

Ascertaining DES (Digital Eye Strain) Symptoms Using Machine Learning Libraries

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Abstract

In the IT (Information Technology) funded society we are spending a lot of time in front of digital devices that includes TV, computer screen, mobile, digital projectors. Now a days these digital devices have become part of societal obligation. Keeping the current scenario in concern, we cannot avoid these devices as they keep us socially updated and globally connected but on the other hand they leave a bad impact on our vital organ: eye. Due to excessive screen time we all have signs of CVS (Computer Vision Syndrome). To mitigate these CVS related issues we have to be caution for its symptoms and take preventive actions. This research piece is a contribution in the CVS symptoms caution method. Researchers have tried to find out the ocular symptoms and try to trace them while user is interacting with its digital device. The symptoms that are considered in this research piece are blinking, Redness, Itching and squeezing. The flow of paper will define how these things can be traced from video clip or the frames derived from video clip.

Keywords: Digital Eye Strain, Computer Vision Syndrome, OpenCV, Python Library, Machine Learning, Artificial Intelligence, Blinking, Squeezing, Redness.

1. INTRODUCTION AND CONCERN LITERATURE:

1.1. What and why of Digital Eye Strain:

Digital Eye Strain (DES) alias Computer Vision Syndrome (CVS) is a group of eye or vision related issues. It includes variety of issues: eye itching, watery eyes, eye pain, dry eyes, discomfort in reading, feeling tired or uncomfortable while working. Due to excessive use of computer or digital devices which includes computer, smart phones, e-readers, projectors we might develop these symptoms. Our eyes will feel a strain if focusing too long on a digital device. Strain is being felt because of over exertion of any of the muscle in the eyes primarily ciliary body or six extra ocular muscle [1]. When person focuses on something, ciliary body changes the shape of the lens. When this process is continuous and regular, it sets a fatigue in the eyes. If this fatigue is persistent and enduring it may impact its other daily activities of a person's life. Some issues will not be developed if you read a book for long because the problem is not because of using eyes for long, problem occurs because of poor light, looking at screen from wrong angle or distance, poor posture while reading, screen glare, uncorrected vision problems or a combination of any of these [2].

1.2. Who is at Risk and How to cure it:

When DES or CVS is in concern, a question arises who is at risk? The answer is "Everyone around us". The answer give you shockwave and strain your nerves but this what our concern data says [Reference Figure 1, 2 and 3] [3] [4] [5]. At some point of time everyone is using some digital devices for some purpose. So we all are at risk but our probability of getting DES or CVS increases if we spend more than permissible time with digital device or our sitting posture or angle is not correct, our light is not appropriate or not coming from right direction, if we are not using anti glares or own required glasses or contact lenses and most important we don't take break in between. The question of CVS cure arises only when we are able to diagnose it. Our human body is very well crafted, every part or organ has well defined mechanism to give symptoms for illness and ways to cure it. Similarly eyes have multiple indications when they are strained. In most of the cases people just ignore the symptoms and don't get their eyes checked for CVS. When the symptoms are ignored and require precautions or treatments are not taken, then the ultimate sufferers will be our eyes. To sync with time and give our little to the concern, the current piece of research work is contributing in this direction. Authors are trying to get the strain status of the user while working on digital device. Along with various hardware components some software libraries are used to achieve the objective. The details of the same are available in the section 3 onwards. The next sub-section will gives the glimpse of work already done in this field.

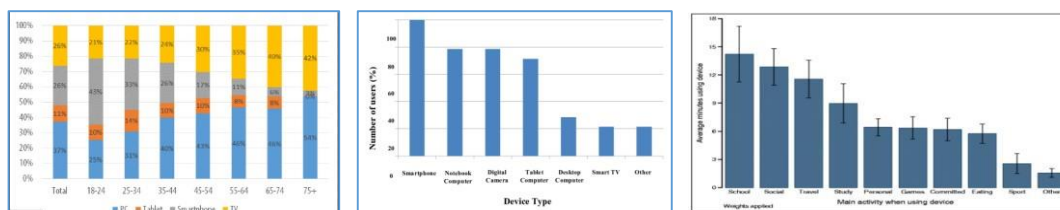


Figure 1(Left): Source: Google Images [5][Use of Digital devices among various Age groups]

Figure 2(Center): Source: google Images [4] No of users of different devices

Figure 3(Right): Source: Google Images [3] Digital devices used for different purposes

1.3. Concern Literature Review:

1.3.1. [6] Authors have discussed what prime causes of DES in great depth. Every symptom and association with the DES explained very well using medical terminology. The paper explained, what all measures users should adopted to identify DES condition at early stage. The differences how digital study material and printed study material effect our eye sight explained very well.

1.3.2. [7] To support the theoretical concepts concerning the use of excessive digital devices leads DES or CVS, A study has been conducted around 350 people of different age groups and main emphasis was their eye health. The information is collected through questionnaire. Questionnaire was carefully drafted to collect information about their interaction with their digital device, type of device, duration, purpose of using digital devices. Conclusions are drawn from data collected through various means and analyzed using various ML techniques.

1.3.3. [8]A detailed survey conducted among graduate and post graduate students, how excessive use of digital devices during the covid-19 period has result into various eye and other associated health issues.

1.3.4. [9] Authors have use Machine Learning Technique in establishing eye strain status while user is working on a digital device. The correlation is establish by monitoring various traceable and non-traceable factors. These factors will be the input to Decision Tree algorithm. Certain rules are generated from decision tree construction and these rules will be the indicators, user has CVS or not. The same is communicated to user through LED light, placed on user’s machine.

1.3.5. [10] Paper is based on Study around covid-19 period and use of devices at that time. TAM (Technology Adoption Model) has evaluated see the impact of these various digital devices on the vision and eye strain status of the users of different countries.

1.3.6. Symptoms linked with digital eye strain:

The terms DES (Digital Eye Strain) or CVS (Computer Vision Syndrome) are easy to pronounce but difficult to establish. There are many symptoms that can associated with these conditions. Like: Dry Eye, Blink Rate, redness, Blue Light hypothesis, Asthenopia: These symptoms can be divided into two groups: External Group: burning, irritation, ocular dryness, tearing, Internal Group: eye strain, headache, eyes ache, diplopia and blur. This paper is focusing on identifying these symptoms through live video.

1. Methodology:

The current paper is an extension of a work already done by authors to identify the eye strain status of the current user while user is working with device [9]. A framework has been drafted where AI and ML techniques are used to predict eye strain status using various symptoms associated with this condition. The framework explain the complete process to decide about the eye strain condition. Eye strain condition is identified through symptoms that are extracted and identified from the video clip. There are various symptoms that can be associated with eye strain condition [Reference 2.3.6] but to limit the scope of current paper only selected symptoms will be explain in the subsequent sections. Complete details of the Symptom, detailed identification procedure and tools and techniques of the following symptoms can be read through next section: Eye Blinking Rate, Redness in Eyes, Itching, Squeezing

1.4. Eye Blinking:

1.4.1. Define Eye Blinking :

Blinking is semi-autonomic closer of eyelids. It’s a reflex that your body do automatically or you can do it persuasively as well. As per medical literature concerning the topic, a normal person generally blinks 15-20 time in a minute [10] [11]. Both increased and decreased rate of blinking in comparison with general blinking rate can be considered as a symptom of some deformity. There are numerous reasons of increased and decreased blinking rate, but keeping the scope of our work, we will discuss it in relation to CVS. CVS (Computer Vision Syndrome) is directly associated with decreased blinking rate [12]. However increase in blinking rate can be a remedy for CVS.

1.4.2. Technical Tools & Techniques:

A recorded or streamed video can detect number of eye blinks in a minute. The underlying technology used for this purpose is Machine Learning (ML) a field of AI (Artificial Intelligence). OpenCV(Open source computer vision Library) is an open source computer vision and machine learning software library that contains more than 2500 optimized

algorithms that provides infrastructure for computer vision applications. OpenCV is originally comprises c and C++ codes but now it is also available to be bind with java or python. OpenCV has many classifiers that can be used for face and eye detection purpose, researchers are using “Haar Cascade” to achieve their objective [13]. Haar cascade is face detection based classifiers available in Open CV library of python. These classifiers are trained through various positive (images of faces) and negative (images without faces) images to train the classifier.

1.4.3. Flow Eye blinking detection techniques:

following are the steps in identifying the eye blink:

- I. Record video
- II. Extract frame from video
- III. Take a frame
- IV. Locate face in the frame [Using python algorithm][OpenCV python library]
- V. V. Locate eyes on the face using OpenCV Library
- VI. Count number of blinks in a minute
- VII. Compare no of blinks with threshold and set the flag value.

2. REDNESS IN EYES:

2.1. Define Redness in Eyes:

Bloodshot eyes is the common medical term use for red eyes. When sclera [Ref: Picture1] (white part of eye) is abnormally red, then we call this condition as blood

shot condition. It is generally a pain less (near the surface area [14].

Redness in Scalera irred due to swollen blood vessels

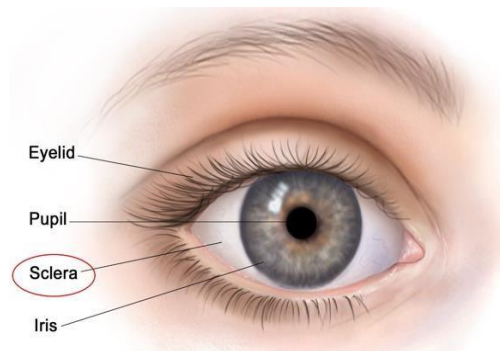


Figure 4: Image Source: Google Images [15]
Figure 5: Image Sources: Google Images [[16]]

2.2. Tools and Techniques:

Artificial Intelligence has given a significant contribution in medical diagnosis and health care. Certain libraries have offered functions and modules that can identify various symptoms through video clips or picture frames. One such library is OpenCV. Open CV (Open Source Computer Vision Library), mainly aims computer vision.

Originally OpenCV was developed by Intel in 1999 but later it is supported by Willow Garage and is now maintained by them [17]. It offers modules to perform advance vision research.

To identify the redness in sclera, HSV (Hue Saturation Value) of OpenCV is used. HSV are color properties that help us in distinguishes between colors. It is based on very basic concept that every color is made up of three primary colors (RGB) and the value of these three primary colors ranges from 0-255. When we understand the balancing of these three primary colors, we can easily obtain the basic object color recognition. Identifying the eye color or sclera color will help us in identifying redness in the eye.

2.3. Flow of Sclera Detection technique:

The sclera color diagnosis have gone through following steps:

- I. Record the video through attached web cam.
- II. Convert the video into frames
- III. Then apply the rest of the process in loop.
- IV. Take a frame, locate face on the frame using OpenCV library
- V. Try to detect the eyes on the face using OpenCV library
- VI. Apply HSV on eyes part
- VII. Compare the HSV value with RGB conversion table
- VIII. If the color is red
- IX. Update the redness flag = true
- X. Repeat the loop till all the frames of video clip are completed.

3. SQUEEZING:

3.1. Define Eye Squeezing:

Blepharospasm is the medical term used for unconscious movement of eyelids. When eyelids are closed or slightly closed, they both are the severe form Blepharospasm. When eyelids are overlapping each other we call it closing of eyes. When eyelids are not exactly overlapping but close to each other, still person can view, but the size of the eyes are reduced as compare to its general form, we call it squeezing.



Figure 6: Image Source: Google Images [[18]]

3.2. Tools and Techniques:

In order to get conclusion about eye squeezing the initial size of the eye should be compared with size of an eye after 1 hour or threshold decided as per requirement. OpenCV library can be used to identify the size of the object in an image.

3.3. Flow of Eye squeezing detection technique:

Here the object is the eyes of the person in concern. Following steps are practiced:

1. Record the 1 minute video of the user in the first 5 minutes of log in process.
2. Extract the frame from the video.
3. Arrange all the frames in a loop.
4. Extract one frame and try to locate face on the image.
5. Locate eyes of the face.
6. Try to identify the size of the object by using "Pixels per metric ration". to get the size of an object, we should have two properties [19]:
 - a. Property 1 : we should get the dimensions of the object in measurable units like mm[millimeter], inches etc.
 - b. Property 2 : we should get the reference of the object means, object should be uniquely identifiable using position or color.
7. Extract the size of both eyes and save them in variable I_E_L [Initial_Eye_Left] and I_E_R [Initial_Eye_Right]
8. Record one minute video of a user after 1 hour or as per threshold decided.
9. Repeat the step 2 to step 6.
10. Extract size of both eyes and save them in variable P_T_E_L[Post_threshold_Eye_Left] and P_T_E_R [Post_threshold_Eye_Right]
11. If the size of $I_E_L > P_T_E_L$ or $I_E_R > P_T_E_R$ 12. Then set flag squiz = true.



a. Figure 7: Eye Itching: Source: Google Images [[20]]

4. EYE ITCHING:

4.1.1. Define Eye Itching:

Ocular Pruritus is medical term used for eye itching. Eye itching can be due to allergy or "dry eyes". [21]. Dry eyes are symptoms that can directly be correlated with CVS (Computer Vision Syndrome) [6]. When we are looking at the computer for long, we try to concentrate more and generally we blink less, when blink rate is lower than a normal blink rate, our tears evaporate more quickly. Water level, mucin and oil is off from our eyes and our eyes are termed as "dry eyes". Then we feel itchiness in our eyes.

4.1.2. Tools and Techniques:

OpenCV Library is used along with MediaPipe Library for tracking eye and hands in a video clip or from frames. MediaPipe Library uses a Hand Landmark model [Reference Picture 5]

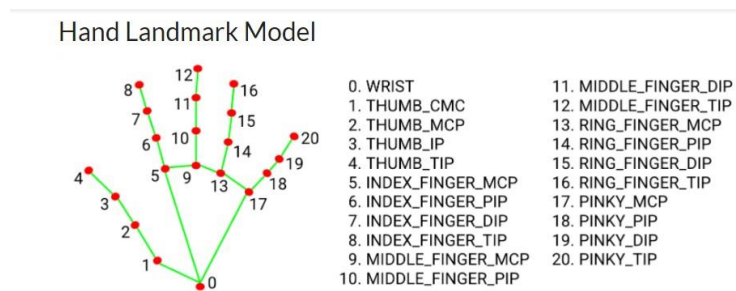


Figure 8: Hand Landmark Model: Image source: [22]

FLOW OF EYE ITCHING DETECTION TECHNIQUE:

Our system is trying to detect above mentioned condition through this computer vision by using with following sequence:

- i. As per the need we have to track two things:
- ii. Hand and Eyes
- iii. For detection of both the objects, we will record the video and use OpenCV library to locate face first.
- iv. Once face is located, eyes are located over the face [L_E_L (Left_Eye_Location)] & [R_E_L (Right_Eye_Location)].
- v. Eye location points are marked.
- vi. Then hands are located using hand landmark model.
- vii. We can either point out any finger or thumb
- viii. Using OpenCV modules, hand locations are marked. [L_H_L (Left_Hand_Location)] & [R_H_L (Right_Hand_Location)]
- ix. If any of the following is true, we can put the itching_flag = true
 - a. (L_H_L == L_E_L) or (L_H_L == R_E_L) or (R_H_L == R_E_L) or (R_H_L == L_E_L)
 - b. One time touching an eye or eyes with hands can not be considered as itching so In this process we need record how many time, user is touching their eye during the recording in a variable called itching_no.

5. CONCLUSION AND FUTURE SCOPE:

In order to contribute in DES or CVS condition of the masses in this digital society, authors are working to establish a framework that will identify the eye strain condition through video clip recorded during sessions. To establish eye strain condition, various symptoms need to be identified. This task is completed through various OpenCV python library along with few hardware components this task is completed through defined set of steps. The next step is to put recorded results in framework and generate results so that a well functioned AI and ML based algorithm can be generated to help the general public.

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