

SURVEY OF AN EYE TRACKING – EYE TRACKING TECHNIQUES AND APPLICATIONS

¹Dr.N.Nandhagopal, ²S.Navaneethan, ³V.Nivedita, ⁴Dr.S.Anbukaruppusamy

¹Associate Professor, ²Research scholar, ³Research scholar, ⁴Professor

^{1,4}Electronics and Communication Engineering, Excel Engineering College, Namakkal, India.
^{2,3}Anna University, Chennai.

Abstract: Eye Tracking implies the process of quantifying where our vision is called as the point of gaze. Measurements shall be carried out by the eye tracker which archives the movement of our eyes and they make. Eye tracking stores the point of gaze and the eye ball movements in connection to the ambience and it is commonly based on the optical tracing of the corneal reflections also known as pupil center corneal reflection (PCCR). The eye tracking can disclose what people view at screen; the hierarchy in which the visual parts are fixated upon, how much time the fixation lasts. There are variance eye trackers which are based on screen and glasses eye trackers. In screen based eye tracking the devices which entails respondents to look before a monitor with screen based content and in glass based eye trackers the mobile devices are employed to be fitted close to the eyes then the glasses possibly move during the process when a large amount of movement takes place. The devices of eye tracking are contiguously generated and launched on the market. In this paper we have narrated the methods of eye tracking which are being emerged in the real world, furthermore the methods of eye movement and their factors for quantifying have investigated. Apart from implies the state of art, mentions the possible applications of eye tracking in health care which have not been briefly scrutinized yet.

Index Terms – Eye Tracking, Iris Recognition, Pupil, Iris Code.

INTRODUCTION

The eye detection or eye tracker is the sensor technology that permits a device to get to know distinctly where our eyes are focused and it regulates our presence, attention, drowsiness, consciousness and other fatigue states. This intelligence shall be used for acquiring the deep accurate and understanding in to consumer behavior or to model the new interfaces across diverse devices. When comes to eye tracking in the real world the three factors comes to our mind that is construe the human behavior, allows hand free interplay, and user experiences of the humanized user interfaces. By adjoining the eye tracking with other input modules, for instance keyboard, mouse, and voice. Employing the eyes as a pointer at a screen the methods of eye tracking facilitates interoperation with nodes and other gadgets when the user unable to resort their hands as a input form.

Biometric technology

It is a measurement and statistical determination of identifying people's distinct physical and behavioral traits. The biometric technology is mainly used for recognizing and access control and also for sensing the individuals when they are under surveillance. The bare ground of biometric authentication is that each person can be precisely sensed by his or her unique behavioral factors. The term Biometric is originated from the Greek work where Bio is Life and Metric is to measure. The two important types of biometric technology identifiers are depend on either physiological factors or attitude characteristics. The Biometric technology works by the factor of authentication by biometric verification which turns in to increasingly regular in corporate organizations. Some biometric methods such as quantifying a person's gaze which can drive with indirect contact with the person is being authenticated. The components of biometric devices include,

- a) The gadgets for reading or scanning device to store the biometric factor being authenticated.
- b) To convert the scanned data in to regularized digital format and to compare the actual points which are observed and stored data.
- c) Considering the database for securely storing the biometric data for the usage and comparison in future.

The Biometric data can be possessed in a centralized database though new biometric implementations often relies on procuring biometric data locally and according to that the biometric data is cryptographically hashed as a result so the authentication and identification could be attained without open access to the biometric data itself.

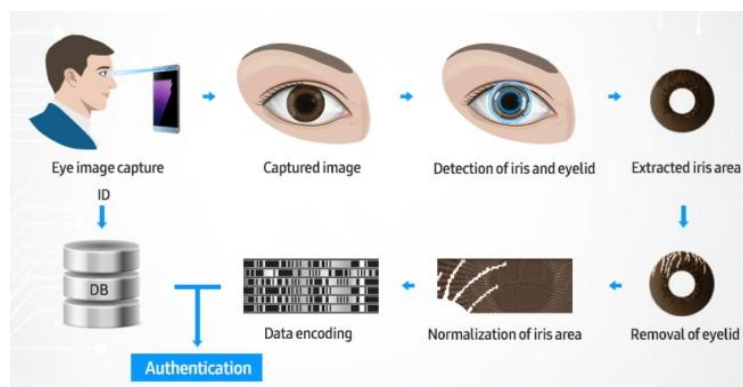


Fig.1 Detection and Authentication of an Eye

Human Iris

The Iris is a slim circular structure in an eye responsible for limiting the diameter and the pupil size so that the amount of light towards reaching the retina is rapidly. In humans the color of iris is commonly blue or

brown whereas the pupil in the centre is circular black spot and surrounded by the white sclera. The cornea is utterly clear so it is invisible except the gloss luster it gives the eye. The eye color is defined in terms of the individual person's of Iris which comprises of two layers the front and the beneath the front layer is pigmented fibro vascular also known as stroma and the beneath layer is pigmented epithelial cells. The Iris is bifurcated in to two regions,

- a) The Pupillary zone is the inner region whose border poses a boundary of the pupil.
- b) The ciliary zone is the outer region which extends to the origin in the ciliary body.

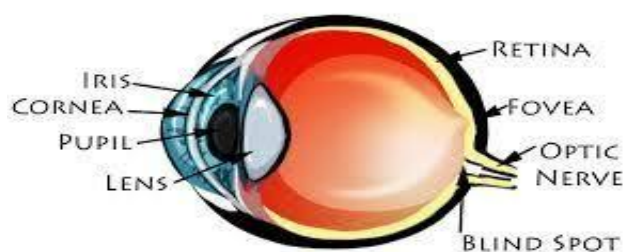


Fig. 2 Human Iris

Iris Recognition

Iris recognition is an auto system of biometric identification which uses the techniques of mathematical pattern recognition of motion images in both of the irises of the individual eyes whose bottleneck patterns are special, even, and could be seen from long distance. There are many algorithms based on iris pattern recognition techniques proposed by authors in that the author John Daugman evolved and patented the first realistic algorithms to conduct a iris recognition. The classification of algorithms based on two factors.

- a) Visible wavelength iris image.
- b) Near infrared (NIR) version.



Fig. 3. Iris Recognition

Advantages and disadvantages of Iris scan

The advantage of iris scanning is the accuracy and reliability. The prediction of accuracy and reliability is to be ten times accuracy than fingerprinting which poses around 1 in 100,000. The fingerprints are consistently exposing and conformable to the damage and the pupil around the eye is intrinsically guarded by the cornea (the transparent eyes in the front layer) and the model seems to sustain integrally remains same for decades. Unlike pattern recognition the fingerprint scanners also require the direct contact and have to be kept spotlessly clear. To scan the iris the method of processing should be done safely and hygienically at little bit distance from the eye.

The disadvantages of scanning the iris includes bigger initial cost and in the fact that there is still remains relatively untried technology for example in some instances we have found a higher rate of unsubstantial matches to the originally derived.

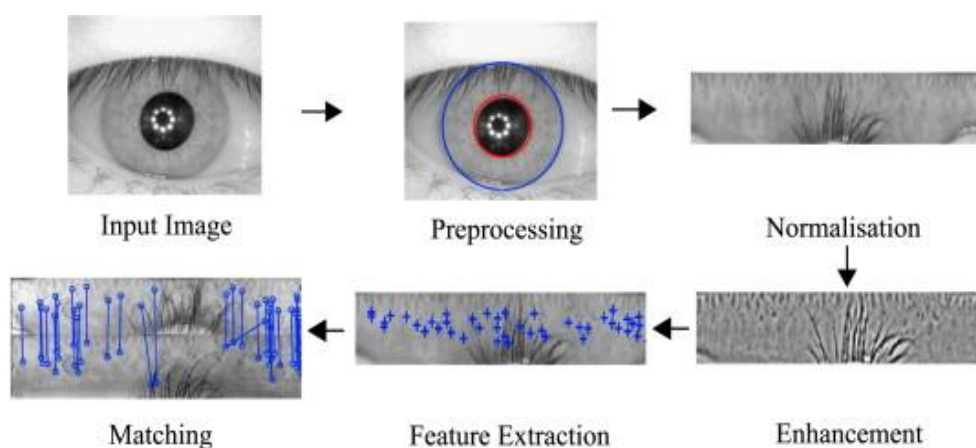


Fig.4. Steps of Processing using Iris Scanner

The iris scanning seems to be a futuristic but the backbone of the system is bare digital camera. Iris scanning employs both visible and short infrared light to snap a evident high quality contrast picture of persons pupil around the eye. In the short infrared light when look at the person's pupil in the eye is black and it facilitates the system to separate the pupil and iris. When we look back the iris scanner the rear end of camera automatically focuses or resort the mirror in the computer to ensure that the eyes are positioned exactly. Typically the eyes are 3 to 10 inches from the camera. While the camera in mobile takes a image the system resides are,

- a) The center of the pupil
- b) The edge of the pupil
- c) The edge of the iris
- d) The eyelids and eyelashes

II. EYE TRACKING TECHNIQUES

The research in eye position tracking and some eye movements has implied in the previous article which are mostly in psychology. Though pursuant to the evolvement of eye tracking techniques during the past decades, the broader exploitation of eye tracking methods and its characteristics has turned in to viable. For over the period of time the methods of such information gathering have been influentially changed. In fact the most precise or exact and at the same time the intrusive methods are based on a contact lens furnished with images. The visual activity sheds off rapidly from the retina to the visual periphery. The optimal visual activity has found in a parafoveal area of 1-5 degrees from the fovea.

In order to process the visual eye we shall shift the eye balls such that we aim it in such a way that we procure the highest resolution which is in the fovea. The anatomy of the individual person's eye ball movement relies on the muscles of the eye.

- a) Superior rectus muscle.
- b) Inferior rectus muscle.
- c) Lateral rectus muscle which lies opposite symmetrically.
- d) Inferior oblique muscle that is adapted from the movement of eye balls. Typically an eye fixation takes time about. 5 seconds commonly the eye processes all visual data driven during a fixation and started the execution of the any action. In case any execution required. When more data is present then another fixation is required. The techniques of eye tracking are,
- e) Electrooculography (EOG)
- f) Contact lens techniques
- g) Limbus tracker
- h) Video based pupil
- i) Corneal Reflection



Fig. 6. Eye Image Recorded with and without IR Filter

Electrooculography

The electrooculography is one of the techniques of eye tracking methods. The electrooculography exploits the corneo-retinal method which exists between the front and back of the human eye. The corneo-retinal is quantified with the exploitation of physical electrodes presented in the surrounding of the eye. While the eye spins towards the person or any things it will turn in to more positive on the other side the rotation in the opposite direction becomes less negative. The electrooculography method is viewed as connectively cumbersome and inopportune for the entities.

Disadvantage

The restriction of this use solely for the laboratory essays without the viability for its application on a day to day basis and gadgets scenarios.

Principle

The eye acts as a dipole in which there are classified in to two categories that are anterior pole which is positive and the posterior pole which is negative.

Left Gaze: the cornea moves towards the electrode which are far the outer canthus of the eye in left that results in negative trending transition in the stored potential variance.

Right Gaze: the cornea moves towards the electrode which are far the inner canthus of the eye in left that results in positive trending transition in the stored potential variance.



Fig. 7. Electrooculography

Contact Lens

The more precise and most intrusive techniques of eye tracking is contact lens which is provided with mirrors. It is being embedded in the eye a thin copper wire is presented in the silicon annulus and the contact lens is associated to the optical device such as a magnetic coil that scales the difference of the electromagnetic field while a person spins his or her eye balls. Though due to the complexness of method the scale of the experiment has to be restricted to 20 min even when the eye is unconsciousness which curbs the employment of the method. A method that comprises identifying one or more patterns on the modeled contact lens on the eye of the individual person. The direction of the eye ball in the person's eye is evaluated based on the

detection of the one or more pattern elements. The modeled elements could be detected using a single pixel sensor. The pattern which contains for an instance the pattern may be having a different forms of colors.

Advantages

The advantage of availing contact lens for tracking the eye and viewing the information of 3D in that they are more pragmatic that is miniature, small weight, and portable. When compared to other peripheral devices the contact lens is mainly employing for 3D viewing information.

- a) Furthermore the contact lenses can accord highly precise tracking eye information in moderate cost. For an instance when using contact lenses for the eye gazing or tracking the performance function will be good than the one that can be accomplished along with based on camera eye tracking methods.
- b) When compared to camera based solutions which entails established high resolution cameras, contact lenses facilitates for giving at low cost solutions which make them more appropriate for customer products.
- c) In the diverse embodiments, a amalgamation of marker and marker less based eye tracking methods availing contact lenses furnish interoperate with entities such as video game, projected virtualized user interface. And augmented reality user interface.
- d) In one embodiment the person can be outfitted with a magnetized contact lens which may be captured by one or more electromagnetic sensors positioned far a video game console.

Contact lens techniques

There are two types of techniques employing in contact lens which are as follows.

- a) Sclera coil
- b) Mirror reflector

Sclera Coil

The sclera search coil is relied on the current flow through induction loop and it is a fine temporal resolution. In sclera the supreme spatial resolution is less than 10arcsec which is not comfortable as well as easily adapted for the animal research. The sclera lens also called sclera contact lens and it is a colossal contact lens which rest on the sclera and poses s tear filled vault over the cornea. The sclera lens are designed for to handle a diverse of eye situations most of which do not reciprocate to other forms of treatment. The modern sclera lens are build up of a highly oxygen permeable polymer which are special in their framework in that they suits on to and assisted by the sclera the white portion of the eye. The reason of the exclusive positioning is typically related to a particular patient whose pupil can be much sensitive to assist the lens instantly. While comparing to corneal contact lenses the sclera coil swell outward more. The

area between the cornea and the lens is replenished with artificial tears. The semi liquid which is formed in a tiny elastic reservoir, complies to the inconsistencies of the deformed cornea which empowers vision to be retained suitably.

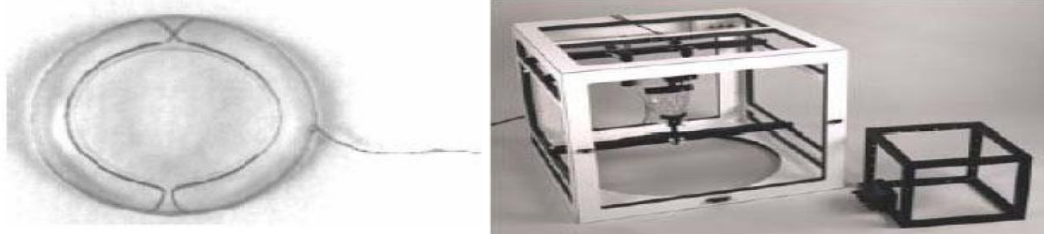


Fig. 8. Scleral Search Coil

Sclerar Mirror

It is a suction cup mounted mirror that reflects optical reference beam. The important inertial mass better the good temporal solution the moderate spatial accuracy is 1 degree which is exquisitely inopportune requires anesthesia and the detailed sampling epochs solely head immobilization required. Sclera mirror is a prototypical lens dated back early 1880’s. these sclera lenses are modeled by using a substance to make a mold of the eye. The contact lenses will be shaped to comply with the mould. In previous sclerals were not contain oxygen preamble which gravely limited the amount of oxygen imparted to the cornea of the wearer.

The sclera of contact lens yields surged again after oxygen permeable things. It was firstly exploited in rigid gas permeable in short RGP lenses turned in to available for other users. The latest evolvement of digital imaging methods has permitted some providers to estimate and testify the fitness of great accuracy. A multitude of sclera fabrications has also posed contact lens include sclera lenses with practiced points of adjustment available. So that every lens could be adapted through a lathe to be better match the contours of the single eye.

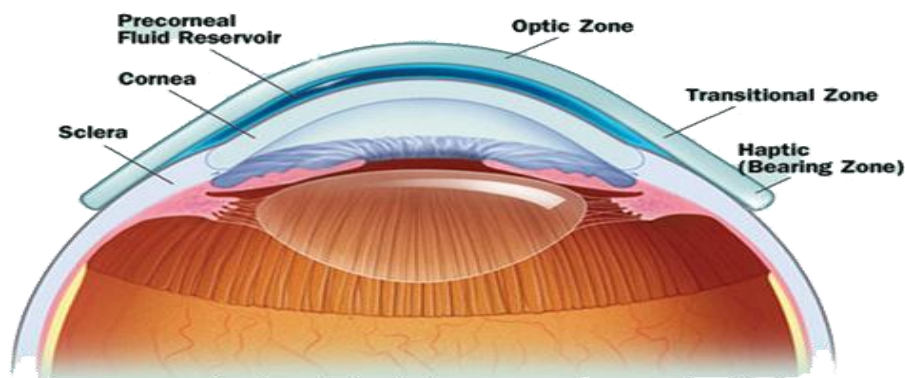


Fig. 9. Sclerar Mirror

Limbus Tracker

Limbus tracker depends up on the differential reflectance of sclera and the iris and it is a high temporal resolution which are less than 1000Hz, exhibits poor spatial accuracy and it has a very limited operating range that is 10 degree and horizontal EM's only. In limbus tracking the two bare approaches for POG computation. The first is relied on 3Dmodel of the rotations of eye ball and calculation of ray emission from a central point within the eye. Then the POG is computed as the dividend of the ray and some surface of interest in the environment. The limbus tracking comprises of three common steps performed on each eye image frame which are as follows,

- a) Image preprocessing
- b) Feature detection
- c) Ellipse fitting

Image processing

In image processing it is essential to filter the each frame so that blur or noise in the image is alleviated while restoring as much as viable. As like starburst algorithm we embark the process of eye camera image along with gaussian filter to mitigate the noise of image. The Gaussian filters are beneficial in mitigating noise sensitive to any algorithm that exploits gradient information. In addition the dividable nature of 2D Gaussian allows effective implementation. Mostly the noise in video or image begets using OTS cameras is because of lossy compression. The lossy compression algorithm shall be anticipated to pose some sensitive artifacts in the motion video. As number of artifacts are empowered the videos could turn in to more compressed. The algorithms we have used here specifically became to permit artifacts as long as they just simply noticeable. It is commonly known as merely noticeable difference. The image processing methods are typically much sensitive to the artifacts than the human eye.in most shortened schemes bifurcate the image in to tiny blocks and perform a conversion of each block separately. The elements with in the block are rounded. As adjacent blocks are different we are left with borders with small edges. There are inopportune borders poses wise gradients that cover the sharp gradients with the edges of the desirable factors. The Gaussian filter smoothens the picture removing highly localized gradients the gradients which are wiser are blurred but not ousted. In starburst the complete gradient picture has not prefiltered instead calculated during traits detection. It was conceived that processing a mitigated computation. Though gradient assessing is barely a driven one which are analogous to Gaussian smoothing and evolve with the derivative of the Gaussian. We have chosen to facilitate implementation by computing the gradient.

Feature detection

In limbus tracker feature detection are found as two steps. As in starburst the feature points in first step comes from the starting seed doing and ends the ray as it comes out from a dark region. In the second step

the feature detection method is iterated with rays back out from the side features towards the seed point. It tends to surge the multitude of feature points on the pupil around the eye. The light does not ends until the length of the gradient component equals with the ray transcends the some fixed threshold.

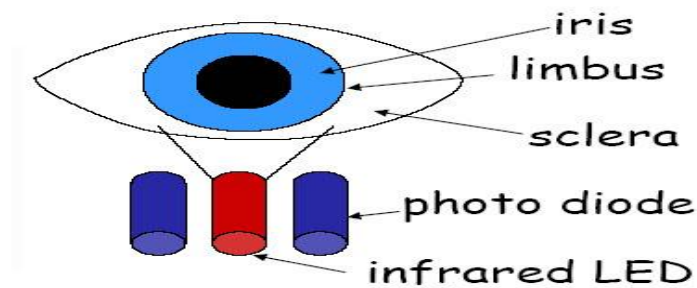


Fig. 10. Feature Detection

Though this method is somewhat effective in some lighting conditions but it is quite delay sensitive to the fixed threshold chosen. Recognizing of an perfect threshold is amazed by the fact that increased thresholds are quite useful for gleaming light in the lower thresholds in dark light.

Ellipse fitting

The starburst algorithm exploits the random sample consensus (RANSAC) model to suite the ellipses to the feature points. It was selected because of the tolerance of the outliers. The outliers are typical in the witnessed feature sets. Here we are creating random ellipses in a same manner but instead of assessing it based up on the factors of real image. The proposed algorithm that is starburst is accomplished using the ellipse fitting. The starburst ellipse fitting is in addition becomes bottleneck to distinguish ellipses that unbiased the span of pupil. The feature points could be divided in to one of two similar sized bins. The feature point dividing permits the creation of ellipses in to two sets which are,

- a) One relates to iris/sclera limbus
- b) The other is pupil/iris boundary

An eye tracker which permits the use of calibration coefficients between sessions instead of recaliberate the every session is preferable.

Determining the position of an eye

A set of eye archives procured from an eye tracker is context to the latest image processing aimed at evaluating the subsequent positions of the eye and the direction of a gaze. The image based eye identification and sensing is an wide subject and variance methods have been evolved to abstract pupil from an image of the eye. In the literature it is divided in to two main groups appearance based and feature based.

Appearance based methods

In appearance based methods it directly calculates the factors from the occurrence of eye images and assess the points of gaze exploiting a function mapping to a region of groups.

Feature based methods

The feature based methods may review an image of an eye in order to get its traits which for an example the pixels of blackest that relates to pupil or iris. The infrared light application makes possible the process since it augments the contrast between the two elements of an eye. Many of this kind of methods avail an image segmentation during that processing an image has been translated in to grayscale and context to binary threshold to accomplish a evident image in which the pupil around the eye is implied by a dark region. A suitable threshold value has used to abstract the region relating to the pupil is clearly essayed. The center of gravity of the dark region is assessed center of the iris.

The process in which the dark region is ascertained in to white one may also detected. In sometimes when a picture is factored by low resolution and contrast the standardization of the histogram image is employed. This process augments the contrast of the determined image permitting the point out of details slightly visible. The various approaches are presented by the Timm and Barth (2012) availed the snap gradients and a derivational function of the vector field traits which permits to model the relationship between the determination of relative position of an image gradients and a likely center of the eye. It relevant to the location where almost all gradients vectors intersect.



Fig. 11. Variance of Eye Movements

Video Based Pupil

One of the most popular methods of eye tracking is video based pupil eye tracking method shortly known as (VOG) which records the eye rotations in terms of digital video cameras. The process of eye tracking captures a consequent images. The eye locations and rotations are decided by the resort of the data procured from the images captured. In addition the eye camera has to be located in a way that images remain clear in

the recording. The VOG eye detectors don't entail direct contact with eyes it facilitates more applicable and less intrusive. However newly relatively it's a bottleneck and very expensive this method is due to the technological, image processing, and feature detection algorithms evolvement has turned in to affordable for the broader research fraternity. Though it must be reminiscing the accuracy of eye trackers it influentially relies on the resolution of images they archive.

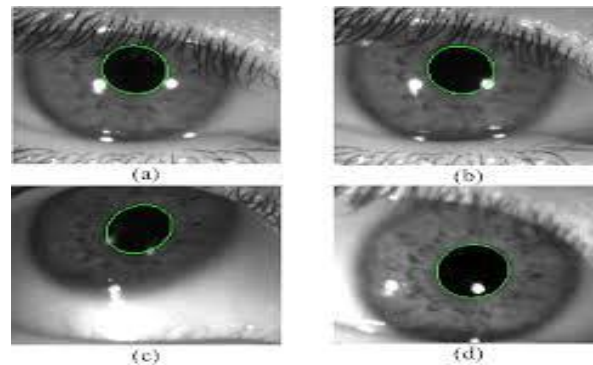


Fig. 13. Video Based Pupil

Corneal Reflection Technique

The corneal reflection technique is relies on the real time image processing to identify and localize pupil around the eye and corneal reflection. The corneal reflection technique required the IR Illuminator which is to sense the data happening in the ambience. The temporal resolution relies on the eye camera frame rate such as 60, 120, 240, 500 HZ). The corneal reflection moderates the spatial accuracy which are less than 1 degree. Here the bright pupil is bit robust versus dark pupil around the eye in the daylight. In corneal reflection technique there are two factors which are as follows,

- a) Head mounted
- b) Remote optics



Fig. 13. Corneal Reflection

III. APPLICATIONS OF EYE TRACKING

The eye tracking allows recording the position of an eye and movements rries on optical detecting of video based analysis or corneal reflections so that creating the examination of eye movements and gaze gestures or positions in both 2D and 3D ambience viable. The eye tracking assists to review the human processing of

visual data for interplay and diagnostic applications. The eye trackers were earlier the vast and cumbersome. Eye trackers scales attention, interest which poses a great method for human behavior research. The following eye tracking applications are most typically used which are as follows,

- a) Academic and scientific research
- b) Market research
- c) Psychology research
- d) Medical research
- e) Usability research
- f) Packaging research
- g) Pc and gaming research
- h) Human factors and simulation



Fig. 14. Application of Eye Tracking

IV.CONCLUSION

This paper has presented an survey of eye tracking techniques and its applications. In Biometric technology we have identified the measurement and statistical determination of identifying people's distinct physical and behavioral traits. The biometric technology is mainly used for recognizing and access control and also for sensing the individuals when they are under surveillance. In eye tracking techniques the paper has reviewed the traits of each technique specifically which would be beneficial for reference. The techniques such as Electrooculography (EOG), Contact lens techniques, Limbus tracker, Video based pupil, and Corneal Reflection. And the last the applications of eye tracking has been investigated typically.

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