

Techniques Used for Eye Gaze Interfaces and Survey

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Abstract

Eye movement tracking is a method that is now-a-days used for checking the usability problems in the contexts of Human Computer Interaction (HCI). Firstly we present eye tracking technology and key elements. We tend to evaluate the behavior of the user when they are using the interface of eye gaze. Used different techniques i.e. “electro-oculography, infrared oculography, video oculography, image process techniques, scrolling techniques”, different models, probable approaches i.e. “shape based approach, appearance based methods, 2D and 3D models based approach and different software algorithms for pupil detection etc”. We have tried to compare the surveys based on their geometric properties and reportable accuracies and eventually we conclude this study by giving some prediction regarding future eye-gaze. We point out some techniques by using various eyes properties comprising nature, appearance and gesture or some combination for eye tracking and detection. Result displays eye-gaze technique is faster and better approach for selection than a mouse selection. Rate of error for all the matters determines that there have been no errors once choosing from main menus with eye mark and with mouse. But there have been a chance of errors when once choosing from sub menus in case of eye mark. So, maintain head constantly in front of eye gaze monitor.

Keywords: Eye movements; Eye gaze; Eye tracking; Augmented Reality (AR); Gaze-based interaction; Iris detection; Eye tracking algorithms and Human Computer Interaction (HCI).

1. Introduction

For human computer interaction, natural user interface is a system that user handles through natural activities linked with natural behavior of human being. Natural user interface could also be handled in different ways that depends on users’ needs and objective. Our analysis field is gaze-based interfaces. EYES are normally used for observation not for control. Eye movements are extraordinarily fast, natural and need very little accurate aware effort. Direction of gaze implicitly indicates main target of attention.

An interface of gaze tracking enables the users through movement of eye to guide a system. Gaze tracking has number of possible applications that’s helpful for society. Gaze tracking finds application in medical research and for police work purpose. Recent application of Eye tracking involves scrolling impact like after we move our eye up or down consequently it will scroll up or down.

1.2 Literature Review

We have conducted a comprehensive survey of ten research papers and compare them.

Kayung-Nam *et al*[1] discusses the estimation and eye-movement tracking. Variety

techniques of eye gaze tracking are used for this purpose. Techniques comprising the Limbus, electro oculography, Eye-lid tracking, Pupil 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, scleral 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.

Jowers *et al* [10] worked on Computer aided design tracking interfaces and gives different models that are used to collect gaze information to support dynamic shape study 2D vector sketch editor. Different implementations of eye tracking interfaces are described. Totally different eye tracking methodology area unit are introduced during this paper. To implement the eye tracking interface, this paper describes assorted so as a result its outcomes and user study are reported. This paper results are positive.

2. Analysis

Eye Expose was "natural," "faster" and "less annoying" when put next to other approaches. They additionally reported that they liked not having to move their hands off keyboard to use mouse when compared to using expose. Subsequent factors such as normalization, illuminating conditions, specific region and accuracy in eye detection are needed to increases the effectiveness and efficiency of eye gaze based models. So these factors ought to be analyzed. Parameters should be chosen carefully because they are responsible for efficiency and effectiveness of output. System should be of low cost easy to use. Following methods such as fixation leveling, saccade algorithms, co-ordination between aye and hand are developed to spice up the accuracy and user's expertise of gaze-based inform.

2.1 Parameter Table

Table 1: Displays all possible parameters

Parameters	Value
Tracking approach	Non- intrusive, Intrusive
Tracking type	Vision based, Image data, Eye data
Input	Eye typing, Eye image, Hand, Keyboards, Mouse-based
Iris center detection	Longest line scanning Occluded circular edge matching algorithms
Reference model	2D Simple mark 2D and 3D digital models 2D vector sketch editor
Imaging system	Orthogonal projection
Resolution	8x10 1/60 sec. resolution 640x480 pixels resolution 800 × 600 pixels and a field of view of 37 × 28 degrees.
Sensing technology	Video Cameras, Stereo Cameras, Video Glasses, Microphones, Audio, Black/white gaze tracker camera, Micro-displays, Graphical displays
Tracking algorithms	Geometric models, Image to screen mapping, Eye models, Starburst algorithm, Image processing, Data filtering, Pupil detection
Gazing points determination	Geometry based, Adaptive estimation, Feature based gaze estimation, Appearance based gaze estimation
Measuring eye gaze	Computer vision, Image processing, Eye-gaze selection techniques
Fitts' Law	Speed and quality difference between Eye-gaze and mouse selection
Set of interaction techniques	Eye movement-based (gaze-based) interfaces, Graphical interface, incorporating real-time fixation recognition, Local recalibration, Nearest-neighbor selection, Various dwell times and timeouts.
Interaction techniques in AR system	Manual inputs, Gestures interfaces, Speech interfaces
Gaze tracker technologies	Displays, Optic devices, Image sensors, Real-time Signal processing, Eye detection sensor
Methodology (Approaches)	Appearance based methods, Feature based shape methods, Shape based approach, Sequential search strategy, 3D model based approach, Deformable shape model, Interpolation- based approaches
Tracking techniques	Limbus, Electro-oculography, Pupil, Cornea reflection Eyelid tracking, AAC techniques, Infrared oculography, Video oculography, Scrolling techniques with gaze-repositioning, Scleral search coils etc.

2.2 Analysis Table

Table 2: Displays analysis

Reference	Parameters						
	Author	Tracking approach	Tracking type	Input	Iris center detection	Reference model	Imaging system
[1]	Kyung-Nam <i>et al</i>	Non-intrusive	Image data	Eye image	LLS, Occluded circular edge matching algorithms	2D Simple mark	Orthogonal projection
[2]	Linda <i>et al</i>		Vision based	Hand, Mouse	N/A	N/A	N/A
[3]	Susanna <i>et al</i>		Vision based	Eye typing	N/A	N/A	N/A
[4]	Dan Witzner <i>et al</i>	Non-intrusive	Image data, Eye data	Eye image	N/A	2D and 3D Digital model	N/A
[5]	Chennamma <i>et al</i>	Intrusive	Vision based	Eye	N/A	N/A	N/A
[6]	Robert <i>et al</i>		Image data	Mouse based	N/A	3D model	N/A
[7]	Alex <i>et al</i>		Image data, Vision based	Eye image	N/A	N/A	N/A
[8]	Sharma <i>et al</i>		Image data	Eye image	N/A	N/A	N/A
[9]	Manu Kumar May 2007		Eye data, Image data	Eye image, Hand, Keyboard, Mouse	N/A	N/A	N/A
[10]	Jowers <i>et al</i>	Non-intrusive	Image data	Mouse, Keyboard	N/A	2D vector sketch editor	N/A

Reference	Parameters						
	Author	Resolution	Sensing technology	Tracking algorithms	Gazing points determination	Measuring eye gaze	Set of interaction techniques
[1]	Kyung-Nam <i>et al</i>	8x10	Video camera, Microphone	Starburst, Geometrical model, Image processing, Data filtering	Geometry and Adaptive based	Image processing, Computer vision.	Gaze based interfaces
[2]	Linda <i>et al</i>	1/60 sec. resolution	Audio	N/A	N/A	Eye gaze selection technique	Eye movement and Graphical interface, Incorporating real-time fixation recognition, Local recalibration, Nearest-neighbor selection, Various dwell times and timeouts
[3]	Susanna <i>et al</i>	640x480 pixels, 800 × 600 pixels and a field of view of 37 × 28 degrees.	Black/white gaze tracker camera, micro displays	Image processing	N/A	Computer vision	Gaze based interface, Real time fixation recognition
[4]	Dan Witzner <i>Et al</i>	N/A	Video camera, Graphical displays	Eye model, Geometrical model	Feature and Appearance based gaze estimation, Geometry based	Computer vision	N/A
[5]	Chennamma <i>et al</i>	N/A	Stereo and Video cameras	Geometry model	Featured base gaze estimation	Computer vision	N/A
[6]	Robert <i>et al</i>	N/A	Video and Stereo camera, Video glasses	Image processing, Data filtering, Pupil detection, Starburst	Feature based gaze approach	Image Processing, Computer vision	N/A
[7]	Alex <i>et al</i>	N/A	Video based	Image processing, Image to screen map	N/A	Image processing	N/A
[8]	Sharma <i>et al</i>	N/A	N/A	Eye model, Image processing, Pupil detection	N/A	Image processing	Real time fixation recognition
[9]	Manu Kumar May 2007	N/A	N/A	N/A	N/A	Pointing and selection	Graphical and Gaze based interfaces
[10]	Jowers <i>et al</i>	N/A	Graphical displays	Image to screen mapping	N/A	Eye-gaze selection	Graphical interfaces

Table 2: Analysis Table

Reference	Author	Parameters				Results
		Interaction techniques in AR system	Gaze tracker technologies	Methodology (Approaches)	Tracking techniques	
[1]	Kyung-Nam <i>et al</i>	N/A	N/A	N/A	Electro oculography, Limbus, Pupil, Eyelid	Proposed eye gaze tracking methods are seen to be successful at 8x10 screen resolution. Geometry based estimation better than adaptive estimation. But Results from large head movements, error in eye movement tracking.
[2]	Linda <i>et al</i>	N/A	N/A	N/A	N/A	Results show that, for a simple task, it takes 60% less time to select an object with our eye gaze technique than with a mouse. Beneficial for the larger screens, workspaces, and virtual environments of the future; and will become increasingly practical as eye tracker technology matures.
[3]	Susanna <i>et al</i>	Manual inputs, Gestures and Speech interfaces	Displays, Optic devices, Image sensors, Real-time signal processing	N/A	N/A	The results of the gaze-controlled AR system show that the system does work, but it needs considerable development and further user studies before it can be a realistic option in real end user settings.
[4]	Dan Witzner <i>et al</i>	N/A	N/A	Appearance based methods, Feature based shape methods, Sequential search strategy, 3D model and Deformable shape model, Interpolation-based	Limbus, Pupil, Cornea reflection, Scleral search coils	Future gaze tracking systems should still be low cost, easy to setup, minimal or no calibration, and good gaze estimation accuracy and natural head movements. Some requirements are conflicting e.g. flexibility and a low number of calibration points.
[5]	Chennamma <i>et al</i>	N/A	N/A	Model-based, Appearance based, Interpolation base	Electro Oculography, Scleral search coils, Infrared and Video oculography, Limbus, Pupil, Cornea reflection	Future developments in eye tracking need to centre on standardizing what eye movement metrics are used, how they are referred and interpreted in the context of interface design. No standard yet exists for the minimum duration of a fixation. The intrusiveness of equipment should be decreased to make users feel more comfortable. 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.
[6]	ROBERT GABRIEL LUPU <i>et al</i>	N/A	N/A	Feature based gaze approach	Pupil, Video Oculography	Solutions are focused on commercial remote camera-based eye-tracker systems for which the light source and

						camera are permanently affixed to a monitor. Because these commercial systems including software and support are expensive, some low cost mobile devices for eye tracking were developed
[7]	Alex Poole <i>et al</i>	N/A	N/A	N/A	Electro Oculography, Scleral search coils, Pupil, Cornea reflection	Continued growth in the use of the eye tracking method in HCI studies looks likely to continue as the technology becomes increasingly more affordable, less invasive, and easier to use.
[8]	Anjana Sharma <i>et al</i>	N/A	N/A	N/A	AAC techniques	Explore the significance of eye gaze based methods for designing better AAC systems. Results shows that the system recovers from tracking errors due to sudden head movements or slow blinking in case of drowsiness. Controlling and adjustments of parameters enhances the output. Further the AA system should be of low cost and convenient to use
[9]	Manu Kumar May 2007	N/A	Eye detection sensor	N/A	Electro oculography, Scleral coil, Scrolling techniques with gaze-repositioning	Discusses some challenges and their solution for using gaze-input. Explore design space of interaction techniques that use gaze information for everyday computing tasks and propose technology and business model changes to enable the emergence of low-cost, mass-market eye trackers.
[10]	IestynJowers <i>et al</i>	N/A	N/A	Shape based, 3D model based	Pupil, Cornea reflection	The results are positive and indicate the potential for eye tracking as an interface for supporting shape exploration in CAD.

3. Conclusion and Future Work

In close to future once one’s need to regulate a computer it should be doable merely to look at display. This might make it inessential to find out a way to operate with a keyboard or to regulate a mouse. Interface of eye gaze is the foremost common technique of human computer interaction that guaranteeing decade. However many options of eye movement create existing interface shape is insufficient as a substitution for more pointing tools.

Today human eye-gaze can be recorded by relatively everyday methods. This thesis argues that it is doable to use eye-gaze of a computer user within interface to help management of application. As eye-tracking devices improve in quality and accuracy and reduce in value, interaction designers will have power to sense the user’s attention and intention.

Floor-mounted systems useful however prohibit user’s movements. Whereas Head-mounted systems consistent however uncomfortable. Poorly

implemented eye management can be extraordinarily annoying. Choose parameters carefully. Dominant and changes of parameters may be done to boost output. Humans are not used to activating objects simply by observing at them thus following skills i.e. practical controlling of an eye fixed, ability to read and to take care of head constantly in front of eye gaze monitor are required by user to realize positive response. In short, future eye gaze tracking systems should be

- Low in cost
- Easy to use
- Normal movement of head and precision under illumination changing conditions

Special contact lenses are appropriate approach to make accurate recordings of gaze tracking, so user should wear this type of contact lens for better gaze point selection. Interaction designers will have the ability to make such gaze tracking systems that are according to user’s intension and attention.

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