

Chapter 19

An Elucidative Review on the Current Status and Prospects of Eye Tracking in Spectroscopy



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Abstract This study examined how the measurement of eye activity is done using various technologies. Eye tracking (ET) is dominant and prominent. It analyzes the gazing direction of people and measures the entire functioning of the eye. In this paper, we will come to know about various technologies for eye tracking and can able to choose the best approach. Irrespective of technology, as the eye is the most affected part, we can employ this technique in all fields. The main motto of this is to demonstrate a full-fledged review of diverse topics and techniques used in eye tracking. We will be seeing some interesting techniques like skin electrodes, contact lenses, head-mounted and remote systems, and the approach behind them. Most importantly we will learn what is pupil center corneal reflection technique (PCCR). ET gives numerous application which relates to the interaction between humans and computers. This paper also incorporates various elements which took part in the selection of a particular eye-tracking method.

Keywords Eye tracking · Pupil center corneal reflection technique · Skin electrode · Contact lens · Head-mounted · Remote system

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19.1 Introduction

Eye tracking clearly says it tracks the positions and movement of the eyes. This method is mainly to understand the conscious and unconscious information using pupil center corneal reflection reported in 1901, and some of the techniques invasive such as using contact lenses and non-invasive techniques like remote trackers and the important application which is video-based combined pupil/corneal reflection can be used by the techniques such as fast image processing. In this paper, we can see what are all the things measured with an eye tracker, interpret eye gaze data, use eye tracking in various fields, and clear information about all the techniques involved in eye tracking and how this review will help future aims and modifications. One must know what is this eye tracking and why it has a specific significance. To understand this, simply let me give a real-time example. Assume we are in one room where we are giving some explanation on some topic and someone was delivering the content by keeping some kind of glasses for his eyes! Now my question is have you all been satisfied with such delivery content in which you aren't able to observe the receiver's eye movements and expressions? Need a genuine answer! Absolutely no, because among the total body, one must always be attracted by eyes as they will provide clear-cut information than those of listening.

So from this, we can say we are always interested to see the eye movements of others as they will say exactly what a person is gazing at whether it may be while watching television ads, browsing websites, and any other kind of activities. We can run eye tracking studies by using an ordinary webcam also whether it may be built into a laptop or an external one or by using a special device called an infrared eye tracker but it all depends on our purpose or needs and conditions. We can do a small activity on eye tracking using a cool tool that is available online. Eye trackers can measure observers gazing points with high resolution and accuracy using some optical sensors and projection patterns. I want to convey one interesting thing here we humans have peripheral vision and central vision. Both may vary based on the concentration of cones. To say that nearly our peripheral vision got 70 times less resolution than you do in your central vision which is a beautiful thing! Though one can see an object it does not mean that an observer can able to recognize entire objects. To understand this better, we will take a well-known example that everyone once in our childhood has done that activity, that is nothing but in newspapers or Funday books, we will see two similar images given and we need to recognize differences or simply we can say that we need to tell what all the things are present in that. After we have done this, we will come to know that for the first time, we will be able to specify some things and other things also we saw, but compared to the remembered things, other things are less concentrated by us. So based on eye gazing points things may vary. With this intro, we will proceed with further things which we are all interested to know like does eye tracking gets affected by our head movements? Does blinking have any effect? As said earlier we will come to know about fixations and saccades in detail and how the different approaches for eye tracking differ like normal processes, image processing, and using infrared radiation. What are the future scopes, their

advantages, metrics, and some important applications and electrodes used for eye tracking? Before that one doubt, you may all have is does infrared light affect or harm our eyes. The answer is no it doesn't have any harmful effect if we see fire does it harm our eyes!! To know all this we need to know about Tobii, which is the Swedish top company for eye tracking, and the three persons of Swedish who found the potential of eye tracking with a lot more inventions. [1–5]

Significance: Our eyes and their viewing ability are the brain's primary things to get to know about the things or information happening around us. With eye tracking, one can able to find where the person is looking at. Eye tracking does not define brain choice but it can able to analyze and estimate the ultimate decision made by the brain.

Nowadays compared to human–human interaction, human–gadgets interaction became prominent and most electronic gadgets have touch screens using fingers as an input source. Now if we see to observe the changes or operations happening in software, we just need an eye. So, for every step eye movement is the key point.

As we know our pupils will always be in working condition. We call that stage a saccade. But to see or visualize a particular thing our pupil must concentrate on one point. This state is called fixation. Therefore, we can say that changing our pupil movement is changing our concentration. In this review, we can see how eye-tracking systems use the most available method called the corneal-reflection/pupil-center method.

19.2 Why Eye Tracking?

Though we have given clear-cut ideas on eye tracking, to make it much easier to understand its significance, we have given one image below! Have you recognized which image was shown in Fig. 19.1? Hope it is well known for all its boost! We can take anything in nature as an example. Now when we can buy any product in our care boost as soon as we buy a product our first focus is on MRP/Manufacturing date in most cases. Though we open our both eyes, we are seeing a whole image, but we can concentrate on one specific thing at a time, it does not mean other things are not seen, if we see carefully, we can indicate with different colors arrowed marks, based on that colors our focus may vary. So, to conclude though a person is looking at the whole image, to grasp his tracking where he is looking at it plays a very important role in psychology, biomedical in all other fields [6–10].

19.3 How Eye Tracking Works

One of the most used eye tracking in which infrared cameras are fixed with the sensor and LED when radiation is emitted that passes through the IR filter, which saves eyes from other effects. The process of eye tracking comes into play when IR radiation

Fig. 19.1 Illustration of Eye tracking



hits the center part of the eye called the pupil which produces corneal reflections in the cornea. Once the image processing unit identified the vector between the pupil and the location of corneal reflections, one can find the gazing points which are popularly known as the pupil center corneal reflection (PCCR) technique.

Figure 19.2 Illustrated how the eye tracking system works, based on the location of infrared light concerning the pupil one can find the gazing point (a) represents looking down and right of the camera, (b) looking straight at the camera, and (c) looking directly above the camera and left of the camera. But whatever the technique we are using for tracking eyes, we need one light source and one camera for recording eye movements. As we know when the pupil continuously moves, we cannot visualize things clearly which we call that state saccade, to see we need to fix our pupil position for getting focused on the things which we call fixation. When infrared light falls into our eyes, there were many layers present inside the eyes which can reflect that in consequence that we are getting corneal reflections. To understand we can observe Fig. 19.3

Mainly when we need to give rest to our hands or the people who cannot use their hands due to their physically challenging issues this is an excellent technique.

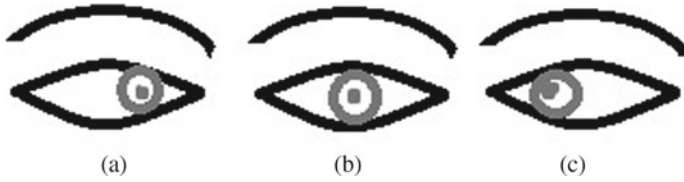


Fig. 19.2 Illustration of how eye tracking works

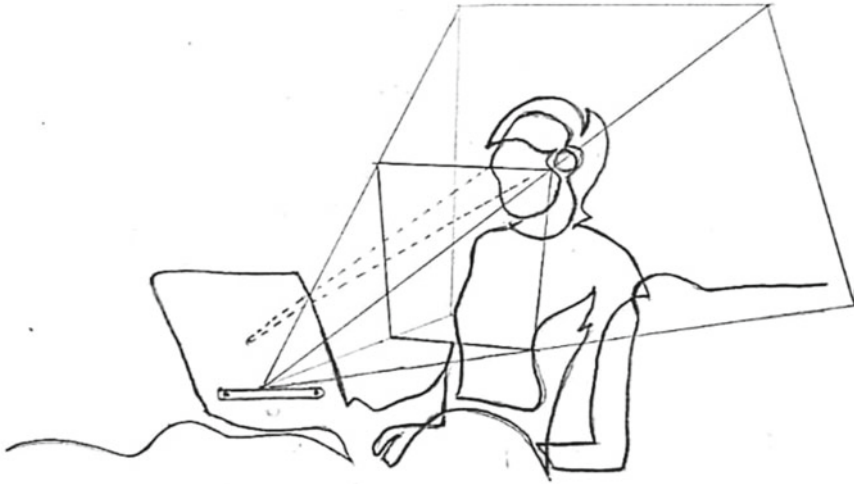


Fig. 19.3 Real-time example of Eye tracking

As seen in the image as soon as cameras have cameras with IR filter project their radiation into the user's eyes it starts finding the target and by using some algorithms, we can calculate the gazing points.

19.4 Eye Tracking and Metrics

As we understood the basic process involved in eye tracking, now we will try to know further information regarding eye tracking. As we said when the pupil is stable and focuses on a particular object, then only we will see the object called fixation and when it is moving continuously, we cannot see called saccade and the result of these two states is called scan path. To say one most knowable example which might be sarcastic that even in LinkedIn profiles based on this particular eye tracking, most of them will get the benefit for sure as many researchers say clearly. Eye tracking had undergone many rapid developments with good efficiency, stability, and many more pros; though those advancements gave good creation and better assumption techniques, some of

the issues were traced out by the reviewers after many submissions on eye tracking. Among all the submissions hardly say only 7 were accepted by the reviewers after reviewing each successful paper. One of the papers was done by X. Zou et al. He has done his paper on task-oriented attention; similarly, one more paper has given an idea on reducing human interference in automating the dynamic process by McClung and Kang [11–13]

19.5 Types of Eye-Tracking Devices

As we have seen the process of eye tracking and the basic methodology is the same for all, we have different types of eye-tracking devices such as screen-based, wearable, and webcam, etc. [14].

To be clear when a receiver gets multimedia stimuli to record the output responses, screen-based device is used to increase information ability from deeper sides of the object. Similarly, when we are particular about some limitations like better contrast ratio, and a good resolution, we are going to track using a webcam device and mostly it can be done even at home without any requirement of the lab. Mainly two measurements were used in eye tracking as we mentioned earlier one is fixation and the other one is scanning path [15]. Scan path is used to view the object with less fixation where long-lasting fixation indicates less efficient scanning and other important eye-tracking skin electrodes; as we said earlier in this method, the electrodes are placed around the eye socket, and when the infrared light got struck, it will measure the retina and corneal reflections, and using this we can track both eyes of the viewer at a time but it is the particular limit but is simple to use. Next one is contact lens. It is fitted around the cornea (non-slipping lens), then tracking can be done by removing the magnetic coil around the cornea lens; compared to skin electrode, contact electrodes provide precise and accurate information, it is also limited to a specific range and it is not much comfort for the user and we have head-mounted electrode by the name a light source or camera is mounted around the head using helmet or headband, and mainly it does not cause restrictions to user head movement [16].

19.6 Applications Involving Eye-Tracking Methodology

19.6.1 *Psychology and Neuroscience*

As we say earlier, eye tracking has its specifications and applications in various fields, among them prominent psychology. In another way, we can say it shows the direct relationship between our eye movements, that is where we are looking and in correspondence to that how we are reacting. As eye tracking measures one's

concentration, similarly, based on eye movements, one can study the insight process happening in the mind, that is our mental process [17].

19.6.2 Cognitive Process

To understand this better, let us speak with an example and the case is shown in Fig. 19.4: let us assume a person is driving a vehicle without any experience, then sudden if any critical situation occurs then? Hard to imagine! So here comes the eye-tracking usage. That is if a person is driving with no experience, if he wears eye-tracking glasses, then if any harm occurs, our subconscious mind can track the issue and give hints before itself [18].

19.7 Medical Research

To diagnose diseases like attention-deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD), obsessive compulsive disorder (OCD), etc., diseases were able to get a solution through eye tracking which will combine with some biosensors. To be simple, it can able to find the drowsiness of a person with this application. Like this, there were many applications including academic and scientific research, marketing, gaming, etc. [19]



Fig. 19.4 Eye-tracking glasses and their impact

19.8 Existing Technologies for Eye Tracking

19.8.1 Video-Based Eye Tracking

In this particular application as we said, there will be a camera embedded with LED and a sensor and when it focuses on one's eyes (either one or both), then the reflections can be seen in a cornea called corneal reflections and from that one can grab one's movements [20].

19.8.2 Interface Usability Eye Tracking

It will represent whether the person is looking at a particular thing or he is reading something or he is just having an overall scan on that, and if he is observing something, then at what concentration he is having on that content, and it also helps to find out whether the user needs a specific thing [21].

19.8.3 Interactive Applications for Eye Tracking

There were many interactive applications like accessibility, non-command-based systems, and virtual displays, and many among them accessibilities have their importance or specific dance. The name accessibility itself tells us it is giving access which in the sense of using eye tracking, one can communicate with others using their eyes! It seems normal but to be clear the persons who are facing brain injuries, spinal cord-related issues, or any strokes. Among such people, eye tracking is a boon we can simply say! [22–26]

19.8.4 PCCR Technique in Eye Tracking

The process of image acquisition is shown in Fig. 19.5. Though we discussed the PCCR technique known as pupil center corneal reflection, its idea works like an infrared camera possessing a filter and an LED source. When light falls on the camera, it passes through the filter to reduce harm to the eye; then once it filters, it hits the pupil in the cornea that gives rise to reflections in the cornea known as corneal reflections, thereby the monitor screen enables and eye tracking comes into play [27].

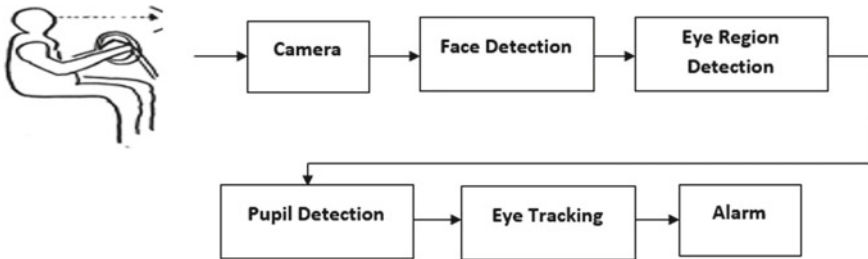


Fig. 19.5 Image Acquisition Scheme

19.9 Advantages of Using Eye Tracking

1. Compared to all other input media, eye tracking is faster which makes it more efficient and accurate.
2. For eye tracking like any other technology, it does not require any special training or coordination like normal users.
3. Eye tracking makes it easy to understand one's area of interest, which everyone likes to know!
4. Eye tracking plays a key role in user readability applications in finding out one's interaction with their environment.
5. As we said eye tracking is very much helpful for disabled or people with some injuries related to the brain, spinal, or any other.

19.10 Disadvantages of Using Eye Tracking

If we say advantages for any one particular technology for sure, there will be some disadvantages or consequences for the same technology. Similarly, eye tracking too has some disadvantages as we are saying their many advantages then definitely the cost and resources are not so reliable or less, so resources are much more expensive we are saying eye tracking can gaze at users' eye movements what about thoughts? As we said to calculate gaze points, we are using many algorithms, so interpretation is not so easy [28–30].

19.11 Future of Eye Tracking

Definitely, in the future, much more possibilities with better, precise, and accurate technologies will emerge for sure, and no doubt that eye tracking is an emerging technology in marketing industries as they are willing to increase the stock market by using eye-tracking technology to grab audience attention as if we take movies as

the best example, the director can narrate the entire cinema in such a way that he will capture each scene by keeping audience perception in mind. Hope in the coming days this technology may replace many activity applications. As we said it is still an emerging technology and not quite there yet, but we can strongly assure you that eye tracking is the most exciting technology ever.

19.12 Conclusion

To sum up, all these points so far discussed, we can say that eye tracking has more importance in the upcoming days. Our eye movements are faster than computers. Through eye-tracking technology, we can make human–computer interaction. It is used to know that human visualization of a subject is being processed. It is useful in many fields, including developing video games, setting the gazing point at conferences, in graphics, and minimizing dangers in air traffic. It is very flexible and easy; through this technology, we get real-time feedback on eye movements. But not the thoughts of people. It can help people with disabilities operate through their eyes. Eye tracking can say whether a person is looking at the screen or just acting as if he is looking. It says a person is reading or searching for a specific word or just scanning. It shows where the person is looking at different parts on the screen or in front.

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