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Human Computer Interaction using Iris and Blink Detection

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Abstract— This paper demonstrates a novel thesis for the human and computer interaction. It represents a hands free interface which eliminates the need for the use of mouse or touchpad. The complete human-computer interaction is controlled by the user's eye movements. Hence, it is useful as an application for the physically disabled individuals. A new algorithm is designed to implement the above stated theory. A LSS algorithm is used for the eye detection.

Keywords— Eye, Blink detection, Longest line scanning, Iris detection, Computer screen.

I. INTRODUCTION

Eye tracking has long been used to analyse user behaviour in a wide range of human-computer interaction. The user's eye movements are used as a medium for the interaction between the human and the computer. This technology is very useful for the disabled people who face difficulty while pressing the keys, using the touchpad or the mouse, etc. and it thus aims at replacing the most common hardware, the mouse. They can overcome such problems only with the help of their eye movements. The goal is to help an active mind which is obstructed and hindered due to the difficulty in communicating. To achieve this goal, we designed a camera based computer interface and that makes the interaction possible by detecting the eye-gaze direction and simulating the corresponding computer mouse input. Since, both the eyes focus on a single point, it is customary to track only one eye.

There are various eye tracking algorithms such as Longest Line Scanning Algorithm, Occluded Circular Edge Matching Algorithm, Six Segment Rectangular Filter, Electro-Oculography, Limbus, Pupil and Eyelid Tracking, Contact Lens Method, Corneal and Pupil Reflection Relationship, etc. The LLS and OCEM is used for iris centre detection.

To implement this process, the suggested algorithm uses a scaled ratio which depends on the measurements of the eye and the display. We use the LLS algorithm to detect the eye and the blink detection algorithm to perform the task such as the right click, drag and drop operations, left clicks.

This technique is useful for the physically handicapped individuals. This process begins and ends using the Ctrl button. As the system does not require any specialized or complex hardware, it is available to the public at a much lower cost.

II. LONGEST LINE SCANNING

Longest line scanning algorithm is used for iris centre detection. Eye position is not sufficient enough for tracking the eye accurately. The direction of visual attention of the eyes must be measured more precisely from the eye image. The reason for choosing iris is because sclera is light and the iris boundary is dark, therefore iris boundary can easily be optically detected and tracked. The **iris** (plural: ***irises***) is a thin, circular structure in the eye, responsible for controlling the diameter and size of the pupil and thus the amount of light reaching the retina. Iris is projected in an elliptical shape. As per the property of ellipse the centre of an ellipse lies on the centre of the longest horizontal line inside the boundary of the ellipse.

Input: an eye image of any one of the eyes of the user.

Output: apply threshold on eye image and other image processing technique such as canny edge detection, etc.

Thresh – threshold of iris colour.
Taking the binary of the eye image
I – taking the binary of the block image
Finding the centroids of the eye image pixels.
Detect edges of I.
If there are exactly two points with longest distance from the centre then select the two points (p1, p2).
Find the midpoint of the two points (p1, p2) = m = (p1+p2)/2

Store the midpoint obtained in the output.

III. BLINK DETECTION

Whenever the eye is not moving blink detection process is executed because whenever the user wants to click using the mouse, the user drags the mouse pointer to the desired location, stops and then clicks. In the similar way the user will look at the desired location, stop and then blink; accordingly the particular task will be performed.

There are two types of blinks:

1. Short blinks which are spontaneous and are involuntary blinks and are ignored by the blink detection algorithm. (shorter than 200 ms)
2. Long blinks which are user specified blinks or voluntary blinks. This blinks are considered for the blink detection algorithm.(longer than 200 ms)

Blink detection algorithm separates the voluntary and the involuntary blinks and detects single voluntary blinks or sequence of blinks. (Applications, like fatigue monitoring, human– computer interfacing and lie detection.)
Eye-Blink detection algorithm consists of 3 major steps:

1. Eye region extraction
2. Eye-blink detection
3. Eye-blink classification

Correlation coefficient is the similarity between the current eye images with respect to a saved eye image. Correlation Coefficient can be used to measure the openness of the eye.
If the coefficient for any two consecutive frames is lower than the predefined threshold value TL or greater than predefined threshold value TH, then eye blink is detected.
If the blink is detected between 250 ms and 2s then such blink is considered as voluntary control blink otherwise involuntary eye-blink detection.

IV. EYE

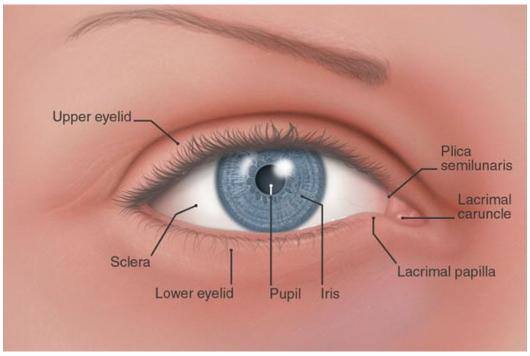

Fig. 1 Structure of an eye:

Iris – It is the coloured and circular structure in the eye. It controls the light entering in the eye. Depending on the amount of light entering, the muscles attached to the iris expand or contract the pupil. The larger the pupil more is the light entering in the eye and making contact with the retina. The eye colour represents the colour of the iris.
Pupil – the normal pupil size of a human being varies from 2-4 mm in bright light and 4-8 mm in dark light. They are generally of equal size and located at the centre of the iris. It allows the light to strike the retina of the eye.
Sclera - is opaque, fibrous, protective and the outer layer of the eye containing elastic fibre and collagen. It is also called as the white of the eye.
Dimensions of an eye:
The dimensions of eye differ among human beings by only one or two millimetres. The vertical measure of the eye is generally less than the horizontal measure of the eye. The eyeball is about 1 inch (2.5 cm or 25 mm) in diameter. The eye weighs approximately 7.5 grams (0.25 oz). And the volume of eye is six cubic centimetres approx.
Eye Movement:
There are six muscles that control the movements of each human eye. The six muscles are: the lateral rectus, the medial rectus, the inferior rectus, the superior rectus, the inferior oblique, and the superior oblique. When these muscles exert different tensions, a torque is exerted on the globe that in turn causes the eye to turn, in almost pure rotation, with only about one millimetre of translation. Thus, the eye can be considered as undergoing rotations about a single point in the centre of the eye.
Field of view:
Assuming perfect eyes, one eye around 47°, both eyes around 95°. Depends on what you are doing, looking up close or far away. One eye alone covers 45 to 50 degrees in a cone shape. There is an overlap in your vision, so with both eyes focused on an object you cover about 100 to 120 degrees, about the same as a 32MM lens on a 35 MM film camera. You have depth perception because of the overlapped portion. The overlapping portion is only about 30 degrees or so.
Least distance of distinctive measure = 25cm.
Blinking types:
Spontaneous blink – It can be called as the natural blinking that occurs without the person realizing about any such eye movements. Spontaneous blinking helps in clearing the tears away that are constantly produced by the human eye. It is the most common type of blink and it is so short that your brain is unable to notice them, if you are not focusing on it.
Reflexive blink – The kind of blink that occurs in response to an event or a situation is known as the reflexive blinking. Like a loud sound or an object approaching your eye. It helps in protecting your eye from external threats as the eye closes when a stimulus occurs. These are automatic reflexes that are intractable.

Voluntary blink – Voluntary blinks are caused intentionally by the person. They last for a slightly longer time than the spontaneous blink and can occur for different reasons. For example, if someone's eyes start to feel dry or they feel uncomfortable, they might blink to wet and comfort their eyes.

Importance of iris detection:

The iris of the eye has been described as the ideal part for eye tracking system because iris is an internal organ that is well protected against damage and wear by a highly transparent and sensitive membrane (the cornea). The iris is mostly flat, and its geometric configuration is only controlled by two complementary muscles (the sphincter pupillae and dilator pupillae) that control the diameter of the pupil. This makes the iris shape far more predictable than, for instance, that of the face. An iris scan is similar to taking a photograph and can be performed from about 10 cm to a few meters away. Iris recognition works with clear contact lenses, eyeglasses, and non-mirrored sunglasses.

V. ALGORITHM

1. $eh :=$ *horizontal length of the human eye.*
2. $ev :=$ *vertical length of the human eye.*
   (The standard measure for both the values is $eh = 2.4cm$ *and* $ev = 1.2cm$*)*
3. $sh :=$ *horizontal length of the computer screen.*
4. $sv :=$ *vertical length of the computer screen.*
5. *Divide the eye and computer screen into an* $x - y$ *Cartesian coordinate system consisting of all the four quadrants.*
6. *Calibrate the iris and the center of the screen to make them coincide with the origin i.e.* $(0, 0)$ *point.*
7. *Calculate the scaled ratio* (R) *such that*
   $$Rx = \frac{eh}{sh}$$
   $$Ry = \frac{ev}{sv}$$
8. *Longest Line Scanning algorithm is applied to detect and track the iris movements.*
9. *Locate the current* $x - y$ *coordinates of the iris and let it be equal to* ex *and* ey *respectively.*
10. *Calculate the screen cursor coordinates using the following formulae :*
    Four cases will be possible depending on the position of iris in the four quadrants.
    $sxi :=$ *screen x coordinate before the blink.*
    $syi :=$ *screen y coordinate before the blink.*
    I. $sxi = \left(\frac{sh}{2}\right) - \left(\frac{ex}{Rx}\right)$
    II. $syi = \left(\frac{sv}{2}\right) - \left(\frac{ey}{Ry}\right)$
11. *For a single or left click, gaze your eyes for a pre – defined threshold time value on the folder or the area where you want a click.*
    (Threshold time = 300ms).
12. $sxf :=$ *screen x coordinate after the blink is detected.*
    $syi :=$ *screen y coordinate after the blink is detected.*
    If a blink is detected using the blink detection algorithm then calculate the new coordinates sxf *and* syf *using the formulae stated in step 10.*
    a. *If* $sxf = sxi$ *and* $syf = syi$ *then perform a right click operation of the mouse.*
    b. *Else drag the selected item and drop the item at the new coordinates obtained when the second blink is detected.*
13. *If Ctrl button unclicked, goto step7.*

VI. PROPOSED APPROACH

Fixed values: eh = 2.4 ; ev = 1.2 ; sh = 30 ; sv = 20

Example (1) (See Fig. 5)

1. Calculating the scaled ratio from step (7):

   Rx= 2.4/30 = 0.08

Ry= 1.2/20 = 0.06

2. Locating the iris of the eye at (0.4, 0.6)

ex= 0.4

ey= 0.3

3. Since, the iris is located in the 1st Quadrant:

sxi= (30/2) - (0.4/0.08)
= 10

syi= (20/2) - (0.3/0.06)
= 5

The final co-ordinates on the screen will be (20, 5).

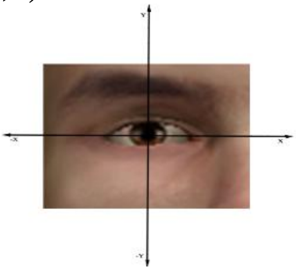

Fig. 2 Sr. no. (1) Iris at the origin (0, 0).

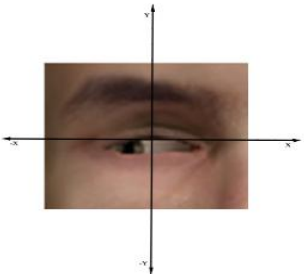

Fig. 3 Sr. no. (3) Iris in the third quadrant (-0.8,-0.6).

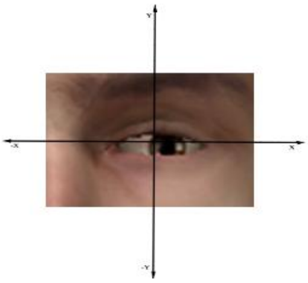

Fig. 4 Sr. no. (4) Iris in the fourth quadrant (0.4,-0.2).

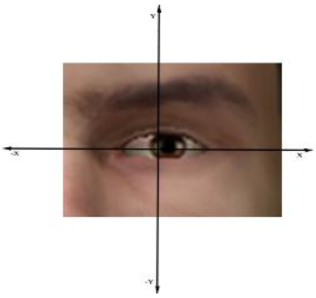

Fig. 5 Example (1) Iris in the first quadrant (0.4, 0.3).

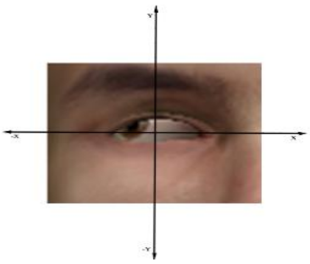

Fig. 6 Sr. no. (2) Iris in the second quadrant (-0.5, 0.4).

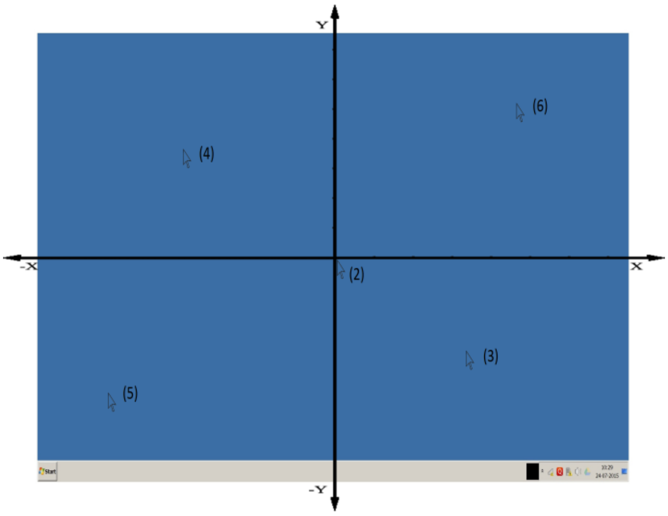

Fig. (7) Corresponding screen cursor coordinates.

Now taking Rx= 0.08 and Ry= 0.06 we perform experiments on a few values:

TABLE I EYE COORDINATES AND THE CORRESPONDING SCREEN COORDINATES

Sr. no.	Fig.	ex	ey	Eye - coord	sxi	syi	Screen -coord
1	2	0	0	(0, 0)	15	10	(15, 10)
2	6	-0.5	0.4	(-0.5, 0.4)	21.25	3.34	(21.25, 3.34)
3	3	-0.8	-0.6	(-0.8, -0.6)	25	20	(25, 20)
4	4	0.4	-0.2	(0.4, -0.2)	10	13.34	(10, 13.34)

VII. FUTURE SCOPE

The System provides a dependable software solution for paralytic people and people with motor disabilities, through uncomplicated eye tracker hardware, which ultimately allows the person with severe disabilities to manage functionalities of computer.

1) Track user eye movement and control mouse movements.
2) Track user gaze at a particular position and thereby enable mouse clicks.
3) Use detected mouse operations to control computer functionalities.

VIII. CONCLUSION

However, if the camera is placed too high above the user's head, in such a way that it is aiming down at the user at a significant angle, the blink detection is no longer as accurate. This is caused by the very small amount of variation in correlation scores as the user blinks, since nearly all that is visible to the camera is the eyelid of the user. Thus, when positioning the camera, it is beneficial to the detection accuracy to maximize the degree of variation between the open and closed eye images of the user. Finally, with respect to the clinical environment, this system provides an unobtrusive alternative. It is concluded that using a web camera as a human computer interface can be viable input method for the severely disabled person.

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