

Cursor Control Using Pupil Tracking

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Abstract— The research carried out in this technical paper suggests an innovative application of the widely implemented eye tracking techniques which can be very helpful to users with physical disabilities and enable various mediums of communication to the needy. The project mainly comprises of three sections namely image capture, image processing and cursor control. Adequate illumination needs to be used for capturing an image which will provide a well-defined shape of the pupil. This is done using infrared light since it is invisible to the naked eye and hence will not cause any strain to the user. The camera needs to be modified to capture infrared light and reject visible light. For this an infrared pass filter is mounted right before the image sensor. After obtaining the image, the shape of the pupil is recognised using Hough Transform and the centre coordinates are extracted. The coordinates provide a near accurate point of gaze of the eye and hence helps in determining the exact point on the screen where the user is looking. These coordinates will instruct the computer mouse to move to a specific location. The laptop screen size needs to be calculated first to appropriately map the received coordinates of the pupil centre. When the pupil cannot be detected for a specific range of delay a blink action will be registered and the program will instruct the mouse to execute the click function. This application of eye tracking can also possibly make way for new human-computer interaction methods.

Index Terms— Eye Tracking, Hough Transform, IR pass filters Pupil Detection.

I. INTRODUCTION

Eye tracking is a technique of determining either the point of gaze or the movement of an eye relative to the person's head. An eye tracker is a device for detecting and recognising the different positions and movements of the eye. The cursor of a computer basically can access any part and any functionality of a computer. Being able to control a cursor using only eye movements hence provides access to the complete functionality of a computer. MATLAB is a powerful tool for image processing because it provides so many inbuilt functions in toolboxes like Image processing toolbox, Computer system vision toolbox etc. Implementing shape detection using Hough transform has been made a lot easier by the updated image processing toolbox ver. 8.0.

II. WHAT IS EYE TRACKING?

Eye tracking is a technique for measuring the gaze or movement of an eye. This helps identify where the user is looking and has various applications.

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1. Eye attached tracking

This type consists of an attachment to the eye such as a special contact lens with a magnetic field sensor and the movement of this is tracked assuming that the lens will not slip significantly as the eye rotates. These lenses can provide extremely sensitive and precise recordings of eye movements this can greatly help scientists study the patterns of eye movements and apply these movements for desired functions.

2. Optical tracking

Optical tracking uses a non-contact external method for detecting and tracking the eye movement. Generally Infrared light is used to obtain corneal reflections which give well illuminated images of the eye. These images are sensed by a modified video camera or any other modified optical sensor. Exact rotation and movements of the eye are tracked with the help of the obtained infrared illuminated images.

Generally the centre of the pupil is determined in these corneal reflection images and the coordinates of the centre are used for the desired applications. These methods, are widely preferred for being very inexpensive and not requiring any kind of physical modification to the user's body.

3. Electric Potential measurement

This category involves measuring the electric potentials with the help of electrodes placed around the eyes. The eyes can manipulate. The derived electric signal is called Electroculogram (EOG). When the eyes move from the centre towards the periphery, the cornea approaches one electrode while the retina approaches the other electrode. This change in the electric potential and ultimately the EOG signal is measured and the movement of the eye is tracked.

Before using any eye tracker a simple calibration procedure is usually required. Every movement of the eye is tracked and specific functions are assigned to the different movement patterns and positions of the eye. It is still an emerging field with upcoming innovative applications in all kinds of every day devices for example in phones, different wearable devices etc.

III. CONSTRUCTIONAL DETAILS

The project requires minimal hardware, however some modification to the camera is required to obtain well filtered infrared images. The camera needs to be mounted on a frame which can be worn by the user. The camera used is a regular 8MP camera with optical focus.

1. Infrared pass filters- Usually cameras come with an IR blocking filter right in front of the image sensor. This filter is placed to reject some amount of IR light and pass visible light to obtain a good quality image. However for this application the reverse of this is required. There needs to be an IR pass filter which will block visible light and only pass IR light. The commonly used IR blocking filters work on the principle of selective blocking. They are designed for a cut-off wavelength and the design may differ from camera to camera. They block the light with wavelength higher than the cut-off wavelength i.e. the IR

wavelengths. On the contrary, IR pass filters are designed to pass IR wavelengths and block lower wavelengths. These filters may be a little difficult to find in the market but an IR filter can be found among many of presently obsolete items, for example the storage film of the floppy or the exposed negative film of reel based cameras. For this project a floppy disk film was used.

2. Modifying the camera-any regular camera consists of two main parts, the lens and an image sensor (usually a charge coupled device CCD). In the camera used there is a lens mount which can be unscrewed. We need to filter the visible light and pass infrared light and for this we need a filter. However this filter should not affect the resolution and the focusing of the camera. Hence this filter is placed right before the image sensor. Before placing this filter, the IR blocking filter of the camera needs to be removed which is an easy process. After the camera has been modified it simply needs to be mounted in front of the user's eye.
3. Mount- In order to create a comfortably wearable mount we can use the frame of a pair of any random sunglasses and attach the camera on it to detect the eye from a close range.
4. Distance from the screen to the user- This distance needs to be optimized appropriately in order to be able to accurately differentiate the different positions of the eye and properly track the centre. If this distance is too large then the movement of the pupil will be very less for traversing the range of the screen hence it will become difficult to accurately track the centre position. If the distance is too less then the eye movement will be too large and because of the curvature of the eye

IV. FORMULATION

The first thought that led to the formulation of this project was to enlarge the scope of image processing application for the benefit of the physically challenged people. Thus, the main idea of this project was to enable the physically challenged individual to manage the home appliances with ease, which in turn would make them equally independent as a normal human being. An inspiring example is Professor Stephen Hawking, an English theoretical physicist, cosmologist, author and Director of Research at the Centre for Theoretical Cosmology within the University of Cambridge. Hawking has a motor neuron disease related to amyotrophic lateral sclerosis (ALS), a condition that has progressed over the years. He is almost entirely paralysed and communicates through a speech-generating device. Despite his debilitating illness, he has done ground-breaking work in physics and cosmology, and his several books have helped to make science accessible to everyone.

Our project aims at helping people with similar problems and providing them access to a plethora of information and possibilities. The project also aims to curb the problem of cost of manufacture, as it is evident that no manufacturer will initiate any project that would increase the cost of production and thus decrease the volume of sales. Also less cost will help more number of people benefit from it.

V. WORKING

The project is composed of a webcam, infrared LEDs and a Laptop. The purpose of this project is to achieve complete functionality of the mouse, just by the movement of the eye. This project has been implemented using MATLAB version 2014a. We use basic principles of image processing like colour recognition and shape recognition (circle detection) for the detection of an eye pupil.

The webcam is being mounted on the frame of a sun glass. Mounting the camera exactly in front of the eye is crucial as it is required to obtain a focused image of the pupil to ensure proper detection. The camera captures the live images of the eye and sends the data to the computer. Infrared LEDs are mounted on either side of the camera lenses. The purpose of the infrared LEDs is to provide a well illuminated image of the of the eye pupil and at the same time they do not cause any strain to the eye. An infrared pass filter has been mounted right before the image sensor of the camera. The purpose of this filter is to pass infrared light whilst blocking visible light. This is essential to obtain a well-defined image of the eye pupil as shown in the image below.



Fig.1 Greyscale image

Using colour thresholding we filter black colour components from the image to obtain a black and white image. This is done because circle detection in a greyscale image may cause detection on unwanted circles or may detect the radius or the centre inaccurately. For thresholding, a proper threshold value needs to be selected to obtain a well filtered binary image of the pupil.

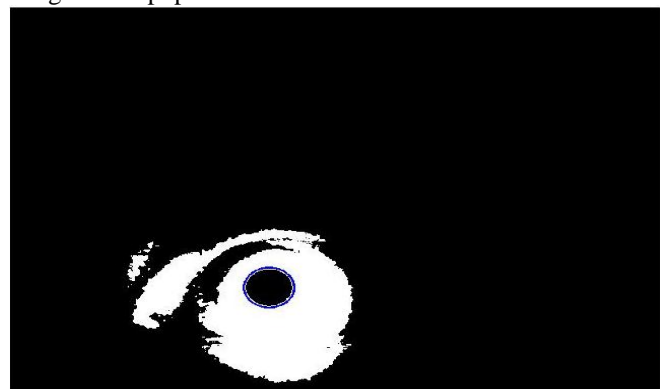


Fig.2 Binary image with detected circle

Then using shape detection (circle detection) techniques we detect a black circular shape and find out the centre of that

circle. The centre coordinates will provide the centre point of the gaze of the individual. This will help track the exact point where the user is looking. This is necessary for accurate tracking of the pupil. Centre detection can be done on the greyscale image also but it may not always produce the required results. The image below demonstrates circle detection in the greyscale image.



Fig.3 Greyscale image with detected circle

The camera repeatedly extracts frames from the video and carries out the same colour and shape detection procedure to continuously track the centre of the pupil

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Command Window
New to MATLAB? Watch this Video, see Examples, or read Getting Started.
>> testwithcirclecentre
centersDark =
    310.5650    208.6247
fx >> |
```

Thus we can accurately track the movement of eye pupil using MATLAB to assign the co-ordinates of the extreme position of the eye. Then MATLAB uses these co-ordinates to instruct a computer mouse to move to a specific location on the screen. The MATLAB program will continuously track the centre of pupil and instruct the mouse to move to corresponding co-ordinates.

A blink of the eye will interrupt the continuous process of shape and centre detection of pupil. This interruption will execute the clicking action of the computer mouse. A blink action is registered when the shape of the pupil cannot be detected for a specific delay of time. At this point the program instructs the mouse to execute the click action. Thus the user achieves complete control of the cursor movement of the mouse through eye movement.

VI. LIMITATIONS

The project finds limitations in the following mentioned areas.

- The project as mentioned earlier is proposed for physically handicapped and paralyzed people. It requires certain assistance for its operation in the areas of setting up the webcam and the laptop as well as initiation of the MATLAB program.

- For the perfect calibration of the webcam with respect to the eye it is required to take into consideration the movement of the user's head as well.
- The process of initiation is a time consuming process as it requires accurate set up for proper calibration ensuring its smooth functioning.
- At present, only either the left/right click actions of a mouse can be executed. Other actions such as scroll and middle button click cannot be executed. This will need an extra input either from the other eye or some other external input.

VII. FURTHER APPLICATIONS

The scope of this project can be widened by increasing the number of functions such as managing an onscreen keyboard, which would enable the user to type short messages using any text editor. Also, programs such as paint can be designed specifically for easing the accessibility to the user. Applications can be designed to enable control of lights, fans, television set and other home appliances. It can also be used for operating and thereby accessing various mobile functionalities such as an intruder alarm to alert other household members of the assistance required or informing someone in emergency situations by sending a pre-drafted message on selected mobile numbers when the user is physically unable to send distress calls.

VIII. CONCLUSION

The project, when implemented by taking proper care of the limitations as mentioned enables a physically handicapped or paralyzed person to gain complete control over the mouse of a laptop or a computer by the movement of the eyes. This project enables user to become more independent and makes him capable to handle his/her work that can be managed using a computer/laptop.

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REFERENCES

- [1] <http://www.mathworks.in/help/images/hough-transform>
- [2] <http://www.mathworks.in/help/images/edge-detection.html>
- [3] <http://www.mathworks.in/help/images/ref/imfindcircles.html>
- [4] http://en.wikipedia.org/wiki/Stephen_Hawking

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