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Eye Gaze Controlled Virtual Keyboard

Partha Chakraborty, Dipa Roy, Md. Zahidur Rahman, Saifur Rahman

Abstract: ***Human Computer Interaction is an emerging technology which refers to a vast number of algorithms and different types of techniques to enhance the interaction process. Eye gaze technology is one of the most significant techniques of modern science and can be used in many areas like security, typing, information tracking etc. The need of the system for physically disable people motivated many researchers to develop systems which can be used only using the eye gaze and blinking. In this paper, we are going to represent the development of a virtual keyboard which work by detecting eye gaze and eye blinking. It involves building a system that capture video directly from PC camera and detects human face, eyes. To detect face accurately we will follow a simple rule as the eyes and lips are always in the sample place as image, which will make the eye detection process much easier. To do this we are going to use an approach that involves the 68 points of face which is specific and must exist in every face as- the eye area, top of the chin, eyebrow, nose, outside edge of face etc. It also detect eye gaze as left, right to select keyboard portion and eye blinking to select the desired key from the virtual keyboard on the board. The goal of this system is to type without using finger or hands. Such types of application are really important and blessings for those people who completely lost the control of their limbs. The methodology is described including flow-charts for each stage of the system and then implementation results has described.***

Keywords: ***Eye gaze, Eye blink, Virtual keyboard***

I. INTRODUCTION

In the field of video analysis, several bio-metrics systems like-face detection, eye detection, iris detection has gained significant consideration and are being appreciated in recent years. Those systems are quite complicated because of some crucial dependencies like facial expression, orientation, light, camera resolutions, etc. However, it is a technology that is being used widely in a variety of applications like security. The human eye is one of the most important and eminent parts of the face and also convey different unique information of human. At present to form a more promising system 'Eye detection' is another option. By detecting eye and tracking the movement of the eyeballs many useful interfaces can be developed. Due to the rapid development of technology, there is a great demand for Human-Computer Interaction. Many precious systems are being developed for people to make their life more secure and easy. But there was a need to develop such systems for the people who can't work spontaneously, who are only able to perform any involuntary action. Many disabled people have only the action that they can perform of their own free will is the blinking of their eyes. Because of this, many human interaction systems are developing based on eye gaze.

Eye-tracking systems use different types of image processing techniques like filtering, sharpening, etc. based on eye bio-metrics. In image processing, the input data is acquired first and then it is converted into digital form. In the digital image, various types of mathematical operations are applied to get a more enhanced image to perform the next operation. There are many systems and applications that are based on human eye tracking. Various kinds of human-computer interfaces exist that make use of human eye movements and eye blinking [1]. Some interfaces make use of eye movement for controlling the mouse cursor, some systems track eyes to check the drowsiness of the driver during a drive. Many eye-tracking techniques are also used in medicine and optometry to diagnose certain diseases [2].

Eye gaze controlled virtual keyboard is an example of today's developed technology. The idea behind the virtual keyboard is to display the keys in a rectangle form like a keyboard and continuously light up the keys one by one at a time. Whenever the desired key light up, we would just need to close our eyes and the key will be pressed automatically. The face is known as the index of one's mind while eyes are called windows to the soul of the human. The eyeball movement and blinking ratio provide an enriched window into a person's intention and demand. Here, the eye-tracking system refers to the technique of measuring the movement/activity of eyes. To track the movement of eyes we have to detect eye and eyeball first. Again, face detection is the early step of eye detection. Accurately identification of landmarks within the face is a crucial step in the eye detection process. Tasks such as facial identification, expression analysis, age estimation, and gender classification are often built upon a facial land-marking component in their methods [3-4]. Very recently, Guarin [5] described an automated facial land-marking tool which is used in the characterization of facial displacements in sufferers of facial palsy; while the work by Anping [6] uses landmarks as predicted by Active Shape Models to assess facial nerve paralysis.

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* Correspondence Author
Partha Chakraborty, Department of CSE, Comilla University, Cumilla - 3506, Bangladesh. Email: partha.chak@cou.ac.bd
Dipa Roy Department of CSE, Comilla University, Cumilla - 3506, Bangladesh. Email: dipas.9193@gmail.com
Md. Zahidur Rahman, Department of CSE, Comilla University, Cumilla - 3506, Bangladesh. Email: mzahidur.bd@gmail.com
Saifur Rahman, Department of CSE, Comilla University, Cumilla-3506, Bangladesh. Email: saifurrahmany43@gmail.com

A. Contribution of Our Work

In one way, the eye gaze controlled virtual keyboard should be seen as just another potential access method for those people who are physically disabled. Again users generally find eye gaze access easier, less fatiguing and loss restrictive. This work will help afflicted people to type their text without touching the keyboard. Our main aim of this project is to minimize the effort for typing and to enable typing of those people who are crippled and are disable to type by using their finger. Some people have only eyes as their potential. They can't write and are unable to pick up any pen or to type by their finger. For different types of physical disabilities, many students can't continue their studies even can't interact with others. Eye gaze controlled keyboard technology can give us the ability to help those students to continue their study and other work. It can help people to lead a normal human life.

II. RELATED WORK

Studies have been conducted on several eye tracking, eye blinking techniques during the domain selection and analysis phase of this research. Christos Sagonas presents a comparison of performances of different methods on face detection on a newly collected data in his paper [7]. In recent years, eye gaze and blinking technology have become an emerging field of science. Scott MacKenzie and Behrooz Ashtiani also provide a text entry system by eye blinking which used a scanning ambiguous keyboard [8]. It will we more fruitful if one takes a look at the paper created by Anjana Sharma to know deeply about various eye gaze techniques, algorithms, and models [9]. Michael Chau and Margrit Betke have presented a system that detects the user's eye blinks and analyzes the pattern and duration of the eye blink [10]. An overview of different types of eye or eye blink detection works survey also has described by Grauman and Magee et al [11]. A large number of techniques have been investigated in the past to track eye movements and among them, three eye-tracking techniques are most popular and are widely used in several applications. These are Videooculography (VOG), Electrooculography (EOG) and Infrared pupil corneal reflection (IR-PCR).

An eye-computer interface is a system that allows acting operation depending on the eye. In this system, no muscle movements are required. The eye-blink-controlled systems distinguish between voluntary and involuntary blinks and interpret single voluntary blinks or their sequences [12]. Vision-based eye blink detection techniques can be broadly classified into two terms: Vision-based eye blink detection techniques can be broadly classified into two terms. Active eye-blink detection: This type of techniques depends on special illumination and it uses the retro-reflective property of the eye. Light falls in the eye from an object and reflected from the retina. This kind of eye blink detection technique gives more accurate results and it is also a quick, robust way [13]. Passive eye blink detection techniques do not use any additional light source and the blinking ratio is detected from the sequences of images within the visible spectrum. Applied Science Laboratories has developed a passive eye detection system for eye tracking. It requires a head-mounted camera to track eye movements which is uncomfortable for many users. There are some recent works in detecting eye gaze too. In 2019, Partha Chakraborty analyzed the gaze pattern to calculate the level of visual focus of human's attention [14].

III. METHODOLOGY

The eye gaze controlled typing system mainly work by detecting eye and then detects eye blinking to select the desired key. This system took five main parts to write using virtual keyboard. First, the system detect face and draw rectangle around the face. To detect face, the system uses HoG descriptor by following dlib in OpenCv. The Histogram of Oriented Gradients (HOG) is a Haar based feature description widely used in the area of computer vision and image processing. It is used for the purpose of face detection which follows the sub window based approach by creating several windows on image. The technique counts occurrences of gradient orientation in localized portions of an image. It is widely used face detection model which is more accurate than other method. It is based on HoG features and linera SVM. The Haar based face detection process by using HoG descriptor is as follows:

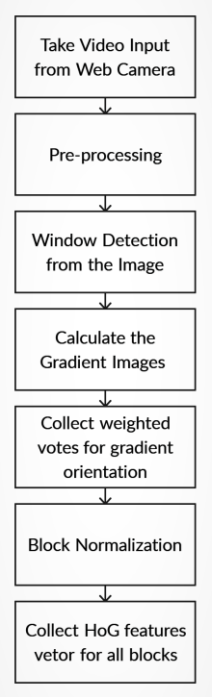

Fig. 1. Face detection process using HoG feature descriptor

Second, the system detects eye for that we used shape predictor 68 face landmark which uses 68 specific points and must exist in every face as eye, nose, lips, eyebrow and face area. To do this we are going to use the approach which was invented by Vahid Kazemi and Josephine Sulllivan in 2014. The Shape predictor 68 face landmarks is shown in the Fig. 2. Third, the system detects eye blinking. We took the point that eyes blink when upper and lower level iris mixed for a while. We draw two lines in the eye vertically and horizontally. During eye blinking, the vertical line got vanished. Fourth, eye gaze is detected to choose the keyboard portion. Eye gaze detection was done by detecting eyeball and applying a threshold on it. It also counts the white part of the eye.

Fifth, to write using eyes we created a virtual keyboard on the screen. Here, we use 50 keys that include 26 letters, digit and some sign. Using this keyboard we can write only by blinking eyes.

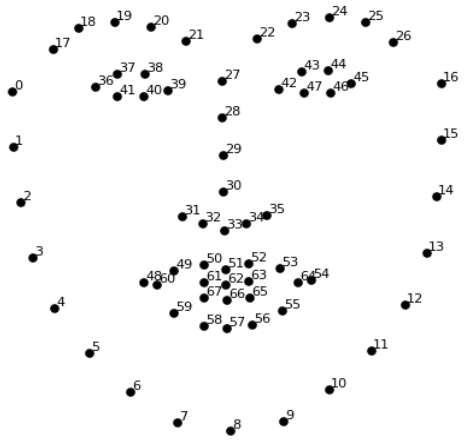

Fig. 2. Shape predictor 68 face landmarks

A flowchart of the proposed system has given below to show the overall techniques of eye gaze controlled virtual keyboard:

Fig. 3. Flow-chart of the system

IV. SYSTEM ARCHITECTURE

In this paper, we have designed a system to provide the writing power without hand. Users will be able to write by their eyes. To construct the system we have to use a webcam to capture live video. From the video, the system will detect face and eye using facial landmark structure. The system will be built on several parts as dace detection, eye detection, eye gaze and movement detection, eye blinking detection, virtual keyboard on screen, select left, right part of the keyboard and finally write using eye blinking. The overall system architecture is shown in the Fig. 4.

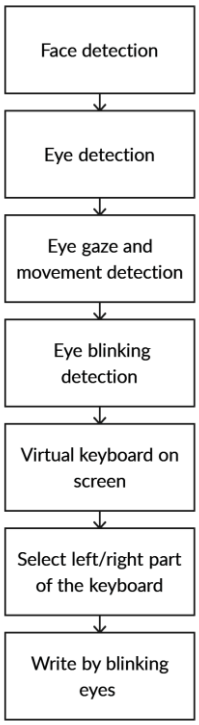

Fig. 4. Architecture of the system

A. Face Detection

Face detection is a process of identifying human faces from any digital image or video. It has various applications like security, social media, medical, law enforcement, etc. OpenCV and dlib are being widely used to detect face by using various methods. In this system, we are using the HoG face detector in Dlib.

B. Eye Detection

Using the face landmarks detection process we can point out 68 specific landmarks points of the face. For each point of 68, there is a specific index assigned. From this approach, we need to detect only the eyes. Point index for two eyes:

- Left eye points: (36, 37, 38, 39, 40, 41)
- Right eye points: (42, 43, 44, 45, 46, 47)

Fig. 5. Eye point from facial landmarks

C. Eye Gaze and Movement Detection

In this section, we detect the eye gaze point based on the movement of eyes. Ours eyes have two colors, the eyeballs are normally black or brown and the remaining part is white. So we can detect the movement of the eyeball. Here we only detect eye gaze as right, left or center point. For this, we apply a threshold on the eyes image and point the eyeball to detect movement.

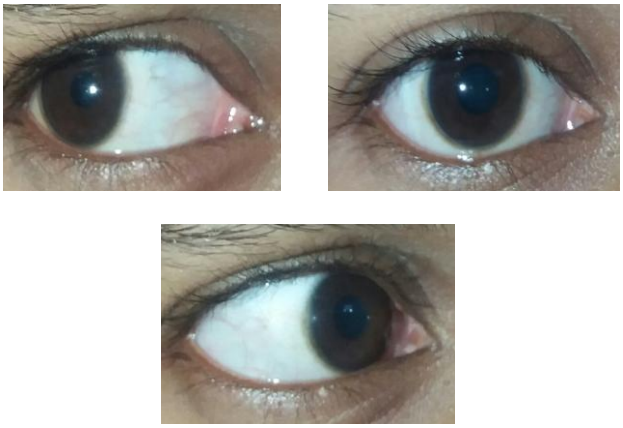

Fig. 6. Eye ball position (a) Left (b) Center (c) Right

D. Eye Blinking Detection

Eye blinking is a reflex that closes and opens the eyes rapidly. Eye blinking is a natural process and it happens very quickly. Here, we have to find out what occurs when we blink our eyes. It is easy to point out that an eye is blinking when:

- The eyeball cannot be seen.
- Eyelid is closed.
- Upper and bottom eyelashes connect together.

We should bear in mind that all of these actions must happen for a while (approximately 03 to 0.4 seconds). If those actions take much time then we will say that eyes are closed. In this system to detect eye blinking, we create two lines. One line crossing the eye horizontally and another line in vertically. When the vertical line gets vanished we can say that the eye is closed or blinking. This is when the lines look like when the eye is open:

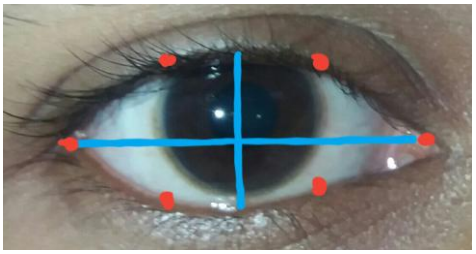

Fig. 7. Line when eye is open

And this is when the eye is closed:

Fig. 8. Line when eye is closed

E. Virtual Keyboard on Screen

For the system, we create a virtual keyboard and divide it into two parts. The basic idea behind the keyboard is as same as the old QWERTY keyboard. In the left part we put 1, 2, 3, 4, 5, Q, W, E, R, T, A, S, D, F, G, Z, X, C, V, SPACE, DELETE, and some sign. The right parts keys are-6, 7, 8, 9, 0, Y, U, I, O, P, H, J, K, L, B, N, M, SPACE, DELETE and some sign. We can now choose a key from the keyboard by eyes to type.

F. Keyboard Part Selection

In this part, we select one portion of the keyboard by using eye gaze. For this, we calculate the gaze ratio from the left and right eyes. If the gaze ratio is less than 0.9 than the right part of the keyboard will open otherwise left part will be selected.

G. Keyboard Part Selection

Finally, we can write using our eye blinking. We will calculate the eye blinking ratio and if the ratio is more than 5 than the active letter will be selected to print. Each of the keys will be lighted up one by one. Whenever one key is lighted up we have to close our eyes for some moment and the key will be selected.

V. EXPERIMENTA RESULTS

The system was implemented in real-time and all implementation results were recorded. Here, we represent all of the recorded results with respective figures.

A. Face and Eye detection

After running the program web camera of the pc is opened. The first step of the system is face detection. So, face detection in real-time implemented using Haar based HoG feature descriptor and to detect eye we use facial landmarks method with dlib.

Fig. 9. (a) Face detection (b) Eye region detection

B. Eye Gaze Detection

To detect eye gaze we calculate eye gaze ratio from both left and right eye. We detect the screening point at which eyeball is looking. We can only define eye gaze as the center, right and left. To select the keyboard part we have to use eye gaze. If we look at the right and close our eyes for some time, the right part of the keyboard will open and if we look at the left part left side will open.

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Fig. 10. Eye (a) Gaze on left side (b) Gaze on center (c) Gaze on right side

C. Eye Blinking Detection

The main task of the system is typing which is done by eye blinking. Here the eye area is taken from the video stream and then we apply a threshold to detect eye-ball more accurately. We calculate the eye blinking ratio to differentiate between the normal eye blinking and the desired blinking type. We set a value as 5 and compare it with the blinking ratio. Whenever the blinking ratio is more than 5, key from the keyboard is printed on the whiteboard. Left eye, area after applying threshold and blinking is shown below:

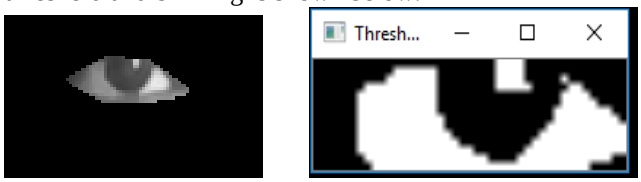


Fig. 11. Eye ball detection (a) Left eye (b) After applying threshold

Open eyes and blinking eyes figure:

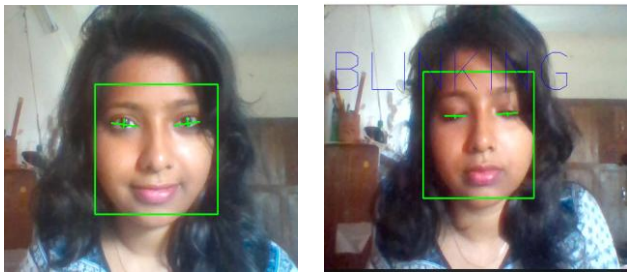
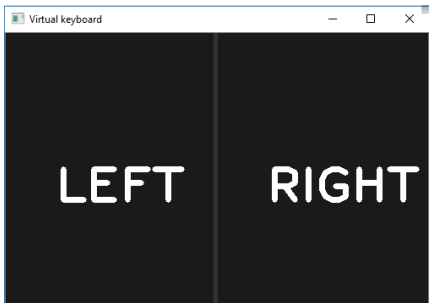


Fig. 12. Blinking detection (a) Open eyes (b) Eyes blinking

D. Keyboard Selection

To select the left or right side of the keyboard we calculate gaze ratio. If the gaze ratio is more than 0.9 (constant value) left side of the keyboard will be opened otherwise right side will open. In this case, we have look at the left or right side and close our eyes for some moment that is around a second or more to open the keyboard. Implementation results are shown in Fig. 13.



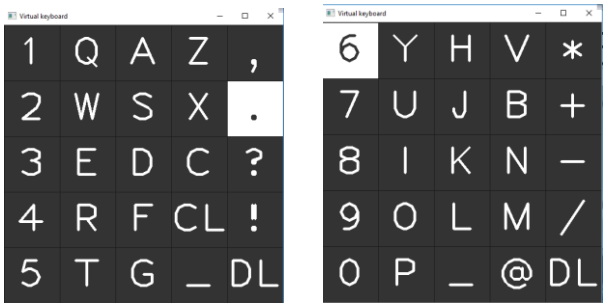


Fig. 13. Keyboard (a) First look of the keyboard (b) Left side of the keyboard (c) Right side of the keyboard

E. Key Selection and Writing

Each key of the keyboard is lighted up. Mainly we are lighting up each key for 10 frames and then the next one. Thus, when our desired key is lighted up we just have to close our eyes for around seconds and the key will appear on the board shown in Fig. 14.

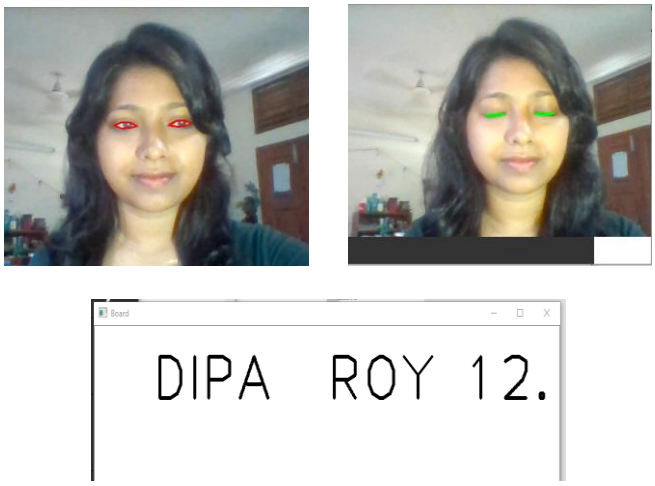


Fig. 14. (a) Looking at the keyboard (b) Selecting key by closing eyes (c) Writing on the board

F. Results

We have run our program several times and compared all the results. The system is not 100\% accurate. Though our key selection with eye blinking is much accurate, eye gaze detection as the right or left side is poor. However, this limitation is possible by using a high-resolution camera.

Table- I: Results summary

Total gaze analyzed	1568
Total eye blinking analyzed	2288
Missed false positives in gazing	90
Total missed blinks	320
Typing accuracy	90.13 %

VI. CONCLUSION

In this paper we have broadly described about the aims, objective and motivation behind the system. Again, we discuss about the methodology of our system with appropriate figure and description, and implementation result.

We implemented our system about thousands of time to check the result and record it to summarize the accuracy of our system. At the end of this paper we show the obtained results which show that the proposed system allows for accurate eye gaze and blinking detection with the rate of approximately 91%. We also checked our system for the people wearing glasses on their eye and the system was quite good to detect eyes and eye blinking through glasses. But it give some false result in case of eye gaze detection because of the reflection of the light in the glass it cannot detect eyeball accurately. Others accuracy level was fine. The system has got some limitation due to its environment and lacking of features. As it is the primary step of building a user friendly system, we can't effort much features. Though the proposed system will provide a robust and a sort of blessings technique to write for physically damaged people, it is not a quick way of writing for normal people. In our system each of the key is lighted up one by one, so we have to wait until our desired key is light's up., which is time consuming. Again, writing board size is not much large to write thousands of words. We can use this board to write around 100 letters. So, one can use it to write short note or message. It is possible to enrich the proposed system by further work.

The proposed system in this paper provides a new dimension in the life of those people who haven't any other physical abilities without eyes movement. This system will help afflicted people to type their text without touching the keyboard. Our main aims of this project is to minimize the effort for typing and to enable typing of those people who are crippled and are disable to type by using their finger. And surely this system will come out as a robust technique and blessings for the users.

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AUTHORS PROFILE

Partha Chakraborty is a faculty member in Faculty of Engineering; Comilla University, Bangladesh is currently working as an Assistant Professor at the Department of Computer Science and Engineering. He obtained Master of Science (M.Sc) degree with thesis and Bachelor of Science (B.Sc) degree with distinction in Computer Science and Engineering from Jahangirnagar University, a renowned public university of Bangladesh. His current research interest includes Computer Vision, Robotics, Image Processing, and Artificial Intelligence. He published his research articles in various international journals. He is actively engaged in educational activities.

Dipa Roy is currently an M.Sc student in the Department of Computer Science and Engineering of Comilla University, Bangladesh. Her research interests is image and video processing, Machine Learning and Computer Vision.

Zahidur Rahman Zahid passed BSc from Department of Computer Science and Engineering, Comilla University. Zahidur does research in Data Mining, Information Science and Artificial Intelligence and image processing. Currently worked as a Lecturer in Britannia University, Cumilla, Bangladesh.

Saifur Rahman is currently a student in the Department of Computer Science and Engineering of Comilla University, Bangladesh. His research interests is in Data Science, Machine Learning and Natural Language Processing