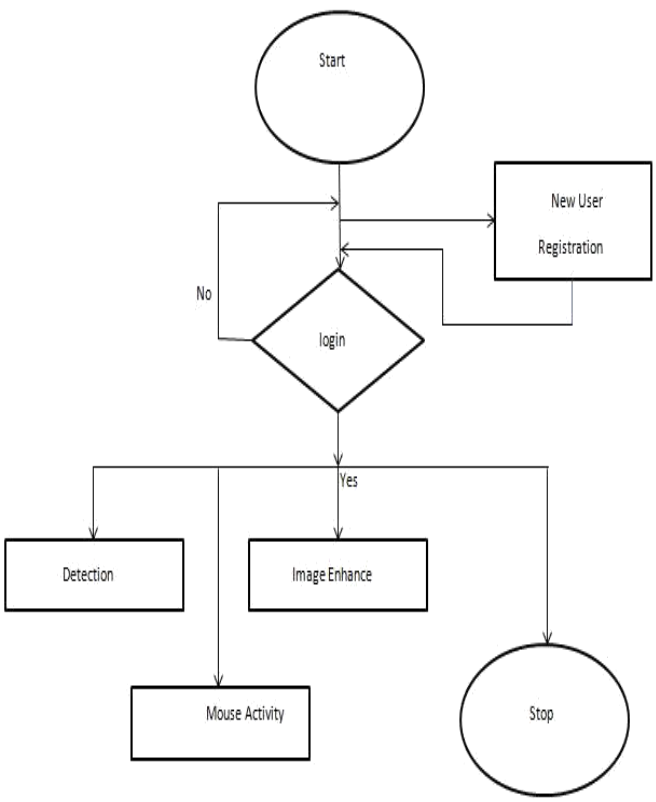

Figure 4. Flow Chart

6. Applications

1. Hands-free PC control can be used to track faces both precisely and robustly. This aids the development of affordable vision based user interfaces that can be used in many different educational or recreational applications or even in controlling computer programs.
2. Mostly this system is useful for handicap people to enjoy many computer activities and gives them opportunity to cooperate with the computer society.
3. The real life situation of eye tracking system. Eye tracking is test usability of software, interactive TV, video game, advertisement and other such activity. Eye tracking are used for reading techniques. Eye tracking uses to examine usability of websites where user will focus their attention on. The motivation from image viewing behavior, expectation of regarding web site and how use view web site.
4. On execution the application makes the cursor move with the help of the eye independent of the desktop.

7. Advantages

1. Hands-free mouse cursor control system.
2. Facilitating the incapacitated to use computers

3. Mouse pointer control through eye movements.
4. Real time eye tracking and eye gaze estimation is achieved through eye based human computer interaction provide.
5. Simulating mouse functions, performing different mouse functions such as left click, right click, double click and so on using their eyes.

8. Conclusion

A system that enables a disabled person to interact with the computer was successfully developed and tested. The method can be further enhanced to be used in many other applications. The system can be adapted to help the disabled to control home appliances such as TV sets, lights, doors etc. The system can also be adapted to be used by individuals suffering from complete paralysis, to operate and control a wheelchair. The eye mouse can also be used to detect drowsiness of drivers in order to prevent vehicle accidents. The eye movement detection and tracking have also potential use in gaming and virtual reality.

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