Evaluation of Eye Gestures for providing Input to Computer-Based Applications: Traversing the journey from Intuition into Reason

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Abstract

Fuzzy ideas based on intuition, hold potential for evolving innovative new approaches to Design interface. Young minds in the classroom, with a bit of support, dare to dream. Their ideas need to be nurtured with reassurance that even if they fail, there is learning in the journey of experimentation.

This paper presents a user centric approach in exploring effectiveness of eye movements as an input medium for operating a personal computer. To establish the results, the process followed included a thorough study of eye movements from various perspectives including the study of eye gestures used to communicate in a traditional Indian dance form.

The eye movements recorded through above study were compiled into categories based on their relevance to provide as input to a personal computer. Further, User tests were conducted to investigate patterns of eye movements and eye gestures while working with the computer. User's preference was sought for a particular category of eye movement / gestures. The results were compiled to establish heuristics that could be followed in design of interface and experience by designers. The paper in the process also makes critical observations on the efficiency of using eye movements as an input device over the conventional keyboard and mouse.

Keywords

Eye Gestures, Physiology, Psychology, Bharatnatyam

INTRODUCTION

Young students in the Design program at IIT Guwahati are increasingly taking a keen interest in domain of Design and Human Computer Interaction (HCI). The issues involved include

studies in cognition and design. Founded on basic coursework in design in the earlier years, these students choose to undertake summer internship with researchers abroad during their third year. In their final year, selection of projects becomes an extension of their internship experience in pursuing projects in such related areas. More often their proposals are ideas that are raw. The role of the teacher as the 'Guide on the side' proves to be critical. Their ideas need to be nurtured with reassurance that even if they fail, there is learning in the journey of experimentation. The case presented here is one such experimental design research project undertaken to explore if eye gestures could be used to control and operate a computer.

By definition Eye movement is the voluntary or involuntary movement of the eyes, helping in acquiring, fixating and tracking visual stimuli [1]. Literature search undertaken pointed that using the eye as an input device over other input devices has proved to be more effective and efficient in cases that also include operation of the computer by physically impaired people. Also research has proved that use of eye input is 111% faster than the mouse, 75% faster than function keys, and 37% faster than the use of multiple keyboards [2].

However, after proving the efficiency of this mode of communication between computer and human, research that has currently been done in this area are only limited to control of mouse pointer and focus on functionalities that are limited to mouse left click. There seems to exist scope for exploring if eye gestures could be considered as a mode of input device for manipulating the functions of a computer rather than using the established conventional devices such as the mouse.

There seems a paucity of published research on this subject in the current area of research. It was therefore felt essential to study related areas whose analysis could then be extrapolated for deriving a methodology for conducting and recording eye behavior gathered through direct user tests. Hence the study undertaken culminated into consideration of physiological and psychological aspects involved in eye movements.

The physiological aspects led to the study of the different type of eye movements: Saccades, Vergence, Pursuit, Vestibular Ocular reflex and Optokinetic Responses. Notes on physical limitation of eye movements were also made for future reference. The purpose of doing the psychological analysis was to examine eye movements that are

triggered by cognitive stimulus. Since these triggers are psychological, it was felt that they could be used to understand the cognitive state of the user and to provide appropriate visual feedback.It may be noted that the above aspects of eye movement were mostly focused on involuntary form of eye gestures.

Considering the non-conventional nature of the study where the objective was to examine the use of eye gesture as an input device, the study was extended to consider communication through eye gestures involved in Bharatanatyam – a traditional Indian dance form. This particular dance form was chosen since an important aspect of its performance involves symbolic communicating through eye movements.

RECLASSIFICATION OF EYE GESTURES

Technically eye movements are defined as either voluntary or involuntary. From the study of eye movements we could identify that there also exists a movement in which the eye movements are involuntary but there exists an indirect purpose that has triggered the eye movement. I such situations the purpose is known to the user but the user is not aware of the eye movements that are happening. For example while reading a text on the screen the user is not aware of the saccades that are happening. This reclassification was felt important and necessary for recording our observations.

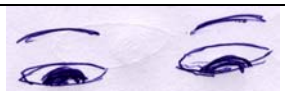
SETTING UP THE EXPERIMENT FOR USER TESTING

Based on these observations, an experiment was set up in a combinations of screens on a computer. The variations of the screens were a combinations of text, images and buttons. The objective was to see the effect of content on eye movements and make inferences compatible with any type of content on the computer screen. These were presented to an invited group of users. The participants were students form IIT Campus. The experiment was set up and conducted using Tobii Eye movement recorder. Eight users were presented with five types of screens. The gestures were recorded in form of both eye gaze data and webcam data which were subsequently analysed.

RESULTS AND INFERENCES

The data recorded in the experiments initially seemed to be too varied from user to user. However on re-examination and thorough analysis it

was found that the gestures could be categorized into the following different phases: starting, transitional and terminating phases.
The gestures [G] (Surprisingly these were the gestures that were recorded) could be further split into two sub categories viz. gesture [A] and gesture [X]. Here gesture [A] is the normal gesture (which was as expected prior to the test) and was found common in most of the users and gesture [X] was the custom gesture of that particular subject. In some instances gestures [X] also had a complement gesture [Y] which was used to perform the complement of gesture [G]. With the splitting of the data field into these sub categories we achieved a gesture-vocabulary of voluntary gestures that can be used effectively for computer operations.
The results of the gesture vocabulary for major tasks that the users were assigned is listed in the table 1.1.

TASK	GESTURE PERFORMED	ILLUSTRATION (only [A] in case of splitting)
Zoom In	Widening Eyes	
Zoom Out	Narrowing Eyes	
Page Up	Half closed eyes and seeing up away from the content area	
Page Down	Half closed eyes and seeing down away from the content area	
Page Left	Half closed eyes and seeing down left from the content area	
Page Right	Half closed eyes and seeing down right from the content area	
Next Article	[A] Seeing right + [X]	

Previous Article	[B] Seeing left + [X]	
Selection	[A] Drag + [X]	
Deselecting	[A] Drag + [Y]	
Cut	[Y]	
Copy	[X]	
Paste	[Y]	
Right Click	Right eye blink	
Rotation	[A] Head movement to the direction of rotation + [X]	

Fig 1.1: Proposed gesture vocabulary

From the above list of gestures certain heuristics may be considered while designing eye based interactions. These heuristics are as follows:

•Complexity of Eye gesture depends upon the cognitive load of the screen content. This means if there exists content that has greater cognitive load then simple eye gestures must be used.
In this case it might be good option to provide buttons on the screen to be manipulated by using eye gestures

•While performing gesture for page movement control on screen, the gaze data showed an unusual eye gaze if any image is present in path of the gaze.
It is therefore recommended that, non-text content should not be located in the path of gaze for page control movements.
Alternatively, a different eye gesture may be assigned that does not involve focusing on an image (half closing, blinking etc)

• It was noted that eye blinks happen only during reading and not much during interaction.
Hence during interaction, eye blinks can also be used in the gesture vocabulary. But these gestures must be disabled while reading.

•In the instance of control over a group, control gesture must be performed first, Subsequently the elements of group should be selected by selection gestures.

• It was carefully observed that when users refer to image content, the eye movements jump very fast from text to pictures unlike when compared to reading. Hence this speed can be detected.
Accordingly photos/Images can be zoomed in and out of the view to provide enhance interaction

• Selection of a short two line paragraph, may be done using eye gesture that drags across the lines of the paragraph.
For selection of longer length of paragraph, selection may be done by running the gesture diagonally across the paragraph.

•If a set of buttons are used on a screen, direction of eye gestures can be used in detecting the button the user wants to click. It has been observed that eye movement over a button may not be accurate but direction is accurate, so direction can be used in detecting the button user wants to click

• The user is not accustomed to the control of selection cursor by eye gestures and uses extra eye movements (ex. gestures to change the paragraph and to change the words).

•Initially user is not adapted to use of different gestures for different command, therefore commands should be introduced incrementally starting from the primary commands

•Length of saccades can be used to separate a reading gesture from a controlling gesture whose movement is similar to reading eye movement

• It is observed that while gestures are very quick use Buttons are easier for decision making. So in case whenever a user is confused, a button menu should be presented

•Visual responses should be adequate as user is hyperactive while performing eye gestures.

FUTURE WORK

The above research demonstrates how voluntary, semi-voluntary and involuntary eye movements can be used to establish an efficient

communication between eye and computer. The methodology followed in the experiment can be further explored to generate user-oriented results.

The results indicate interesting possibilities for further research for the following areas in building a more user-oriented eye control system:

1. Study of Types of contents and their effect on eye gestures
2. Environment: The need for the study of different eye gesture that can emerge for different type of environments (ex Noisy Vs Silent).
3. Merging of eye based input with other input modes: Eye gesture though efficient, may not be perfect in all cases as it is impossible to exactly predict the eye behavior which users will use while working with the computer. So an intermediate mode could be established where eye based input are used in conjunction with other input modes.

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