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A Review: Towards Quality Improvement in Real Time Eye-Tracking and Gaze Detection

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Abstract

Human Computer Interaction (HCI) has increased attention for the past decade and has increased User Interface (UI) designs for various applications. Real time eye-tracking and gaze detection can provide a means of user input for HCI. Eye-tracking and gaze detected data can also be exploited to track user emotions, as a means of Non-verbal communication. Many HCI gaze input systems have been developed as User Interface for physically and vocally challenged. This work focus on quality issues in eye- tracking and gaze detection with a review of earlier approaches across applications in medicine and education. Explored Quality issues are: use of intrusive or non-intrusive devices, Information source input like Pupil, Iris, corneal reflections, Glint, sclera, 3D eye ball model, Camera and User Calibration, Head or pose invariance, Image Noise reduction such as Glint noise, Iris noise, Illumination variation with Natural Light source, use of Infrared illumination and accuracy degree. Finally concludes with the necessity in selecting appropriate information source as input to improve the quality of real time eye- tracking and gaze detection methods, so as to enhance user interaction in HCI systems in twofold: to increase the learning efficiency in education and a way-out for natural communication with machines in medicine.

Keywords -Human Computer Interaction, Eye-tracking, gaze detection, learning efficiency, emotion.

I. INTRODUCTION

Computers are becoming a member of our day-to-day life, as it supports many functions. Increasingly it leads to the development of Human Computer Interactions

and User Interface designs. Many learners are interested in E-Learning as they are learner centered. As E-Learning is not a controlled learning environment to enhance these systems several categories of user input systems are designed. Eye-tracking and gaze detection have been drawing much attention as user input for HCI during the past decade. Many reasons account for its growth in HCI. Even though it has its own place as user input, it is essential to concentrate towards its quality issues to obtain better performance. The main contribution of the proposed work is to present various applications, that use eye-tracking and gaze detection as user input for HCI and how they differ in the factors like information source, wearable and non-wearable sensors, calibration, noise reduction, pose variations and accuracy degree. As all these parameters cannot be considered at the same time, few factors can be focused to improve the quality of dynamic eye-tracking and gaze detection.

The paper is organized as follows: Section 2 reviews about HCI and its role in medicine and education(E-Learning). Section3 describes emotions as one of the strongest differentiator in user experience and its vital role in HCI and emotional interaction in medicine and education. Section 4 portrays the uniqueness of eye, eye-tracking and gaze detection. The proposed work is presented in Section 5. Concluding ideas and future work are given in Section 6.

II. HUMAN COMPUTER INTERACTION

Human Computer Interaction involves the study, planning, design and uses of how people interact with computers and computer technology. HCI is the field that interrelates with many disciplines as psychology, computer science, cognitive psychology, engineering, artificial intelligence, sociology, anthropology, art sciences etc.HCI is “a discipline concerned with design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them” [1]. HCI incorporates the social as well as cognitive aspects of computing. HCI is categorized as Intelligent HCI [2], Adaptive HCI[3] and it may be combined. Intelligent HCI uses intelligence in the making of user interfaces. Intelligent HCI designs incorporate at least some kind of intelligence in perception from and/or response to users. Intelligent HCI interfaces comprise Speech enabled interfaces [4] and visual tracking devices for user’s movements [5] or gaze [6] that respond accordingly. Adaptive HCI makes the interface that interacts with the users. Adaptive HCI designs may not use intelligence in the creation of interface but use it in the way they continue to interact with users [7]. Adaptations deal with cognitive and affective levels of user activity [8]. The existing interfaces vary in the degree of complexity in terms of functionality and usability with the financial aspect of the machine in the market.HCI user interface designs stand on three different levels of user activity: physical [9], determines the mechanics of interaction between human and computer, cognitive [10] deals with ways that users can understand the system and interact with it, and affective [11]not only make the interaction a satisfying experience for the user but also affect the user to continue the use of machine by changing mind-sets and emotions toward the user [12].The main concern of HCI is to guarantee the 'ease-of-use', operability, discoverability, simplicity, and learnability in

addition to safety, utility, effectiveness, efficiency, accessibility, usability and flexibility[13]. As a result, HCI design issues to be well thought-out to make an extensive distinction in performance, speed, user satisfaction.

A. HCI in Medicine

HCI based techniques in medicine aids to compensate the communication impairment due to physical and vocal disability. Augmentative and Alternative communication (AAC) is an area of clinical practices that finds solutions for communication impairment using different UI in HCI [40]. HCI based interfaces can improve effective communication for disabled in day to day life. Amyotrophic lateral sclerosis is a neuro-degenerative disease that leads to physical and vocal disability [42]. Graphical based UI helps these patients for communicative interactions without the use of physical contact devices.

B. HCI in Education

There are many approaches for facilitating learning over the internet. E-Learning is heart centered in all forms of educational interactions and represents a different mode of communication. There are varieties of definitions of this term. E-Learning is broadly defined as an open system networked with the collection of multimedia technologies. E-Learning is the medium for network facilitated transfer of skill, information and knowledge. E-Learning lies in the potential of learner-centered collaborative learning. The simplest way to define E-Learning is a type of learning situation when instructional content is delivered electronically by means of the internet at the instant people need it. The main functions of E-Learning environment are to provide clarification, tutoring and intelligent analysis of learner's understanding [14].E-Learning benefits include fast delivery, time and location flexibility, personalized and convenient scheduling, collaborative environment, unlimited use of learning materials, learner centric. E-Learning to have a significant place in education it must prove that it is more than a medium to conveniently access content. Researchers have shown that E-Learning systems can make the users in frustrated or confused frame of mind and reduce their interest in learning [26].E-Learning environment needs improvement for enabling the system to offer intelligent help to learners and to effectively carry out pedagogic activities. It is essential to estimate the learner's engagement to the displayed information on a computer monitor to improve its efficiency. Accordingly engagement level can be detected by managing learner's attention with the user interface aids and the design issues play a major role to make an efficient and ease of use.

1) Learning efficiency in E-Learning

HCI is a crucial component of E-Learning systems as it stands for bringing face-to-face learning experience in E-Learning environment. HCI is one of the factors that determine the ultimate learning efficiency in E-Learning environment. A Theory for E-Learning [15] stated ten hypotheses, Hypothesis 8 states "Effective E-Learning practice considers the ways in which end-users will engage with the learning opportunities provided to them". Direct impact of HCI on user confirmsa way how

they perform their work. Efficient HCI is necessary for the effectual use of E-Learning environments. Human-Computer Interaction (HCI) theories and methodologies can support the design of appropriate E-Learning settings responding to the complex and rapidly changing requirements. Basically, E-Learning applications should become smart enough to adapt themselves to the students' learning styles and to assure high standards of user-friendliness and usability, in-order to make learners' interaction with the systems as natural and intuitive as possible. Three types of user interfaces: sensor-based, vision-based and audio-based are available to enhance E-Learning efficiency with HCI. Visual-based HCI interface is considered where user responses can be recognized as a visual signal. Some of the major research areas in Visual-based HCI are Facial expression analysis, Body movement tracking, Gesture Recognition and Gaze detection by Eye movement tracking [16].HCI user interfaces have to be designed with a goal of improving the usability in E-Learning system.

III. EMOTIONS

Darwin [17] in 1872 was the first to study facial expressions who considered emotions to represent mechanisms for the adaption and survival.He identified thirty different emotions categorized into seven groups, clustering similar emotions together. Paul Ekman [18] launched his hypothesis that facial expressions can be programmed by natural side of emotions. He has supported the view that emotions are discrete, measurable, and physiologically distinct. Emotions, are feelings which come about as a result of these physiological changes, rather than being their cause [18].Emotions have been described as discrete and consistent responses to internal or external events which have a particular significance.Emotions are brief in duration and consist of a coordinated set of response reactions, which may comprise verbal, physiological, behavioral, and neural mechanisms. Silvan TomkinsAffect theory [19] introduced the concept of basic emotions, and was based on the idea that the supremacy of the emotion describedas affect system, was the inspiring force in human life. Goleman[20] viewed emotions in socio-cultural items. Shelton [21] noted the importance of learning, for its betterment. Theory ofmultipleintelligence[22] and theory of emotional intelligence [20] construct emotion as analogous to the more traditional cognitive intelligence. As Emotion is one of the strongest differentiators in user experience, its vital role in user's attention management has to be considered. Emotions of person with different degrees of disabilities can be used for communication impairment. HCI useuser emotions as input to augment physically or vocally challengedfor naturalcommunication.

A. Emotions in HCI

Recently, increasing interest has been directed in E-Learning user problems, and as a result, emotional aspects of E-Learning are taken into account[23, 24, 25].Pride-Frustration model has been developed for understanding the emotional phenomenon in E-Learning and found a connection between success and failure, on one hand, and pride and frustration, on the other[26]. Researchers [27, 28, 29, 30] identified the Decisive connection between Emotion and the cognitive process of attention,

memory, decision-making. Significance of emotions in E-Learning was addressed in [31, 32].Thus emotion has been shown to be significant in relation to attention, memory and decision making in the learning process[33].Evidence from the literature and the interviews positions emotion as central and essential to teaching/learning process [33]. E-Learning has been researched to have higher drop-out rates than traditional teaching, Juutinen &Saariluoma, stated the Hypothesis: Emotions affect to the drop-out behavior in e-Learning[26].Emotions and cognition play a balanced role in controlling thoughts and behaviors[34] and both are mutually regarded based on their action. So, emotions contribute to behavior and thought adjustment and cognition contributes to adjusting emotions. Artificial intelligence domain integrates emotions with cognition. The interaction between human beings and computers will be more natural if computers are able to perceive and respond to human non-verbal communication such as emotions. Deciding whether a user is attentive helps in adapting the displayed information of a computer in E-Learning environments. Everyday task such as decision-making, communication and learning are significantly influenced by emotional state of a personality. So, studying emotions by measuring the facial expressions in human computer interaction offers the chance of recognizing the difficulties that users falter upon. This makes an assumption of incorporating emotions in computer systems, especially in user communication interfaces –HCI and E-Learning. Human computer interaction theories and methodologies can support the effectiveness of E-Learning systems by incorporating better didactical and pedagogical approaches thereby making E-Learning applications adaptable to students' learning styles and habit. The importance of emotional states of learner especially identifies relationship between emotions and effective learning [35]. It is a challenge to engage learners and sustain their online learning activities anytime and anywhere. E-Learning applications that exploit social and emotional aspects might therefore improve the quality of education for those distance learners [36].

IV. EYES – EYE-TRACKING AND GAZE DETECTION

Eyes are promising visual organs that can be used to create an interface between man and machine [37]. Eyes and its movements are considered as "a window of the mind", tightly tied with human cognitive processes[38].In the development of a theory of mind [39] detection of eyes is important as eyes also provide critical social signals and the existence of neural processes. The uniqueness and the motion characteristics of the Eyes provide visual cues for understanding the cognitive process. The cognitive process and emotional states can be acknowledged with the Eye movements through the user interface and enhance the HCI. Eye tracking-is the process of tracking either the gaze point (where one is looking) or tracking the gaze point motion, with or without considering the head movement. Eye-tracking[39] can help researchers to understated visual and display based information processing and the factors that impact on the system interfaces [41]. Eye-tracking and calibration algorithms classify eye positions into six categories of looking: up, down, left, right, straight ahead, and eyes closed [42].Eye movements help in tracking visual stimuli. Many categories of Eye movements are there and the basic categorization includes saccades, fixations and

scanpath [43].Fixation is therelatively stationary moment when the eyes are, takinginformation (encoding) with a range of 66 to 416 milliseconds, on an average it last for 218 milliseconds. Saccades are rapid, ballistic movements of the Eyes that abruptly change the point of fixation [44]. Saccades can be bring out voluntarily, but occur instinctively whenever the Eyes are open, even when fixated on a target. Saccade varies in amplitude from the small movements (reading), to the much larger movements (gazing around a room). Scanpath is a complete sequence of fixations and interconnecting saccades. There are other whole hosts of derived metrics including gaze, pupil size, and blink rate. Gaze is the direction where the eyes are pointing in a space. Fixation, saccade, scanpath derived metrics can be interpreted in the context of interface design and usability evaluation [41].Hence Eyes and Eye-tracking are important for many applications - attention management, cognitive analysis, gaze-based interactive user interfaces, gaze contingent graphical displays [43].

A. Eye Gaze

Real time Eye- tracking with gaze detection is applied across the areas of medicine and education in recent years. Man-machine interaction can be made convenient with the gaze interaction. Both the abnormal and normal Eye movements have been recorded and studied to understand process like reading [45]. Eye movements and user's gaze direction on a screen can be detected by the Eye-tracking devices. Gaze detection is mostly an indirect form of interaction between user and machine.Gaze detection provides useful information with fixations, saccades, scanpath. It is possible to draw information about attention, stress, relation, problem solving, successful learning etc.[46] with eye gaze. Gaze data is used for assessing how well a user learns in E-Learning environment and individual's well-being can be detected.

Affect-sensitive ITS [47], gaze tutor [48] uses heuristics to respond to gaze. Detailed monitoring of gaze can give benefits to learners. Researchers identified the prediction of learning gains using the Gaze[49][50].Consequently, it is found that gaze detection helps for learner 's attention management in their day to day learning process.

V. PROPOSED WORK

By considering all the above recommendations, a review of thirty different eye-tracking and gaze detection methods across various applications is carried out. Each system use different eye metrics: fixations, scanpath, saccade, blink rate. Eye-tracking and gaze detection techniques are broadly classified as intrusive and non-intrusive systems. Common classification is based on the nature of Light source used during the detection. This work considers the convenient way to compare the techniques based on the main parameter: users' information source against four other parameters.

A. Classification Based On intrusive and non-intrusive devices

At the beginning stage of eye-tracking system, intrusive devices like wearable sensors were commonly used to avoid illumination variations. Head mountable IR LEDs were

also in use to achieve accurate results. With the growth of eye-tracking systems non-intrusive devices had its impact (See Fig.1.) with better accuracy and user satisfaction.

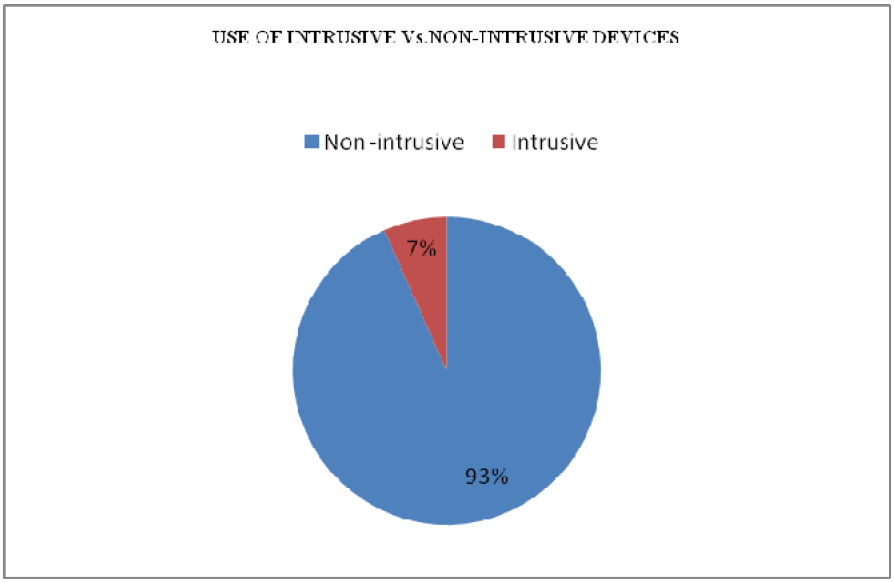

Fig. 1. Eye-tracking system:intrusive Vs. non-intrusive devices

B. Classification Based On Light Source

Use of natural light does not require additionalaids.Accuracyto track and detect eyes during illumination variation is of problem.IR illuminators in eye-tracking and gaze detection systems eliminate illumination variations. Most Of the real time Eye-tracking and gaze detection use IR illuminators to overcome illumination deviation.

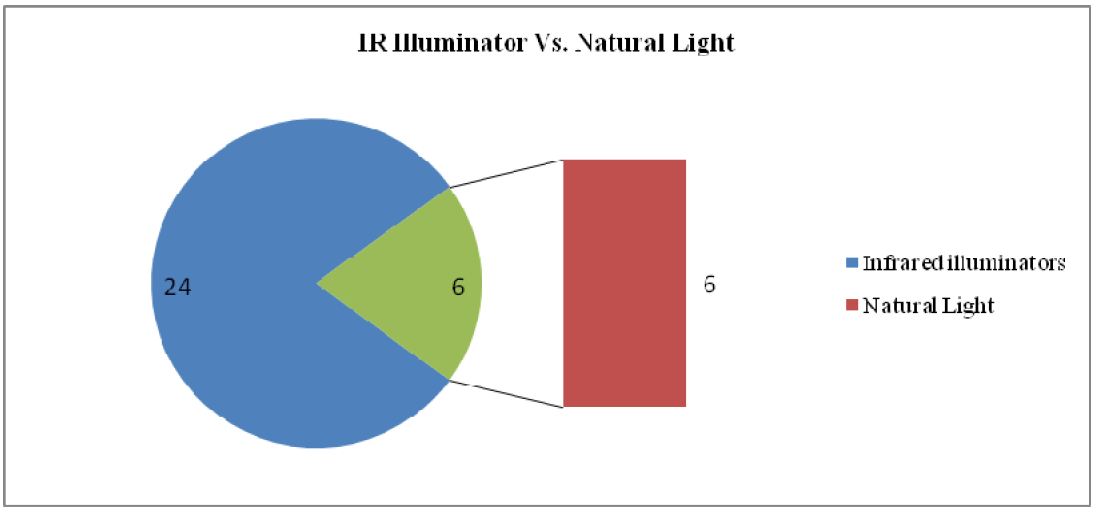

Fig. 2.IR Illuminators in eye-tracking system

C. Classification Based On Users' information Source

Eye-tracking and gaze detection techniques are categorized based on the main parameter: users' information source as input to UI. Rests of the considered parameters which vary between the applications are

1) *Calibration necessity*: Calibration is a procedure in Eye-tracking and gaze detection, which has to be performed beforehand for user, camera or both. User calibration is performed to know where the user's eyes are fixating on the computer screen. Camera calibration is based on visual angle calculation. Calibration is necessary and it varies across the applications- one time calibration or calibration for each new user. Number of calibration samples required for each method also differs. Ease of calibration makes the application smarter but to be aware with accuracy degree, whereas complex calibration causes discomfort for the user with higher degree of accuracy.

2) *Head/ pose movement restriction*: Non-intrusive Eye-tracking and gaze detection systems have difficulty with head movement and pose variations. A few systems confine to a range of head and pose variations or strictly restricted, and others limited to some degree. There are systems that deal accurately with a certain amount of head or pose variations with additional information [51], that are calculated using different approaches.

3) *Noise reduction constraint*: Noise is due to camera noise or image noise, such as glint noise [61], iris noise based on the information source. Image noise is a small-hole like image in the captured image. Image noise occurs when there is too few calibration points [54]. Camera noise may be compensated by adding a certain amount of random error to the measurement [59]. Noise reduction has to be made to acquire improved accuracy.

4) *Accuracy or error degree computation*: Applications calculate accuracy degree or error degree, at horizontal and vertical axis.

Eye-tracking and gaze detection systems gets its input from Pupil, Corneal reflection, Glint, Iris, sclera or with the combination of other sources. Different information sources used in various eye-tracking systems are illustrated (see Fig.1).

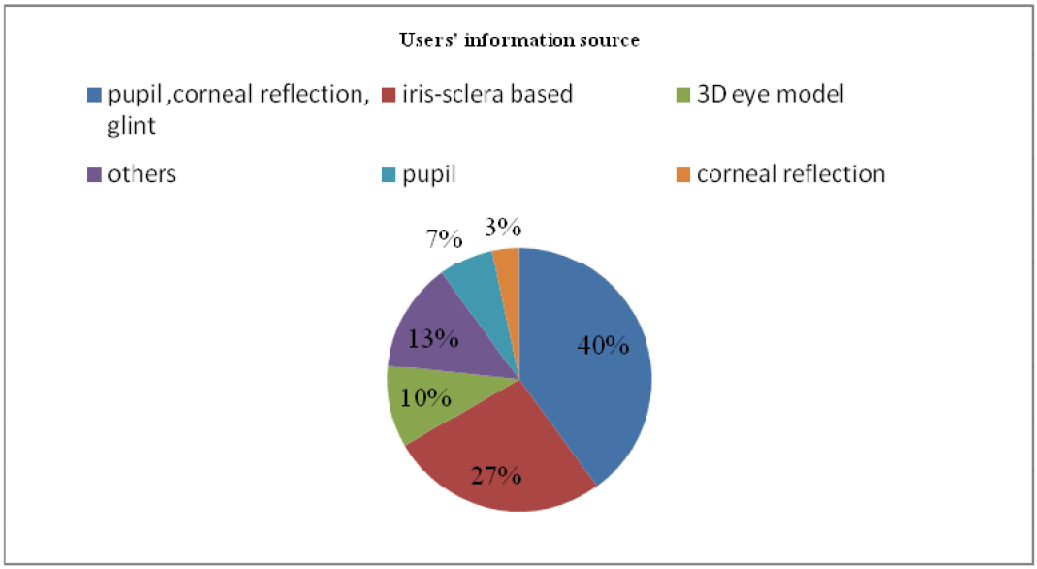

Fig. 3 – Users'Information source –Pupil, corneal reflection and glint, Iris-sclera, 3D eye model

Fig. 4.Display the significance ofinformation source selection. Calibration and head pose variation must be considered as important parameters to achieve good accuracy. Noise reduction plays substantial part in increased accuracy and decreased error rate. Whatsoever matters the most to choose appropriate parameters, it is necessary to have full knowledge of the need and technical limitation of the application.However all the approaches presented in Table I achieve acceptable accuracy

Within their own respective applications with limited errors, each one varies in-terms of calibration procedure, noise parameters, head pose variations, cost etc. Either accuracy or error is calculated in every approach except one.Only few approaches concentrates on objects wearing glasses or Contact lens. It is essential to choose appropriate parameters to enhance HCI with improved accuracy.

Table II presents a variety of applications where the eye -tracking and gaze detection approaches are applied across the areas of medicine, education, industry etc. Clearly eye gaze interfaces is not limited to particular domain, the quality issues are to be well thought-out for real time applications to improve the HCI technology for general-purpose interacting environments.

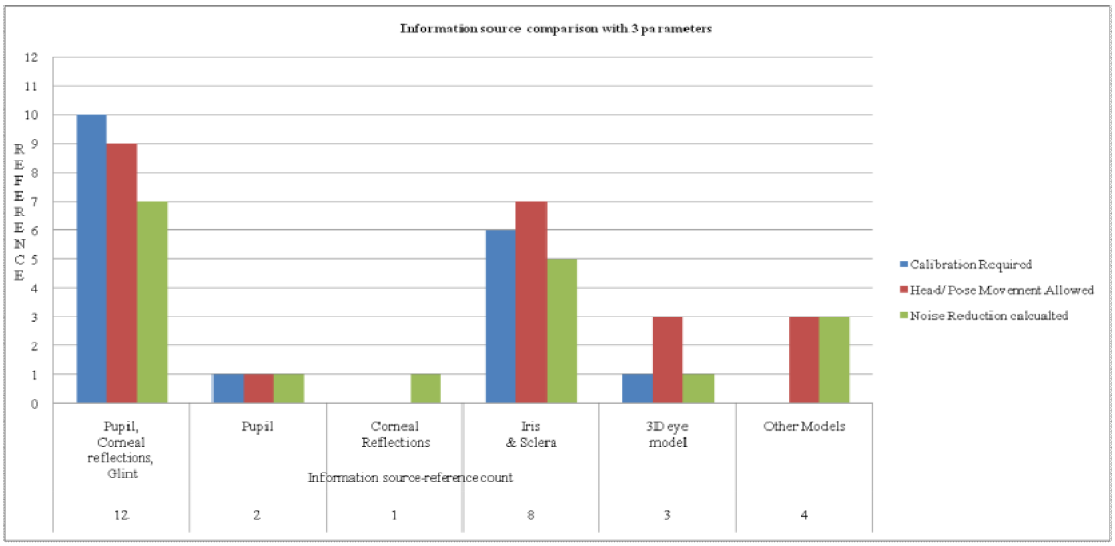

Fig. 4 – Information source selection compared against calibration, Head pose movement, Noise reduction

TABLE I INFORMATION SOURCE SELECTION AGAINST CALIBRATION, HEAD /POSE INVARIANCE, NOISE REDUCTION, EYE WEAR INTERRUPTS

Approaches Reference	Information source	Calibration Included	Head/ Pose Movement Allowed	Noise Reduction	Accuracy Or Error Calculation	Eyeglasses Or Contact lens Allowed
51, 52, 54, 58, 59, 60, 61, 70, 71, 75, 76, 79	Pupil, Corneal reflections, and Glint	10	9	7	11	3
57, 69	Pupil	1	1	1	2	0
63	Corneal reflections	0	0	1	1	0
55, 56, 62, 67, 77, 78, 80	Iris based	6	7	5	7	0
64, 65, 68, 72	3D eye model	1	4	2	4	0
54, 67, 73, 74	Other Models	0	3	3	4	1

TABLE II EYE-TRACKING AND GAZE DETECTION - DIFFERENT APPLICATIONS.

Approaches Reference	Application
51, 52, 53, 54, 57, 58, 62, 65, 67, 68, 70, 71, 74, 75, 77	Real time gaze direction detection
60, 64, 73	Eye tracking
55	Gaze-communication robots, gaze-based interactive sign boards
56	Occulumotor research
59, 61, 69, 80	Visual communication for AAC
78	Assistive Technology-rehabilitation
63	Video Oculography
66	Interactive Graphic display
76	Reading detection
72	Psychological experiments, ergonomic designs, disabled
79	Real time monitoring driver vigilance

VI. CONCLUSION

In this work interactive communication and its importance in various applications with different gaze based techniques and UI have been explored. The significance of Eye-tracking with Gaze based methods for enhancing user interactivity is discussed. An extensive literature survey has been presented to understand the developments and research of gaze usability in computer-based systems - Human interactive systems. This work proposed the quality issues in terms of information source selection against noise reduction, lighting conditions (indoor and outdoor), calibration necessity, head pose invariance, wearing glasses and contact lens. Seeing that HCI interfaces in different environments are designed for users, it is essential to facilitate such interfaces should be safer, interactive, hazard free, reasonable and convenient to use. In this work cost is not taken as an account.

In future, Gaze detection may further be explored for the possibility of designing attention management intelligent agents in E-Learning environment forlearnerswith learning difficulty disorder-Attention Deficit Hyperactive Disorder (ADHD).

REFERENCES

[1] ACM SIGCHI, 1996, “Curricula for Human-computer Interaction”, ACM Special interest group on computer-human interaction curriculum development group [On-line], http://www.acm.org/sigchi/cdg/cdg2.html.

[2] Maybury, M.T., and Wahlster, W., 1998, “Readings in Intelligent User Interfaces”, Morgan Kaufmann Press, San Francisco.

[3] Kirlik, A., 2006, ”Adaptive Perspectives on Human-Technology Interaction”, Oxford University Press, Oxford.

[4] Oviatt, S.L., Cohen, P., Wu, L., Vergo, J., Duncan, L., Suhm, B., Bers, J., Holzman, T., Winograd, T., Landay, J, Larson, J. and Ferro, D., 2000, “Designing the user interface for multimodal speech and pen-based gesture applications: state-of-the-art systems and future research directions”, Human-Computer Interaction, 15, pp 263-322.

[5] Gavrila, D.M., 1999, “The visual analysis of human movement: a survey”, Computer Vision and Image Understanding, 73(1), pp 82-98.

[6] Sibert, L.E. and Jacob, R.J.K, 2000, “Evaluation of eye gaze interaction”, Conference of Human-Factors in Computing Systems, pp 281-288.

[7] Various Authors, 2007, “Adaptive, intelligent and emotional user interfaces”, Part II of HCI Intelligent Multimodal Interaction Environments, 12th International Conference, HCI International(Proceedings Part III), Springer Berlin, Heidelberg.

[8] Te’eni, D., Carey, J.and Zhang, P., 2007, “Human Computer Interaction: Developing Effective Organizational Information Systems”, John Wiley & Sons, Hoboken.

[9] Chapanis, A., 1965, “Man Machine Engineering”, Wadsworth, Belmont.

[10] Norman, D., 1986, “Cognitive Engineering”, in D. Norman and S. Draper (eds), User Centered Design: New Perspective on Human-Computer Interaction, Lawrence Erlbaum, Hillsdale.

[11] Picard, R.W., 1997, ” Affective Computing”, MIT Press, Cambridge.

[12] Te’eni, D., Carey, J. and Zhang, P., 2007, “Human Computer Interaction: Developing Effective Organizational Information Systems”, John Wiley & Sons, Hoboken.

[13] Shneiderman, B., 1986, “Designing the User Interface: Strategies for effective human computer Interaction”, Addison Wesley, Reading, Massachusetts.

[14] Tajudeen, A., Atolagbe, 2002, “ELearning: The Use of components Technologies and Artificial Intelligence for management and Delivery of Instruction”, 24thInt.Conf.Information Technology interfaces ITI 2002, cavtart, Croatia.

[15] Nichols, M., 2003, “A theory for eLearning”, Educational Technology & Society”, 6(2), pp 1-10, ifets.ieee.org\periodical\6-2\1.html.

[16] Yucel Ugurlu, Human Interactive ELearning Systems, 2012, “Using Head Posture Images World Academy of Science”, Engineering and Technology 65 2012

[17] Darwin, C., 1872/1965, “The expression of Emotions in man and Animals” The University of Chicago Press, Chicago.

[18] Ekman, P., 1994, “Strong evidence for universals in facial expressions: a reply to Russell’s Mistaken critique”, Psychological Bulletin 115, 2, pp 268-287.

[19] Silvan Tomkins, 2012, "Applied Studies in Motivation, Emotion, and Cognition", The Tomkins Institute, Retrieved 30 April.

[20] Goleman, D., 1995, "Emotional Intelligence", Bantman Books, New York.
[21] Shelton, C., 2000, “Portraits in emotional awareness”, Educational Leadership, pp 330-332.
[22] Gardner, H., 1983, "Frames of Mind: The Theory of Multiple Intelligence", Basic Books, New York.
[23] Branco, P., Firth, P., Encarnacao, M., &Bonato, P., 2005, “Faces of Emotion in Human-Computer Interaction”, CHI, Portland, OR, USA.
[24] De Villiers, R., 2004, “Usability Evaluation Of an E-learning Tutorial: Criteria, Questions and Case Study”, SAICSIT, Stellenbosch, South Africa.
[25] Yu, F. Y., Chang, L. J., Liu, Y. H., & Chan, T. W., 2002, “Learning preferences towards computerized competitive modes”, Journal of Computer Assisted Learning, 18, pp 341-350.
[26] Juutinen &Saariluoma, 2010” Emotional Obstacles of E-learning “Jyväskylä University Printing House, Jyväskylä97pp 181.
[27] Ferro, T., 1995, “The influence of affective processing in education and training, New Directions for Adult and Continuing Education”, Vol.59, pp 25-33.
[28] Palombo Weiss R., 2000, “Emotion and learning, Training and Development”, Vol.54, No.11, pp 44-48
[29] Clore, G., Gasper, K., 2000, “Feeling is believing: Some affective influences on belief”. InFrijda, N., Manstead, A.and Bem, S. (Eds.), “Emotions and Beliefs: How Feelings Influence Thoughts”, Cambridge University Press, Cambdidge, 1-9.
[30] Worthman, C., 1999, “Emotions:You can feel the difference”, In: Hinton, A., “Biocultural Approaches to the Emotions, Cambridge University Press, Cambridge, pp 41-74.
[31] Hedge, N., and MacDonald, D., 2005, “Affective Considerations in Distance e-Learning”, Proc. of the IASTED Conference on Education and Technology.
[32] Picard, R.W., Klein, J., 2002, “Computers that Recognize and Respond to User Emotions: Theoretical and Practical Implications”, MIT Media Lab Tech Report 538.
[33] Kerry O' Regan, 2003, ”EMOTION AND E-LEARNING”
[34] Gray, Jeremy, R., Braver, Todd, S. and Raichle, Marcus, E., 2002, “Integration of emotionand cognition in the lateral prefrontal cortex”, New York.
[35] Kort, B., Reilly, R., Picard, R.W., 2001, “ An affective model of interplay between emotions and learning: reengineering educational pedagogy-building a learning companion” Advanced Learning Technologies, Proceedings, IEEE International Conference on. 2001, pp. 43 – 46, ISBN: 0-7695-1013-2.
[36] Konstantina Chatzara, Charalampos Karagiannidis, and Demosthenes Stamatis, 2012, “Research on e-Learning and ICT in Education”, DOI 10.1007/978-1-4614-1083-6_19, © Springer Science+Business Media, LLC 2012
[37] Amarnag, S., Kumaran, R.S., Gowdy, J. N., “Real Time Eye-tracking Human Computer Interfaces”, Clemson University Clemson, USA.

[38] XiaMao and Zheng Li, 2012, " Multimodal Intelligent tutoring Systems" E-Learning-Organizational Infrastructure and Tools for Specific Areas, ISBN: 978-953-51-0053-9.

[39] Baron – Cohen, S., 1995, "Mind blindness:An Essay on Autism and theory of Mind", Cambridge:MIT Press, pp171.

[40] Johansen, A.s., and Hansen, J.P.,, "Augmentative and Alternative Communication : the Future of Text on the move, "vol. 5, pp 125-149, springer-verlag.

[41] Poole, A., and Ball, L.J., "Eye-tracking in Human-computer Interaction and Usability Research: current status and Future Prospects", Lancaster University, UK.

[42] Shuo Samuel Liu, Andrew Rawiez, Siavash Rezaei, Teng Ma, Cheng Zhang, KyleLin, Eion Wu, 2011, "An Eye-Gaze Tracking and Human Computer Interface System for Peoplewith ALS and Other Locked-in diseases", Doi:10.5405/jmbe.836.

[43] Dan Witzner Hansen, QiangJi, 2009, "In the Eyeof the Beholder: A Survey of Models for Eyes and Gaze".

[44] Purves, D., Augustine, G.J., Fitzpatrick, D. et al., 2001, " Types of Eye Movements and Their Functions Neuroscience", 2nd edition.

[45] Just, M.A., AND Carpenter, P.A., 1980, "Atheory of reading from eye fixations to comprehensive Psychological review", 87, 4, 329-354.

[46] Calvi, C. Porta, M. Sacchi, D., 2008, "e5Learning, an E-Learning Environment Based on Eye Tracking", ICALT.

[47] Wang, H., Chignell, M., and Ishizuka, M., 2006, "Empathic tutoring software agents using real time eye tracking", ETRA, pp 73-78.

[48] D'Mello, S., Olney, A., Williams, C., Hayes, P., 2012, "Gaze tutor: A gaze-reactive intelligent tutoring system", IJHCS70, 5, pp 377-398, www.elseiver.com/locate/ijhcs.

[49] Bondarvea, D., Conati, C., Feyzi-Behnagh, R., Harley, J.M., Azevedo, R., and Bouchet, F., 2013, " Inferring Learning from Gaze Data during Interaction with an Environment to Support Self-Regulated Learning". AIED, pp 229-238.

[50] Kardan, S., and Conati, C., 2012, "Exloring gaze data for determining user learning with an interactive simulation" springer, pp 126-138.

[51] Dong Hyun Yoo, Myung Jin Chung, 2005, " A novel non-intrusive eye gaze estimation using cross-ratio under large head motion", Computer Vision and Image Understanding, 98, (2005), 25–51.

[52] Kar-Han Tan, David J Kriegman, NarendraAhuja, 2002, "Appearance-based Eye Gaze Estimation ", IEEE WACV'02.

[53] BasilioNoris, KarimBen machiche, Aude, G., Billard, 2004, "Calibration-Free Eye Gaze Direction Detection With Gaussian Processes", LASA Laboratory - EPFL, Station 9, CH-1015 Lausanne, Switzerlandhttp://lasa.epfl.ch, basilio.noris@epfl.ch.

[54] Zhiwei Zhu and QiangJi, 2004, "Novel Eye Gaze Tracking Techniques Under Natural Head Movement".

[55] HirotakeYamazoe, Akira Utsumi, Tomoko Yonezawa, Shinji Abe ATR, 2005, ” Remote Gaze Estimation with a Single Camera Based on Facial-Feature Tracking without Special Calibration Actions”, Intelligent Robotics and Communication Laboratories

[56] ZhorRamdane-Cherif and Amine Naït-Ali, 2008, “An Adaptive Algorithm for Eye-Gaze-Tracking-Device Calibration”, IEEE Transactions On Instrumentation And Measurement, vol. 57, no. 4, April

[57] Rainer Stiefelhagen, Jieyang, AlexWaibel, “Tracking Eyes and monitoring Eye Gaze”.

[58] B. Noureddin, P.D., Lawrence, C.F., 2005, “A non-contact device for tracking gaze in a human computer interface”, Man Computer Vision and Image Understanding “98 (2005) 52–82

[59] Andr´e Meyer, Martin B¨ohme, Thomas Martinetz, and Erhardt Barth, “A Single-Camera Remote Eye Tracker”

[60] Hu-Chuan Lu*a, Guo-Liang Fanga, Chao Wangaand Yen-Wei Chena, b “A Novel Method for Gaze Tracking by Local Pattern Model and Support Vector Regressor”,

[61] YoshinobuEbisawa, 1998, “Improved Video-Based Eye-Gaze Detection Method”, IEEE Transactions on Instrumentation And Measurement, vol. 47, no. 4, August.

[62] Kyung-Nam Kim and R. S. Ramakrishna, 1999 “Vision-Based Eye-Gaze Tracking for Human Computer Interface”0-7803-5731-O/99/$10.00 0 IEEE

[63] Jonathon, B., Hiley, Andrew, H., Redekopp, and Reza Fazel-Rezai, 2006, “ A Low Cost Human Computer Interface based on Eye Tracking”, IEEE Proceedings of the 28th IEEE EMBS Annual International Conference New York City, USA, Aug 30-Sept 3.

[64] Borna Noureddin, Peter Lawrence, 2006, “A Single Camera Eye-Gaze Tracking System with Free Head Motion Craig Hennessey”, ETRA, San Diego, California, 27–29 March © 2006 ACM 1-59593-305-0/06/0003 $5.00

[65] Jixu Chen, QiangJi, 2008, “3D Gaze Estimation with a Single Camera without IR Illumination”, 978-1-4244-2175-6/08/$25.00 © IEEE.

[66] Zhiwei Zhu, QiangJi, 2004, “Eye and gaze tracking for interactive graphic display”, Machine Vision and Applications (2004) 15: 139–148.

[67] Jie Zhu, and JieYang, 2002, “Subpixel Eye Gaze Tracking”, Interactive Systems Laboratory Carnegie Mellon University, Pittsburgh, PA 15213 USA.

[68] YoshioMatsumotoy, Alexander Zelinskyzy, 2000, “An Algorithm for Real-time Stereo Vision Implementationof Head Pose and Gaze Direction Measurement”, Nara Institute of Science and Technology, 8916-5, Takayamacho, Ikoma-city, Nara, Japanyoshio@is.aist-nara.ac.jpz, The Australian National University.

[69] Alberto De Santis, Daniela Iacoviello, 2009, “Robust real time Eye-tracking for computer interface for disabled people, ∗journal homepage: www.intl.elsevierhealth.com/journals/cmpb computer methods and programs in biomedicine 9 6 (2 0 0 9) 1–11© 2009 Elsevier Ireland Ltd. All rights reserved.

[70] Takehikoohno Naoki Mukawa Atsushi Yoshikawa, 2002, ”FreeGaze:A Gaze Tracking System for Everyday Gaze Interaction”, NTT Communication Science Laboratories, NTT Corporation.

[71] Fl´avio Luiz Coutinho and Carlos Hitoshi Morimoto, “Free head motion eye gaze tracking using a single camera and multiple light sources”.

[72] John, J., Magee, Margrit Betke, James Gips, Matthew, R., Scott, and Benjamin, N., Waber, 2008, “Human–Computer Interface Using Symmetry between Eyes to Detect Gaze Direction”, IEEE Transactions on Systems, Man, and Cybernetics—Part A: Systems And Humans, Vol. 38, NO. 6, November.

[73] Thomas, D., Rikert Michael, J., Jones, 1998, “Gaze estimation using morphobale models IEEE conference on automatic face and Gesture recognition, Nara, Japan, April, pp 436-441.

[74] Zhiwei Zhua and Qiang Jib, 2005, “Robust real-time eye detection and tracking under variable lighting conditions and various face orientations”, Computer Vision and Image Understanding 98 (2005), pp 124–154

[75] Jixu Chen Yan Tong Wayne Grayy Qiang Jiz, 2008, “A Robust 3D Eye Gaze Tracking System using Noise Reduction ETRA, Savannah, Georgia, March 26–28.© 2008 ACM 978-1-59593-982-1/08/0003 $5.00

[76] Christopher, S., Campbell, Paul, P., Maglio. 2001, “A Robust Algorithm for Reading Detection”, PUI 2001, Orlando FL USA Copyright ACM 1-58113-448-7-11/14/01...$5.00.

[77] Pérez, A., Córdoba, M.L., García, A., Méndez, R., Muñoz, M.L., Pedraza, J.L., Sánchez, F., 2003, “A Precise Eye-Gaze Detection and Tracking System”, WSCG’2003, February 3-7, Plzen, Czech Republic.WSCG POSTERS proceedingsCopyright UNION Agency – Science Press.

[78] Diego Torricelli, Silvia Conforto, Maurizio Schmid, Tommaso D’Alessio, 2008, “A neural-based remote eye gaze tracker under natural "head motion”, computer methods and programs in biomedicine 9 2 (2 0 0 8) 66–78 © 2008 Elsevier Ireland Ltd. All rights reserved.doi:10.1016/j.cmpb.2008.06.008.

[79] Qiang Ji and Xiaojie Yang, 2002, “Real-time Eye, Gaze and Face Pose Tracking for Monitoring Driver Vigilance, ”Real time imaging 8, pp 357-377, Elsevier Science Ltd.

[80] Abe Kiyohiko, Ohi Shoichi and Ohyama Minoru, 2013, “Eye-Gaze Input System suitable for Use under Natural Light and Its ApplicationsToward a support for ALSpatients”, http://dx.doi.org/10.5772/56560.