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Proposal and Evaluation of Eye-Blink Rate Detection Algorithms for HMD Environment

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Abstract: People spend much time in front of the electronic display screens like computers, laptops, mobile phones or other devices which causes harmful effect on eyes. HMDs that implement virtual reality are widely used today and EBR (Eye Blink Rate) check in HMD environment is required and EBR is important to measure because it can be used as a recommendation for healthy visual field in virtual reality. However, EBR check in natural state is already proposed but effective and accurate measure of EBR is not proposed yet. Therefore, a system that can check the EBR in the HMD environment is required. In this study, we propose EBR for various environment like natural and HMD and evaluate the performance. The performance was evaluated by comparing the proposed algorithm with that of GT (Ground Truth) for 23 subjects. Our result showed that 99% accuracy of proposed algorithm in natural environment. And the proposed algorithm in HMD environment also showed 99% accuracy.

Key words: Image processing, eye-blink rate, HMD (Head Mounted Display), histogram, optical flow, face detection, eye detection

INTRODUCTION

The goal of our research is to propose a new method to efficiently track eyes of a person from real time video image sequences and propose a new algorithm to analyze the Eye Blink Rate (EBR) in a real time. Many people use computers and other display devices these days. The eye has wide range of applications in scientific area and that may create suffer from computer vision syndrome and many more eye diseases. Even it is found that with continuous using of display devices, eye blink is reduced to 60% or even more who uses computer more than 3 h in a day. Therefore, we proposed the robust method to count the number of blinks in natural and HMD. In this study, we suggested two algorithms for natural and HMD. In HMD case it used the IR camera and in natural case it used RGB camera. It requested different approach to count the eye-blink. There are many algorithms that can find out eye-blink in case of natural (Haq and Hasan, 2016). However, there were not any robust or any efficient methods having accuracy 99% till now in case of HMD. Therefore, our main approach was to find out eye-blink in case of HMD.

Literature review

Background theory: Eye blink rate can be defined as the number of eye-blinks in 1 min. The eye-blink is very important factor that should be kept in mind in our daily life while using visual display devices and result of long use of computers or HMD or other display devices may cause suffer from Computer Vision Syndrome (CVS) and many more eye diseases like as vision problems. Many researches had already performed on eye-blink rate but in case of eye-blink using HMD, only limited number of paper were published.

The HMD device that we used to measure EBR in this paper is Fove. Fove debug eye tracking tool is shown in Fig. 1. Fove is the media which gives human connections with the virtual world and it works on eye control virtual reality in Fig. 2. Fove is the virtual reality HMD that basically uses eye tracking. Fove provide more realistic environment and deeply interacts the user with the virtual world. Fove technology enables new form of expression, communication and movement.

Many and variety of eye blink rate detection and counter methods have been already reported by some researchers. Haq and Hasan (2016) proposed an approach in which histogram was used to detect the eye-blink rate but the accuracy of the blink rate was only 87%. These drawback was resolved by our proposed algorithm with robust accuracy and experimental results from 23 different people.

Divjak and Bischof (2009) also proposed the eye blink fatigue detection for prevention of computer vision syndrome and in his study the eye-blink was detected by using optical flow for face and eye tracking. Eye blink accuracy for was about 91% that needs to be improved. The research done by different researchers gave the idea and method to find out the easiest way and the effective method for eye-blink rate detection for determining the

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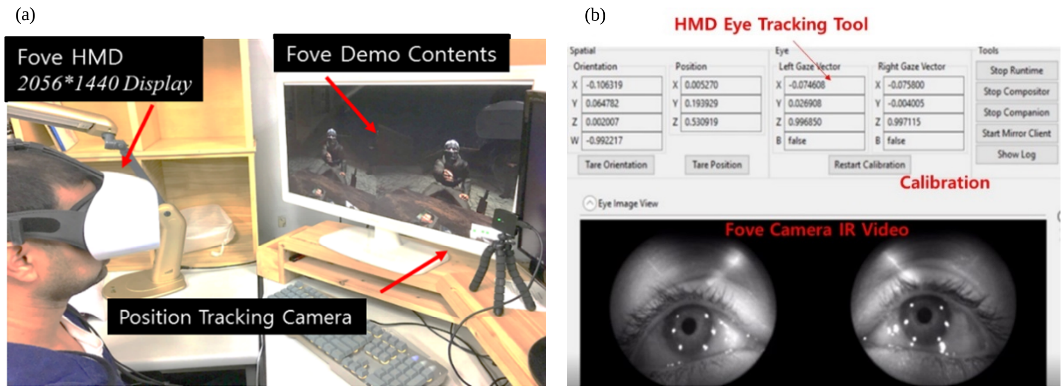

Fig. 1: HMD (Fove); a) Human connections with the virtual world using Fove and b) Eye tracking tool

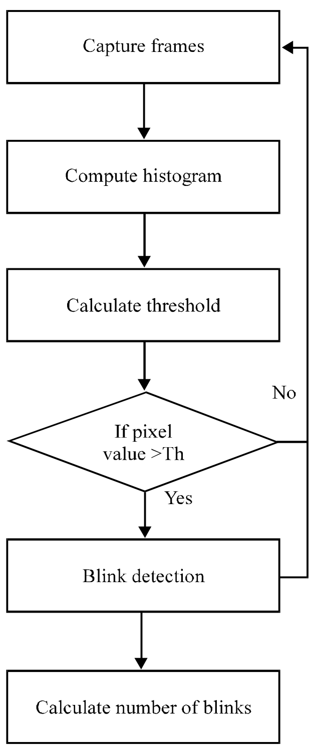

Fig. 2: Flow chart of proposed algorithm in HMD

eye-blink rate in natural and HMD (Fove) and finally their papers, made us able to suggest the rigid and effective method for detection of eye blink rate in case of natural/HMD. And finally we can compare the HMD with natural blink rate.

Husna and Roy (2014) proposed the eye blink rate and face monitoring for fatigue estimation through face monitoring. They proposed eye blink rate during conversation and reading. It needs to be improved in system accuracy because the accuracy was only 94%. Our algorithm accuracy to count blink rate was around 99%.

MATERIALS AND METHODS

Proposed algorithm for HMD environment: Eye blink rate measurement can be estimated by visual observation by recording video or real time video. HMD stands for Head Mounted Display and in our method, we used Fove (HMD). In this study we proposed an effective way for eye-blink rate measurement. We included eye-blink rate for both natural and HMD (Fove) but we emphasize mainly on eye blink for HMD. In case of HMD, the captured video was converted to gray image. Eye-blink detection and counter was performed using histogram analysis and these steps were briefly explained in this paper. As shown in flowchart Fig. 2, the video was captured from the HMD and image frames from HMD was converted into grayscale and in gray scale. Pixel value is a single number that represents the brightness of pixel. Then histogram analysis was done on the gray image and opened eye and closed eye is compared. Black pupil takes vital role in blink detection process. We can observe that number of pixel values at higher pixel values were greater in closed eye than in open eye because of black pupil. We maintained Threshold (Th) between histogram of closed and opened eye. If Threshold (Th) exceeded, then blink was detected and if pixel was lower than threshold again the same process is repeated. And finally after blink detection the number of blink was computed by counting the blink detection.

Proposed algorithm for natural environment: Many methods for eye-blink detection had been suggested and some of them are Circle Hough Transform (Kawaguchi *et al.*, 2000), skin colors detection (Krolak and Strumillo, 2006) and Haar-like features (Bradski *et al.*, 2005; Krolak and Strumillo., 2009). In our algorithm we used the Haar-like features and optical flow for tracking facial region and eye localization in face. We applied haar cascade classifier (Viola and Jones, 2001) and

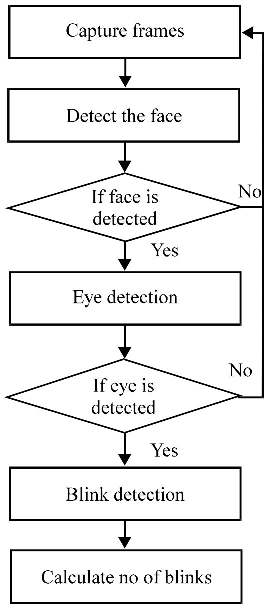

Fig. 3: Flow chart of proposed algorithm in natural environment

optical flow algorithms (Clocksin, 1987; Haussecker and Fleet, 2001) for face detection and tracking The Haar features were computed by convolving the image frame with templates of different size and orientation.

Eye-region localization was performed in an image frame captured from the camera and the position of the eyes in the face image was found on the basis of traditional rules and geometrical dependencies of proportion shows the face divided into six equal squares (Oguz, 1996). The located eye region was extracted from the face image and use as a template for further eye tracking by means of template matching.

In case of natural, face was tracked using optical flow algorithms and finally eye blink detection was performed on the eye-region. As shown in Fig. 3 (Flow char of proposed algorithm in natural environment), the video was captured by camera and on captured image frame face was detected using the haar cascade classifier and optical flow algorithms. If the face was detected, eye detection is performed if not same process was repeated. In the detected face region, eye region were localized using the haar features. Motion estimation was performed in eye region and finally number of blink detection was counted. This process is repeatedly performed.

RESULTS AND DISCUSSION

Experiments: The eye-blink rate was measured in natural state by camera (Model: SONY TD-20). The eye-blink rate determination was done using the distance between camera and person which was 1 m. Finally, HMD (Fove 2056*1440 Display) was used for the eye blink rate measurement in head mount display. After all the experiment environment was completed. We took 2 minutes of video for both natural and HMD state for proper stabilization and one minute video before and after 30 sec. We did experiment on 23 different people and got results shown in Table 1.

We got result of eye-blink in case of natural and HMD (Fove) which is shown in Table 1. As a result, we achieved 99.64% accuracy for natural and 99.27% for HMD (Fove). Thus, the data shown in Table 1 revealed that blink in HMD was lower than the blink in natural.

Figure 4 shows that EBR rate in natural and HMD. Each participant from 23 different people is shown in Table 1. We observed that EBR of each participant in natural estimated was approximately closed to GT (Natural). And HMD estimated was approximately close to GT(HMD).

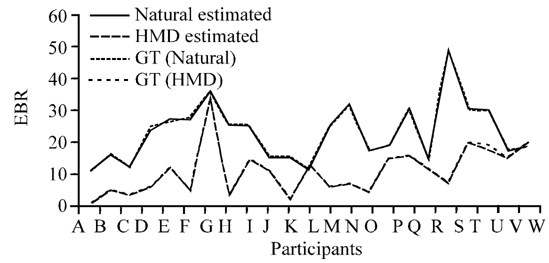

Fig. 4: EBR rate for natural and HMD for each participant

Table 1: Experiment data

Participants	Natural estimated	GT (Natural)	Natural accuracy (%)	HMD estimated	GT (HMD)	HMD accuracy (%)
A	12	12	100.00	2	2	100.00
B	17	17	100.00	6	6	100.00
C	13	13	100.00	4	4	100.00
D	25	26	96.15	7	7	100.00
E	28	28	100.00	13	13	100.00
F	28	29	96.55	6	6	100.00
g	37	37	100.00	34	35	97.14
H	26	26	100.00	4	4	100.00
I	26	26	100.00	16	16	100.00
J	16	16	100.00	12	12	100.00
K	16	16	100.00	3	3	100.00
L	12	12	100.00	14	14	100.00
M	26	26	100.00	7	7	100.00
N	33	33	100.00	8	8	100.00
O	18	18	100.00	5	5	100.00
P	20	20	100.00	16	16	100.00
Q	32	32	100.00	17	17	100.00
R	16	16	100.00	13	13	100.00
S	50	50	100.00	8	8	100.00
T	31	31	100.00	21	21	100.00
U	31	31	100.00	19	20	95.00
V	18	18	100.00	16	16	100.00
W	20	20	100.00	21	21	100.00
Total	551	553	99.64	272.00	274	99.27

CONCLUSION

Our eye blink rate was decreased in case of HMD. At current time the use of HMD devices is increasing and because of this there is the risk of eye disease and therefore, adult as well as young children should take care of this critical situation. They should rest eye for some time while using HMD. Our algorithm efficiently found eye-blink in natural using optical flow and face tracking and in HMD using histogram analysis using Fove (Virtual reality HMD). we recommend HMD user to increase the blink number at time of using HMD because eye blink is essential for healthy eye. We got the effective accuracy in both the case of eye-blink. Our algorithm efficiently found eye-blink in natural using optical flow and face tracking and in HMD using histogram analysis using Fove (Virtual reality HMD). And we got the effective accuracy in both the case of eye-blink.

SUGGESTIONS

In Fove (HMD), the eye blink counter can be added and for a vision test driver license, performance of eye and condition of eye can be tested. Therefore, my study plan is to apply this algorithm inside Fove (HMD) and that can be used in vision test driver license. In future this algorithm can be applied and extended into several applications like in Fove (HMD), vision test driver license, depression and stress detection, etc.

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REFERENCES

Bradski, G., A. Kaehler and V. Pisarevsky, 2005. Learning-based computer vision with intel's open source computer vision library. Intel Technol. J., 9: 119-130.

Clocksin, W.F., 1978. Determining the orientation of surfaces from optical flow. Proceedings of the International Conference on Artificial Intelligence (AISB/GI'78), July 18-20, 1978, IOS Press, Amsterdam, Netherlands, pp: 93-102.

Divjak, M. and H. Bischof, 2009. Eye blink based fatigue detection for prevention of computer vision syndrome. Proceedings of the Conference on Machine Vision Applications MVA, May 20-22, 2009, IAPR, Yokohama, Japan, pp: 350-353.

Haq, Z.A. and Z. Hasan, 2016. Eye-blink rate detection for fatigue determination. Proceedings of the 2016 1st India International Conference on Information Processing (IICIP), August 12-14, 2016, IEEE, Delhi, India, ISBN:978-1-4673-6985-5, pp: 1-5.

Haussecker, H.W. and D.J. Fleet, 2001. Computing optical flow with physical models of brightness variation. IEEE. Trans. Pattern Anal. Mach. Intell., 23: 661-673.

Husna, A.U. and A. Roy, 2014. Fatigue estimation through face monitoring and eye blinking. Proceedings of the 3rd International Conference on Mechanical, Industrial and Energy Engineering (ICMIEE 2014), December 25-26, 2014, Khulna University of Engineering & Technology, Khulna, Bangladesh, pp: 2-5.

Kawaguchi, T., D. Hidaka and M. Rizon, 2000. Detection of eyes from human faces by Hough transform and separability filter. Proceedings of the IEEE 3rd International Conference Image on Processing, Sept. 10-13, IEEE Xplore Press, Vancouver, BC., Canada, pp: 49-52.

Krolak, A. and P. Strumillo, 2006. Fatigue monitoring by means of eye blink analysis in image sequences. Intl. Comput. Sci. Eng. Soc., 1: 219-222.

Krolak, A. and P. Strumillo, 2009. Eye-blink Controlled Human-Computer Interface for the Disabled. In: Human-Computer Systems Interaction, Hippe, Z.S. and J.L. Kulikowski (Eds.). Springer, Berlin, Germany, ISBN:9783642032011, pp: 123-133.

Oguz, O., 1996. The proportion of the face in younger adults using the thumb rule of Leonardo da Vinci. Surg. Radiol. Anatomy, 18: 111-114.

Viola, P. and M. Jones, 2001. Rapid object detection using a boosted cascade of simple features. Proceedings of the 2001 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR 2001) Vol. 1, December 8-14, 2001, IEEE, Kauai, Hawaii, USA., ISBN:0-7695-1272-0, pp: I-511-I-518.