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Designs and Implementation of Computer Vision Interaction for People With Severe Movement Restrictions

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Abstract—**Eye tracking has a long history in the field of medical and psychological research as atool for recording and studying human visual behaviour. Real-time gaze-based text entry can also be a powerful mean for communication and control for people with physical disabilities. Following recent technological advances and the advent of affordable eye trackers, there is a growing interest as well as need in pervasive attention-aware systems and interfaces that have the potential to revolutionize mainstream human-technology interaction. In this chapter, we provide an introduction to the state-of-the art in eye tracking technology and gaze estimation. We discuss the challenges involved in using a perceptual organ, the eye, as an input modality. Examples of real life applications will be reviewed, together with design solutions based on research results. We are also going to discuss the process to match the user requirements and key features of different eye tracking systems to get the most suitable system for specific task and application**

Keywords —**Interaction System, Eye tracking Algorithm, Human Computer Interaction,Eye Tracking Application**

I. INTRODUCTION

Many people who live with paralysis have to face difficulty doing their day to day tasks. While those with limited use of their limbs may be able to get by,but those with full body paralysis have no such luck. Fortunately, most people still retain the ability to use their eyes unhindered. Therefore, tracking eyes has been suggested as a way for paralyzed people to continue interaction with the world. Even children, who are developing social skills or learning a language, interact through sight. If a child has a disability, tracking how their eyes react to learning methods allows teachers and researchers to successfully educate children. Keeping the same issue is consideration the proposed system is to design and implement a patient assistance system for controlling home appliances and interact with computer system using the pupil motion in multiple directions. The system will monitor the users pupil movementand sends directional movement along with eye closing and opening information to the system and the computer system will convert information into event and control the system activities as per. This will help the patient to interact with real world.

II. HEAD AND EYE TRACKING SYSTEM

To address the above concerns an integrated eye head tracking system has been developed which allows for free head and body motion over a range of 1.8 m in any direction (5.8 cubic meters of space). The combined head-eye tracking device is based upon a video eye tracking system and a magnetic head tracking system.

a.Eye Tracking Subsystem

Binocular horizontal and vertical eye position estimates are derived from the relative positions of multiple corneal reflections and the center of the pupil. By using two eye landmarks (corneal reflections and pupil center) whose relative position are invariant under translation, this instrument is able to estimate the angular position of the eye independently of lateral motion of the video system relative to the head. This is of critical importance since perfect mechanical stabilization of the instrument to the head is impossible during dynamic head movements. The optical components of the VTS are mounted on a light weight (total system weight 190 g) eye glasses frame. The system is binocular and two mirror-image optical systems are mounted on each side of the eyeglasses frame. The corneal reflections are generated by illumination with two infrared LED's mounted to the glasses frame. These LED's also serve to illuminate the pupil. Use of infrared (IR) light allows for invisible illumination of the eye. The use of multiple corneal reflections extends the linear range of the system by ensuring that one corneal reflection is always visible on the spherical Surface of the cornea even with eccentric gaze. The images of the pupil and corneal reflections are reflected off of an IR mirror positioned in front of the subject's eye and directed to the cameras. This mirror is transparent to visible light and thus does not interfere with normal vision. The video image is sampled by a custom charge-coupled device (CCD) array that allows images to be sampled at 120 Hz. Images from the CCD camera are processed in real time to obtain estimates of the corneal reflection and pupil center locations. Precise estimation of the corneal reflex is based on techniques described by Eizenman. The estimate of the pupil center and pupil size is based on algorithms described by Landau. The eye tracking subsystem has been characterized recently and compared with the magnetic sclera search coil data recorded simultaneously. This study reported excellent

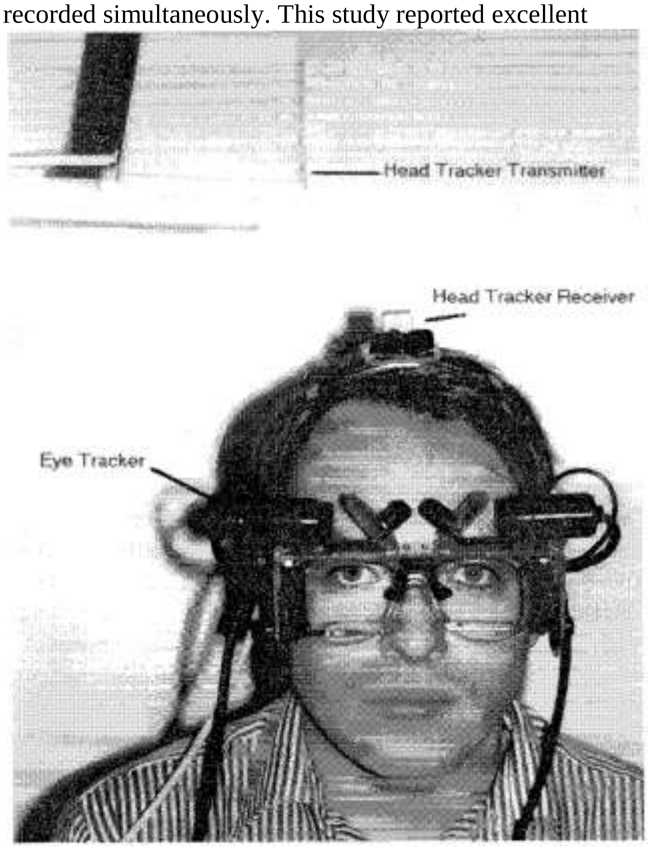

Fig. 1A subject wearing the integrated head and eye tracking system isshown. The head tracker transmitter is located above the subject. The headtracker receiver is a small cube mounted to the goggle assembly (arrow).

agreement between the VTS estimates and search coil data withsomewhat higher noise levels in the VTS estimates. Theresolution of the VTS is less than 0.1" with a range of 140"and &30" in the horizontal and vertical directions respectively[SI. Typical noise in eye velocity records during pursuit taskswas greater than that of the search coil and was approximately4-5"/s. Calibration of the eye tracker can be performed using acalibration procedure requiring 2-3 min. The noise spectraof the eye tracker were found to be flat throughout the 60-Hz bandwidth at a typical value of 8 x deg2/Hz with nosignificant spectral peaks.

B. Head Trucking Subsystem

Six degrees of freedom of head motion are measured by a magnetic position transducer mounted to the eye-tracker goggle assembly. The small (25.4 mm x 25.4 mm x 20.3 mm), lightweight transducer is mounted on a strap over the top of the head close to the center of head rotation for azimuth rotation. A fixed transmitting device radiates a pulsed magnetic field in which the head mounted receiver is immersed. The field is sensed by the receiver and processed by a microprocessor to provide three-dimensional (3-D) position information as well as head elevation, azimuth and roll angles. The head tracker provides absolute angular and translational position measurements and does not require calibration for each subject. The head tracker can operate with multiple receivers allowing for measurement of other important parameters such as hand position in hand-eye coordination studies. Measurement quality is compromised by low-frequency electromagnetic interference (EMI) and the presence of large metal objects in the field. TO ensure performance, the transmitter and receiver were located away from sources of EM1 such as monitors and power supplies. The head tracker [17] has a translational linear range of &91 cm and an angular measurement linear range of +180" in azimuth and roll, and 590" in roll. The output power of the head tracker transmitter is adaptively changed in order to maximize signal-to-noise (SNR) ratio without saturating the receiver. Within 24 cm, adaptive gain control increases transmitter power as the distance between transmitter and receiver increases such that SNR is relatively constant. Outside this range SNR deteriorates as the magnetic field strength decreases with distance. With the receiver within 24 cm of the
transmitter, the angular resolution of the system is less than 0.1" root mean square (rms) and the translational resolution is less than 0.75 mm (at 48 and 60 cm the azimuth resolution is 0.75" and 1.78" rms, respectively). The head tracker was designed to make accurate position measurements over the same 60-Hz bandwidth as the eye tracker. The noise spectrum of the head tracker was found to be flat throughout the 60- Hz bandwidth at a typical value of 6 x deg2/Hz with no significant spectral peaks.

C. Evaluation of the Integrated System

Data from the head and eye trackers is synchronized by a hardware control signal that triggers the video frames of the eye tracker in synchrony with the pulsed magnetic field of the head tracker. Data from the eye tracker is also delayed by8.3 ms in order to match the delays of the two subsystems.The dynamic performance of the combined head-eye trackingsystem was investigated by calculating gaze angle and thegain and phase of the VOR during smooth head oscillationsand during active head turns. These results were comparedwith the results of studies using the magnetic scleral searchcoil technique (the "gold standard').VOR Gain and Phase: VOF: gain and phase during activeself-paced head movements were estimated using power spectralanalysis. The target for the experiment was a lit LEDlocated centrally at a distanlce of 1.2 m. Head and eyevelocities were obtained from the position estimates usinga five-point differentiator (30-Hz bandwidth).

Saccadic eyemovements, blinks, and artifact (for example interference ofpartially closed eyelids with the pupil boundary,for artifact associated with video-basedeye tracking methods) were identified and removed. Theremoved intervals were interpolated through with a least squares quadratic fit. Power spectra of head motionPHH(w)e,y e movements PEE(w)a,n d cross-spectral densityPHE(W()t he Fourier transform of the cross-correlation) ofthe eye and head sequences were calculated using Welch'saveraged periodogram (1024 points, 5 12-point overlap) witha Hanning window for sidelobe reduction. We havealso used the magnitude squared coherence (MSC) function,CHE(W=) P ~ E (w) / P ~ ~ (w : tlord~ef~ine(~the) ,co herencebetween the two data sequences. A high degree ofcoherence is indicative of a strong linear relation between thetwo signals 1201. From the MSC, approximate 95% confidenceintervals for gain and phase as provided by Jenkins and Wattswere computed and used to distinguish spectral peaksfrom spurious spikes.VOR gain and phase estimates were computed at the highestpower spectral components, where coherence was always
higher than 0.98. VOR gain and phase estimates for threesubjects are shown in Fig. 2 where gain is always close toone and phase is near 180" (defined as 0" by convention).This is in agreement with studies which indicate that VORgain and phase while fixating a space-fixed stationary target(visually enhanced VOR) are nearly perfect until frequencieshigher than 5 Hz. Since our target was located ata distance of 1.2 m an increase in measured VOR gain is to be expected and ideal VOR gain for our experiments isapproximately 1.1. When this gain enhancement is considered,the gains (range 0.97-1.16) in Fig. 2 are comparable withthe 0.83-1.09 for horizontal arid vertical head shaking duringfixation at optical infinity (ideal gain of 1.0) reported byGrossman et al. and to the results of Collewjin et al.

III. TRACKING OF EYE MOVEMENT

Eye movements are typically divided into two categories: fixations and saccades. For eye tracking purposes, fixations are used to denote a starting point for all eye movements and saccades. Saccades are when the eye gaze moves to another position. An image sensor is a solid state device that takes an optical image and translates it into an electrical signal. An image sensor can be found in the design of any device that captures an image. An image sensor will be needed to implement the Eye Tracking System to capture the image of the eye. In an electronic device, a frame grabber can be used to capture individual still frame shots from a video source. This video source can either be an analog signal or a digital video stream. The individual video frames are usually captured indigital form before any processing is done. One advantage of more modern frame grabbers is the ability to capture multiple frames at once and compress these frames in real time. A Head mounted device will uses a camera to observe the both the pupil and the reflection from the cornea, and transmits the data to a computer which processes the signal and displays the pupil tracking data.

we have attempted to use a common set of definitions as follows:

Fixation: a relatively stable eyeinhead position within some threshold of dispersion (typically over some minimum duration (typically 100,200 mS), and with a velocity below some threshold (typically 15,100 degrees per second).

Gaze Duration: cumulative duration and average spatial location of a series of consecutive fixations within an area of interest. Gaze duration typically includes several fixations and may include the relatively small amount of time for the short saccades between these fixations. A fixation occurring outside the area of interest marks the end of the gaze

Area of interest: area of a display or visual environment that is of interest to the research or design team and thus defined by them (not by the participant).

Scan Path: spatial arrangement of a sequence of fixations.

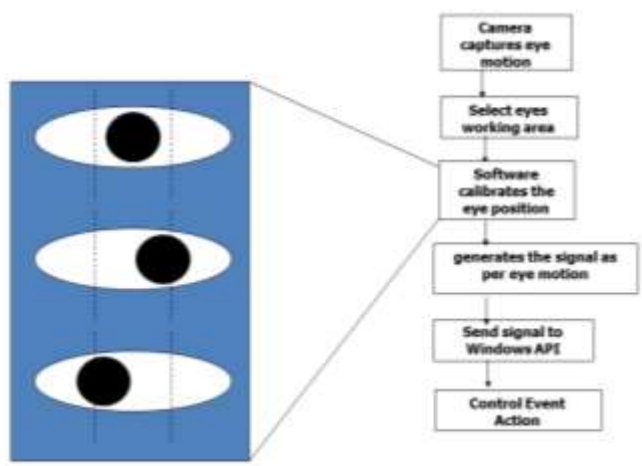

Fig. 2 Proposed system architecture

IV. PROPOSED ARCHITECTURE

The field of human computer interaction has been undergoing a new renaissance lately. While many companies have and are still spending millions to develop highly visually appealing GUIs and state-of–art interaction systems for the common users since the inception of desktops, the development of interaction systems for the disabled has taken a kick start recently. The Eye gaze system is a communication and control system for people with complex physical disabilities i.e. Youcan run system with your eyes. We all are blessed to operate the computer with ease using our hands. But there are some who can't use their hands and for them the voice guided systems have been in use for quite some time now. But in case of paralytic patients with no mobility and speech even though their brains and vision are functional, they can't utilize their intelligence and stay unemployed. Thus, our eye gaze system helps in providing solution to this problem. Our system controls the computer cursor by following the user's gaze. By looking at the control keys displayed on a screen, a person can synthesize speech, control his environment, type, operate a telephone, run computer software, operate a computer mouse, and access the internet and e-mail . Thus, our scheme can be used to enhance the quality of life of people with disabilities, all over the world.

V .RESEARCH METHODOLOGY TO BE EMPLOYED

There are currently two types of eye tracking techniques that are used, Bright Pupil and DarkPupil. Bright Pupil tracking creates a greater contrast between the iris and the pupil which allowsfor a more robust eye tracking. This greatly reduces any interference caused by eyelashes orother obscure features. Bright Pupil tracking additionally allows for tracking in lightingconditions, whether it is totally dark or very bright. This technique, however, is not effective fortracking outdoors. Dark Pupil tracking works to eliminate bright reflections. If the illuminationsource is offset from the path of the eye, then the pupil appears dark.There are significant differences between a manual input source like the mouse and eye position to be considered in designing eye movement based interaction techniques: Eye movement input is distinctly faster than other current input media (Ware, 1987, Sibert& Jacob, 2000). Before the user operates any mechanical pointing device, he or she usually looks at the destination to which he or she wishes to move. Thus the eye movement is available as an indication of the user's goal before he or she could actuate any other input device. Operating" the eye requires no training or particular coordination for normal users; they simply look at an object. The control to display relationship for this device is already established in the brain. The eye is, of course, much more than a high speed cursor positioning tool. Unlike any other input device, an eye tracker also tells where the user's interest is focused. By the very act of pointing with this device, the user changes his or her focus of attention; and every change of focus is available as a pointing command to the computer. A mouse input tells the system simply that the user intentionally picked up the mouse and pointed it at something. An eye tracker input could be interpreted in the same way (the user intentionally pointed the eye at something, because he or she was trained to operate this system that way). But it can also be interpreted as an indication of what the user is currently paying attention to, without any explicit input action on his or her part. This same quality is also a problem for using the eye as a computer input device. Moving one's eyes is often an almost subconscious act. Unlike a mouse, it is relatively difficult to control eye position consciously and precisely at all times. The eyes continually dart from spot to spot, even when its owner thinks he or she is looking steadily at a single object, and it is not desirable for each such move to initiate a computer command Similarly, unlike a mouse, eye movements are always "on." There is no natural way to indicate when to engage the input device, as there is with grasping or releasing the mouse. Closing the eyes is rejected for obvious reasons even with eye tracking as input, the principal function of the eyes in the user computer dialogue is for communication to the user. Eye movements are an example of a more general problem with many new passive or non command input media, requiring either careful interface design to avoid this problem or some form of explicit "clutch" to engage and disengage the monitoring.

Also, in comparison to a mouse, eye tracking lacks an analogue of the integral buttons most mice have. Using blinks as a signal is a less than ideal solution because it detracts from the naturalness possible with an eye movement based dialogue by requiring the user to think about when to blink. Finally, eye tracking equipment is still far less stable and accurate than most manual input devices.

VI. EXPECTED OUTCOME AND FUTURE WORK

After successful implementation of the proposed system it is expected by the system that,

- Hardware should be in a wearable form so that eye viewing camera should track and move along with eye in order to reduce real time eye position tracking from face, this will reduce processing time and speed up the processing.
- System should successfully identify the human eye along with pupil location and generates event signal.
- System should fire a specific action in order to control software application actions or to control a connected hardware devices or the appliances

VII. CONCLUSION

By developing a simplified and low-cost system, eye tracking devices will become a far more marketable and accessible product to the general public. The focus of the developed system will be away from elaborate hardware of the current eye tracking system, but instead toward clever DSP and other software algorithms. Creating robust software to interface the system will also help less technical users to operate the system. Once the system will be ready it can be used by different originations, hospitals, domestic purpose and by care taker person.

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