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# Computer Vision System for Eye Gaze Tracking

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**Abstract:** Eye gaze tracking is a technique use for checking the usability problems in the Human Computer Interaction (HCI). Initially they are present tracking technology and key elements. Eye gaze tracking technique is based on the behavior of the user when they are looking. It can use for different kinds of methods i.e. "electro-oculography(EOG), Sceleral Search Coils, infrared oculography(IOG), video oculography(VOG), different models, probable approaches i.e. "shape based approach, appearance based methods, 2D and 3D models based approach. The eye tracking applications likes human computer interaction, brain computer interaction, assistive technology, e-learning, psychology investigation, pilot training assistance, virtual and augmented reality and so on. The Proposed system uses Head pose detection, eye region detection, eye feature detection, eye vector calibration, Gaze Estimation and eye gaze tracking modules. This system is to design and implement eye gaze tracking system in desktop environment.

**Keywords:** Gaze tracking, Head pose, Illumination Changes, Web Camera, video occulography

## I. INTRODUCTION

Eye gaze tracking has recently research field that has applications in many different fields, including human computer interfaces (HCI), virtual reality (VR), drive monitoring, eye disease diagnosis, and intelligent machin interfaces. In various applications using eye gaze trackin system are shown such as user–computer interaction in deskto environment.

Eye gaze tracking systems can find the position of user i looking at by using image processing and computer visio technologies. Various kinds of gaze tracking devices, invasiv and non-invasive with single or multiple cameras have bee used. Non-invasive gaze tracking systems are designed fo computer users in a desktop environment using a near-infrare (NIR) camera and an NIR illuminator. In this paper video baseu gaze tracking is used. The video based gaze tracking technique is improved by good quality and accuracy of the gaze. The system can take the real time video by using web camera. The real time video to grabs the frames and this frame can check the head position and gives the eye region and this help to detect iris corner and eye center. The gaze error is produced by gaze vector which is sensitive to head movement. The system uses Head pose detection, eye region detection, eye feature detection, eye vector calibration, Gaze Estimation and eye gaze tracking modules.

In Fig. [1] Hierarchy of eye tracking applications likes Interactive and diagnostic. The interactive applications are divided into two types selective and Gaze contingent. Selective systems use the point of gaze as to a pointing device such as the mouse. The selective system can be use in handicapped users. Gaze-contingent systems exploit knowledge of the user's gaze to facilitate the rapid rendering of complex displays. [1]

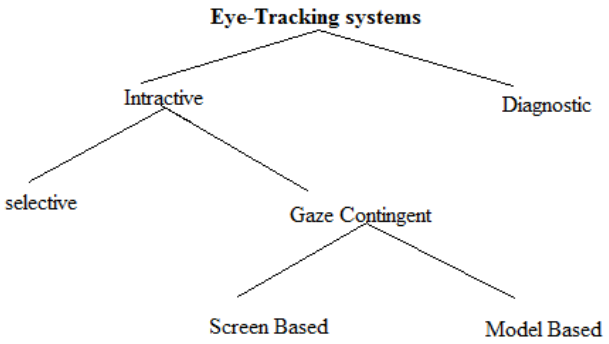


Fig.1 Hierarchy of eye-tracking application [2]

## II. RELATED WORK

Kayung-Nam *et al*[1] discusses the estimation and eye-movement tracking. Different methods of eye gaze tracking are used for this purpose. Techniques comprising the Limbus, electro-oculography, Eye-lid tracking, Pupil detection etc. Image processing and computer vision techniques are used for measuring eye gaze. Estimation based on geometry is better approach than estimation based on adaptive. Object which is under observation is allowable to move in a usual mode. Find out the correspondence between face model and camera image point to compute eye gaze.

Linda *et al*[2] takes the computer as input and demonstrates advantages of eye gaze of human. For this purpose two experiments are addressed in this paper.

Preliminary test result displays that eye-gaze technique is better and faster approach for selecting from sub menus than from mouse selection. In Circle experiment the change of speed through eye is very clear. Authors worked on Fitt's analysis that points out main fact that we have tested that cost is approximately constant if and only if you are moving you eye in limits and in that case improvement of eye is greater.

Susanna *et al* [3] tells in paper that in what way the interaction based on gaze are implemented and used in an augmented reality system. Main purpose was to check gaze control's functionality of application. In AR-system worthwhile tool that is eye-gaze control tool is designed for developing designing interfaces and interaction approaches of the system; and to develop augmented reality with joined eye tracker system.

Dan Witzner *et al* [4] intensions are on detection of eye and tracking of gaze in video based gaze trackers. Different methods and techniques for eye detection and tracking, and eye models are addressed in this paper. Surveys are done for gaze estimation in this paper and compare them on their geometrical based properties and described correctness. In short, that type of system should be built that are easy to use and of low cost, negligible, normal movement of head and under illumination changing conditions, estimation accuracy for gaze should be good. There is problem that some experiments are conflicting such as low number of calibration and flexibility.

Chennamma *et al* [5] worked on non-contacting based on video gaze tracking development. This paper includes terminologies and definition, improvements in this filed and development of this filed in future. Different methods are used in this paper to track motion of eyes such as electro-oculography, infrared oculography, video oculography, sceleral search coils etc. Feature-based gaze estimation, appearance-based gaze estimation methods are used for gaze tracking. The gaze tracking system needs to become low in cost and accuracy of data capture needs to improved in order to make them useful tools.

Robert *et al* [6] describes some representative past studies for eye tracking. This paper also involves aspects of different types of devices and well-known applications, different software algorithms for pupil detection, recording eye movement, data filtering, image processing etc. An eye-tracking application covers human computer interaction (HCI), brain computer interaction, e-learning, virtual reality and so on. By use of eye tracking methods in e-learning it is possible to capture learner behavior in real-time.

Poole *et al* [7] tells main concepts of tracking technology of eye their usage in HCI. To alert researchers of many eye movement measures, this paper helps to give an applied guide. Different methodologies such as electro oculography and video based eye tracker etc.

Sharma *et al* [8] describes study to understand main ideas of Augmentative and alternative communication (AAC) and for developing effective AAC. These research papers identify and utilize different eye gaze methods. Some issues related to interactivity limitations, performance issues, price, orientation, sound resistance, capable to work in narrow lightening situations, simulation, maintenance and real time detection, etc in designing such models have been discussed in this paper.

Manu Kumar [9] presents gaze based interaction techniques developed as part of dissertation. Main aim of this research is to augment current interaction techniques. This paper focuses on gaze enhanced scrolling techniques, offerings several different methods for gaze-based scrolling including augmenting manual scrolling techniques. Different applications are used that describes design and evaluation of eye-gaze based techniques for switching between applications. Also discusses use of eye-gaze based password entry to lessen threats of shoulder surfing and explains that why the obvious implementation of such a system fail to work. This research also present new idea for eye- gaze based interfaces and discusses some of challenges for using eye-gaze input and presents solutions to these challenges. It discover design space of communication techniques that use gaze data for everyday computing tasks and propose technology and business model changes to modify the emergence of mass-market eye trackers, low-cost.

## III. SYSTEM ARCHITECTURE

The system contains number of pre processing steps:

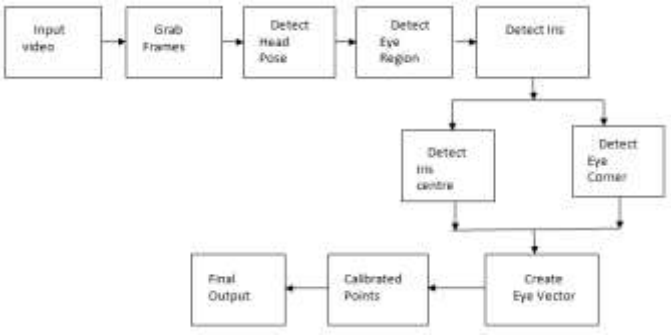


**Figure2.** System architecture

### *A. video capture:*

To capture the video by using the web cam. The video that is capture is used to utilize the open computer vision library

(Open CV) to automatically identify the co-ordinates of face in the frame of video recording.

### *B. Head Pose Detection:*

The head pose detection model first detect the face and roughly classify the pose as frontal problem .The PCA method is used in statistical approach which is used for reducing the number of pixel in face.

### *C. Eye Region Detection:*

In eye region detection model the two-stage method are used to detect the eye region. Local sensitive histogram and Active shape model. The active shape model extracts facial feature on the gray image through which the illumination changes are eliminated. There are three types of active shape model. **1. Feature selection:** The obvious features which are denoted as (Xi; Yi) are selected and expressed as a vector x = (x1.....xn; y1.....yn) T **2. Statistical shape model:** The set of landmark point should be aligned to analyze and synthesize new shapes to those in the training set**.3. Fitting:** This model fit the new shape input by translation, rotation and scaling the vector that contains the facial features.

### *D. Detect the Iris:*

The iris detection model is used in edge detection method. The edge detection method can easily serve as a detector of the iris. The different kinds of edge detector have been evaluated. The sobel operator and canny operator. The canny operator detects the very high no of edges within the eye images.

### *E. Detect Iris centre:*

The iris centre detection model is used to Modify Hough Transform algorithm. The Hough Transform algorithm is a facial feature extraction technique aimed at depending a certain class of shapes such as lines, circles and ellipses within an image.

### *F. Eye Corner Detection:*

There are two types of corner detection **1.inner Corner 2. Outer corner**. The inner eye corner is used for gaze estimation because eye status and is more salient than the outer eye corner and it is insensitive to facial expression changes. The Inner eye corner guarantee the gaze direction accuracy. The Open Cv is used for corner detection.

### *G. Create Eye Vector:*

The eye vector is the combination of the iris centre and eye corner. It provides the gaze information to obtain the screen co-ordinates by mapping function.

### *H. Calibration Process:*

A calibration is the procedure to record the eye vector of users with set of target point at which they look. By using mapping function the relationship between the eye vector and the co-ordinates on the screen is determined. Different mapping functions are used such as SVR model, simple linear model.

## IV. ALGORITHM

**1.** Start capture video by using webcam
**2**. For I=1 to all Frames do
**3**. Extracting facial features by using ASM
**4.** Extract the eye region
**5.** Detect the iris centre X_iris
**6.** Detect the eye inner corner X_corner
**7.** Eye vector is obtained: w = X_corner –X_iris
**8.** Get static gaze point (ua; ub) by mapping function
**9.** Track the face features
**10.** Obtain the face feature and head pose
**11.** Get the displacement (Δua; Δub)
**13**. End for

## V. MATHEMATICAL MODEL

Let X be the system, it represent mathematically using set theory,

$$X = \{F, I; H, R, E, C, Tn; Ts\}$$

**1 .Input Set:**

$F = \{fi; 0 < i < n\}$ .....set of video frames.

where,

n = no of frames.

$|F| \neq 0$

**2. Pre-processing set:**

**A.** $H = \{hi; 0 < i < m\}$ ...set of pixels at head position.

Where,

m=no of pixels in head.

$\exists hi \mid hi \in P$

P = {pi; coordinate from PCA Face Model}

$hi \in I$

**B.** $R = \{ri; 0 < i < k\}$ .....set of pixels at eye region.

Where,

k=no of pixel in eye region

$\exists ri \mid ri \in P$

P= {pi; coordinate from PCA eye Model}

$ri \in I$

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**A.** $E = \{ei; 0 < i < k\}$ ***set of pixels in Edge.***

Where,
k=no of pixels in edge.

$$\exists ei \mid ei = \begin{cases} true, dist(ei, ei+1) \pm \theta \\ false, otherwise \end{cases}$$

$$\theta = edgeThreshold$$

$$ei \in I$$

**D.** $C = \{ci; 0 < i < k\}$ ……set of pixels in circle

Where,
K=no of pixels in circle

$$\exists ci \mid ci = \begin{cases} true, dist(x, y), ci) \cong r \\ false, otherwise \end{cases}$$

R=radius

$$ci \in I \ , \ ci \in E$$

**E.** $Tn = \{ti; 0 < i < n\}$ ……set of calibration points

Where,
n=no of calibration points

$$\exists ti \mid ti = \{(x, y)\theta, \Delta\}$$

(x,y) centre of Iris

$$(x, y) = \begin{cases} true, \forall ci(x, y), ci) \cong r \\ false, otherwise \end{cases}$$

$\theta$ =angle between eye centre and Iris centre

$\Delta$ = Distance between eye corner and iris centre

$$ti \in R$$

**3.OUTPUT SET:**

$Ts = \{ti; 0 < i < n\}$ ……set of calibration points

Where,
n=no of calibration points

$$\exists ti \mid ti = \{(x, y)\theta, \Delta\}$$

(x,y) centre of Iris

$$(x, y) = \begin{cases} true, \forall ci(x, y), ci) \cong r \\ false, otherwise \end{cases}$$

$\theta$ =angle between eye centre and Iris centre

$\Delta$ = Distance between eye corner and iris centre

$$ti \in R, ti \in Tn$$

## VI. IMPLEMENTATION

In implementation phase first capture the whole face image and detect the attributes of face and eyes. After detecting the attribute and apply the eye gaze tracking method as shown in fig 3.

## VII. EXPERIMENTAL RESULT

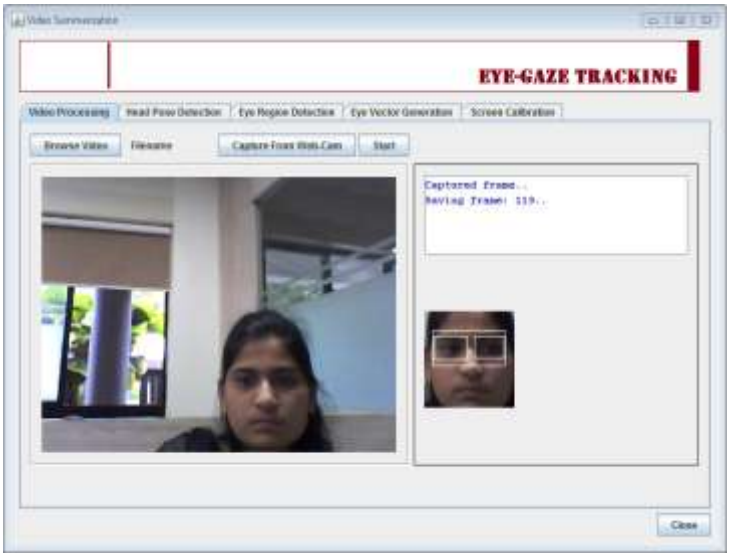


**Figure3**. Face and Eye region Detection

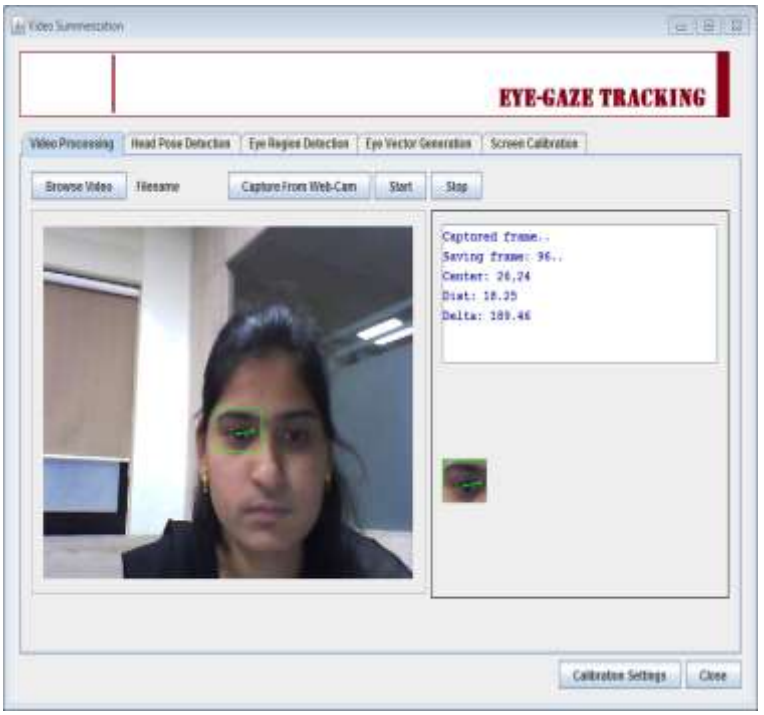


**Figure4.** Eye centre and Eye corner detection

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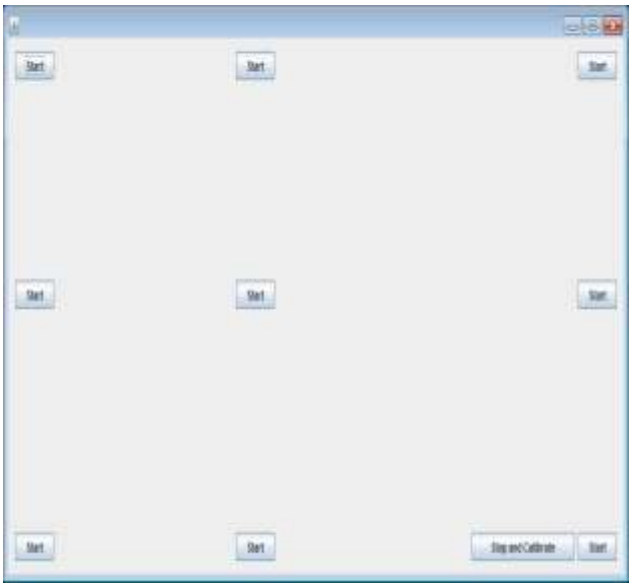

**Figure5**. Calibration Process

### A .Data table Discussion:

**Table1.** Input Data

| Sr. No | Target Points | No. Of Eye Images Trained | Screen Resolution |
|---|---|---|---|
| 1 | 9 | 10 | 1024x768 |
| 2 | 9 | 15 | 800x600 |
| 3 | 9 | 20 | 1152x864 |

To estimate the system, first select the input in terms of number of points on the screen to be set as Target Points for desktop screen calibration and number of eye images used for training as input triplets (XY co-ordinate. Distance, Angle) and desktop screen resolution for calibration. Table1 shows the input taken for the experiment.

### *B. Results:*

**Table 2.** Performance measurement table

| Sr.No. | No. Of Eye Images Tested | No. Of Images Calibrated | No. Of Eye Images Correctly Calibrated | Recall | Precision |
|---|---|---|---|---|---|
| 1 | 10 | 9 | 7 | 0.77 | 0.9 |
| 2 | 20 | 15 | 11 | 0.73 | 0.75 |
| 3 | 25 | 18 | 15 | 0.83 | 0.72 |

Table2. Shows the performance measurements calculated after testing the system. I keep training environment as it is for testing purpose. The system performance is measure in terms of Precision and Recall.

1. Precision = No. Of Images Calibrated / No Of Eye Images Tested

2 .Recall = No. Of Images Correctly Calibrated / No. Of Images Calibrated.

Result analysis assume precision as accuracy measure while recall as availability measure. After carrying the testing phase we found the Mean Precision (MP) and Mean Recall (MR) as 0.73 and 0.72 respectively.

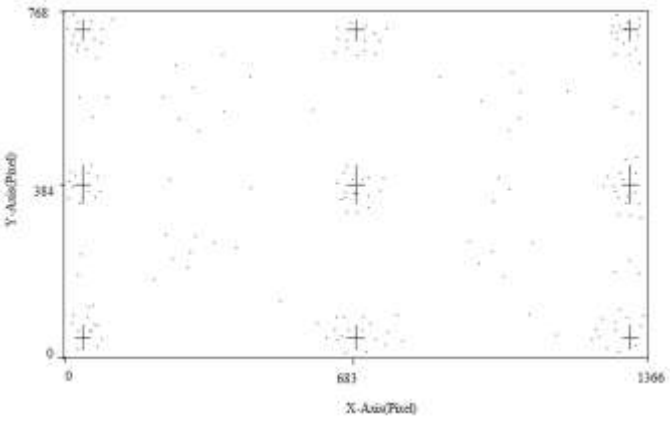


**Figure6.** Points of gaze are marked as the dot points, while the target point is marked as a cross. The *x*-axis and *y*-axis correspond to the screen coordinates.

### *C. Result Graph:*

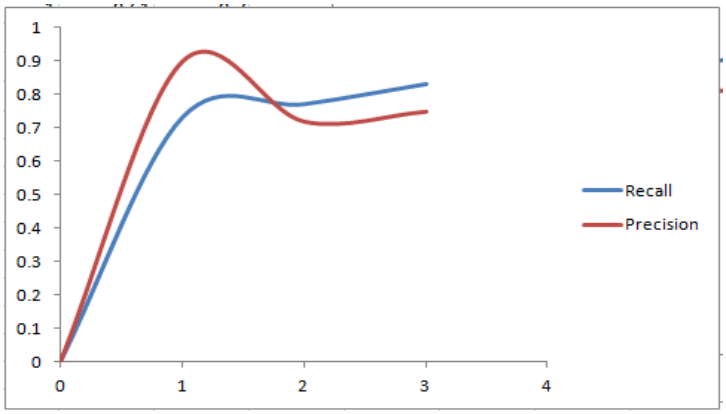


**Figure7.** System performance measurement graph

The above graph represents the analysis of availability of system and it also represents the accuracy of system.

## VIII. CONCLUSION

Eye Gaze Tracking can detect a piece-wise eye corner and the edge strength helps to locate the iris centre and find the position where user is looking. The accuracy and robustness of the gaze estimation is improved by Eye centre, Eye corner and head movement.

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