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CVS Identification through Live streaming using Machine Learning: An Elaborative Framework

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Abstract: Use of technology in the health sector has brought substantial expansion in identification of disease at an early stage. Our current piece is an effort to contribute more in the same direction. In the current piece of work authors are trying to identify the presence of CVS (Computer vision Syndrome) from a live video. Identification is based on few traceable and non-traceable factors that are carefully chosen under the guidance of a medical concern. Artificial Intelligence plays an important role in the detection of eye fatigue through a classification and prediction algorithm. Our current piece of work will be a great help for all those who have to spend multiple hours continuously in front of a screen or device due to Education, Professional commitments, entertainment or any other valid or invalid reason. The prominence of our work is more relevant in the current scenario where most of the jobs are executed through online mode due to the pandemic.

Keywords: Computer Vision Syndrome, CVS (Computer Vision Syndrome), DES, Digital Eye Strain, Machine Learning, Eye Strain, Eye Fatigue, Screen Time, Naïve Bayes, Traceable and Non-Traceable Factors

1. **Introduction**: Information technology, one of the fastest growing streams, is now acting as an essential support mechanism for all other important verticals. Like Marketing, Law, Sales, Production, finance to name a few. All these verticals are taking support Information Technology to execute their day to day activities. Earlier this support was considered as auxiliary advantage but due to this pandemic (Covid-19) this support is now a must to perform their responsibilities and execute their daily chore. It has now become a trend to use Information Technology for Education, Profession, entertainment or any other valid or invalid reason. It enlightens the fact that, in the Information Technology era our daily screen time is much more than acceptable. Owing to this excessive screen time we face eye or vision related problems or we face eye discomfort when we see the screen. We call this condition CVS (Computer Vision Syndrome) or DES (Digital Eye Strain). These words are now very common in our day to day interactions as the number of people suffering from these syndromes are increasing day by day. Earlier people used to take medical assistance when they were feeling some kind of discomfort but now technology is trying to give a little support to the medical stream as well. In the current work authors are trying to figure out the presence of the CVS with the help of a few symptoms that can be noticed through video footage and taking the consent of the user about the symptoms that cannot be noticed through video. The next few section will elaborate the authors' journey to achieve the objective defined

2. **Background Study and concern literature**: Since the beginning of the digital era one can observe its benefits in various streams, but one has to accept the fact that everything that benefits you has some pitfalls in the background. Same fact can be accepted for the Digital era where people have to glare at the screen for more that 40-50 hours in a week for their distinct objective like professional commitments, job profile, and educational objective. Last in the list but quite important these days is entertainment & social connect that sticks the user with the screen for a long time. As the benefits drawn from this digital era cannot be compromised because of its utility in different areas. People are forced to stick to the screen beyond permissible time, despite the fact that this excessive screen time leaves an impact on the eyes of the users. All the problems concerning eye and vision that occurred due to prolonged screen hours are kept in the category of CVS (Computer Vision Syndrome) or DES (Digital Eye Syndrome)[**(Haupert, Sather, & Wojcik, 2021)**]. Lot of work has been done in this direction not only by the researcher but few medical experts and diagnosis canters have also contributed regarding factors that can lead to CVS. Symptoms can be correlate with CVS are : Eye Strain, Headache, Blurred Vision, Dry eyes, Neck & shoulder pain, double vision, red eyes, eye irritation and many more[**(Watson, 2019), (Computer Vision Syndrome, 2021), (Computer Vision Syndrome – Most Popular Eye Problem Amongst Youngsters, n.d.)**]. Researchers have applied distinct research techniques to list the factors that can be noticed if a user is experiencing vision syndrome **(Gammoh, 2021)**. Along with the listing of elements, the percentage contribution of each factor in different age groups and from different devices can also be found in the concerned literature **(Mohamed Zayed, Saied, Ali Younis, & Atlam, 2021)**. When prominent symptoms were established through medical guidance that can correlate CVS during prolonged screen hours then lot of researchers have worked on distinct frameworks to detect the presence of these symptoms in video clips or stills. Fatigue detection system that uses head movements, yawning and eye blinking to detect the driver fatigue is more affordable and portable. The detection system is executed using the camera of a smartphone **(He , et al., 2013)**. This work is extended in which the same parameters are taken but a mathematical model is developed by using time and frequency of fatigue parameters [**(Qiao, Zeng, Xu, & Yin, 2016)**]. Another aspect of fatigue detection is covered where video is recorded and then from the video frames authors are analysing for how long drivers eyes were closed and on the basis they are predicting river's eyes are fatigue or not[**(Sarada Devi & Bajaj, 2008**)]. Another research piece where facial features like eye open or close and mouth open or close are trapped and then passed to the Fuzzy Expert system to produce output regarding driver fatigue **(Azim, Jaffar, & Mirza, 2014)**. Use of Machine learning and Deep learning algorithms in the stress detection can be found in the literature **(Elzeiny & Qaraqe, 2019), (SreeithPanicker & Gayathri, 2019)**. A survey has been conducted on university students and data set is processed using Naïve Bayes, random forest, Support Vector Machine to find stress level among students **(Ahuja & Banga, 2019)**. Not just human behaviour but human interaction with keyboard can also be signal for stress presence. Machine Learning has also contributed in this kind of processing **(Sağbaş, Korukoglu , & Balli, 2020**).

3. **Objective and key features of the framework**: While observing screen time, users don't realize that they are experiencing CVS (Computer Vision Syndrome). The prime objective of this framework is to detect the presence of CVS through video and send an alert message on the user's screen. The framework concludes its objective on the basis of pre-defined traceable and non-

traceable factors. These factors are extracted from video, passed through various execution stages and conclusions derived from the process will be sent to the user to make them aware about the eye strain status of the user referred in the video. It will help the user to take precautionary action and protect themselves from vision related problems. The key features of this proposed system are as follows:

The presence of eye strain is judged on the basis of multiple factors that leave an impact on the eye and need to be monitored.

The framework is supported with an "Alert Device" that receives signals through framework output.

The presence of CVS is detected on the basis of various traceable and non-traceable factors [Reference Table 1]. Symptoms that can directly be observed through video footage are kept in the category of traceable factors. Symptoms that cannot be observed through video frames but are collected from users through pop-up dialog form are kept in the category of non-traceable factors.

The presence of absence of factors (both traceable & non-traceable) is recorded in digital form:

3.1. 0: absence of factor

3.2. 1: presence of factor

Factors recorded will be given to "Supervised Classification Algorithm" to generate class labels by using trained models. Model was trained through a data set that is clinically approved through concern literature, survey results and Medical support.

Classification algorithms produce results in the form of Y & N.

N: Absence of CVS

Y: Presence of CVS

When CVS is observed through the whole process an alert is sent to the user monitor.

Alert is sent in the form of text message through a pop up window and LED blinking on the "Alert Device".

Figure 1: Input and Outcome of Proposed Framework

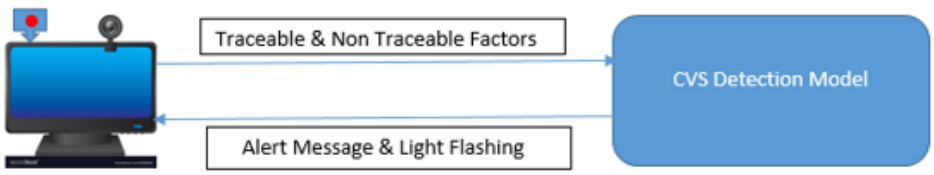


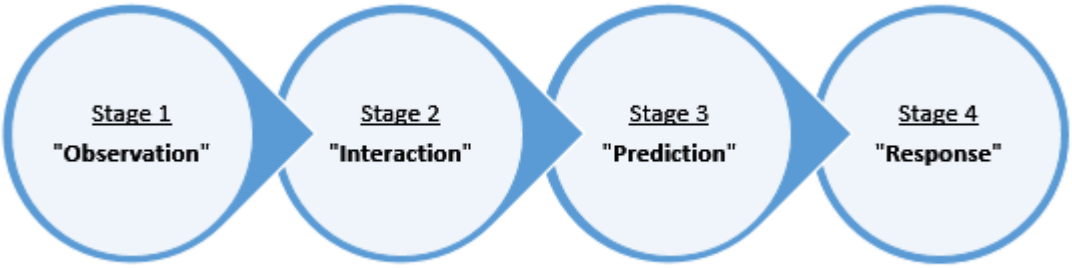
Table 1: Factors for Eye Strain Prediction

Traceable Factors	Non-Traceable Factors
Watery Eyes	Eye pain

Redness	Headache
Blinking Rate	Blurred Vision
Squeezing	Itching

4. **Proposed Framework and Tools Practiced:** This piece of research is amalgamation of two different streams Artificial Intelligence and Medical diagnosis to detect CVS. Artificial Intelligence is used to predict an outcome on the basis of concern literature, survey results and Medical guidance. These bases are utilized to correlate symptoms with the diagnosis. Proposed framework executes in four stages [Reference Figure 2]:

Figure2: Framework Execution stages



4.1. **Stage1 (Observation):** The first stage is called as "Observation" Stage. In this stage video footage is recorded through a webcam and later converted into still frames. These sequential frames are observed to detect presence of traceable factors like watery eye, blinking rate, squeezing, and redness. Presence and absence of these factors are recorded in digital parameters (0 & 1). If at least one factor is noticed then system will enter in stage 2.

Tools Adept: A Video is formed through successive images. Each successive image is called a frame. The same technique is applied at this stage, authors have extracted frames from the video. The terminology used in this context is FPS (Frame Per Second). Generally a video comprises 25-30 frames per second, but this number can be changed as per the requirement of the project. There are many ready-made tools available in the market that take video as an input and produce required frames per second. One such reliable tool by a big IT giant is adopted to perform the frame extraction process and given as input to the "Observing Algorithm". There is a separate algorithm to observe each traceable factor.

4.2. **Stage 2 (Interaction)**: Stage2 will process on the basis of outcome received from stage 1. It is named as interaction state as user interaction is required to complete this stage. This stage will take user input regarding non-traceable factors that cannot be monitored/detected from still frames but important to figure out the presence of CVS among the user. User inputs are recorded and the system will move into stage 3.

Tools Adept: If at least one traceable factor is noticed in the "stage 1" then input regarding non-traceable factors are taken from the currently active user. In order to collect input from practicing users, both machines (user machine and framework executing machine) have to be on the same network. When machines are on the same network, they can send "closeable computer messages" to each other. "Windows" machines offered "msg" & "net send" for this purpose. Both the commands can be practiced using "command Prompt". Although the "msg" command offers more customizable options than the "net send" command. Information regarding non-traceable factors are collected through "closeable computer messages" by listing non-traceable factors as multiple selection boxes. The responses received are saved in the excel sheet.

4.3. **Stage 3(Prediction)**: This stage will perform the prediction task using supervised learning technique of Artificial Intelligence. Recorded inputs of stage 1 and stage 2 are inserted into a classification algorithm (Naïve Bayes) to generate an outcome about presence of CVS (Computer Vision Syndrome) in users observed. Naïve Bayes is a supervised classification algorithm that will consider each factor as an independent factor and try to predict the result on the basis of that. This is an added advantage in our research as each symptom is independent of the other.

Tools Adept: The responses recorded in the earlier two stages are saved in the excel sheet and later converted into CSV (Comma Separated Values) format. This framework requires prediction about CVS (Computer Vision Syndrome) using Machine Learning algorithm. Although excel itself is a very good analyzer, authors have used Weka 3.8.5. Weka 3.8.5 is a free licensed software that comprises various machine learning algorithms for knowledge analysis. It is practiced as a GUI tool for data preparation, classification, prediction and clustering. The classification and prediction tool used in the current work is Naïve Bayes. It's a classifier based on the famous Bayes Theorem.

4.4. **Stage 4 (Response)**: This is the last stage of the framework where a different response is generated by the framework for the observed user. There are possible outcome stage 3 can produce [Reference Key features Point 5]:

Y (Yes): CVS is detected in the observed user. In this condition a user is alerted in following ways:

Text Message through Pop Window

Red LED Light Blinking on "Alert Device" attached on user's machine

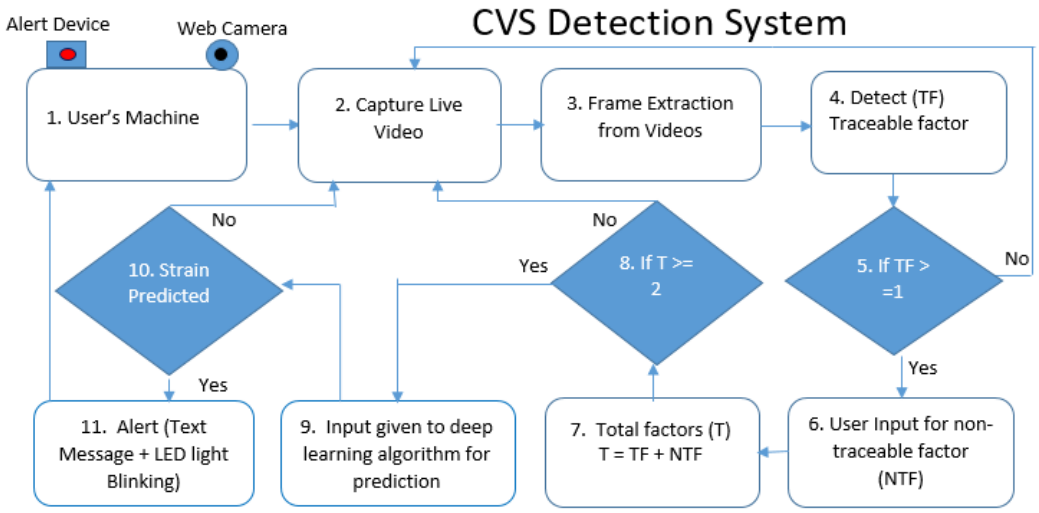
N (No): Absence of CVS: There will be no communication generated by the user and the system will keep on looping from stage1.

Tools Adept: Once a prediction task is done through Weka tool then it is to be communicated to the user. Two different ways are adopted by the framework. First an alert message is sent on the user's machine using the "msg" or "net send" command of windows. In the second communication mechanism light blinking is used to indicate the user in concern. The system in discussion is prefixed with a small "alert device" which is Arduino board that comprises a LED light, small chip and other things to work as per instructions. The signal in LED light will be programmed using PARALLAX (open source programming language for Robots or other devices) and executed in PBASIC. In the code instructions are analysed and signals are sent to blink LED light.

5. **Execution of the Proposed Framework**: The execution of the proposed framework can be explained through figure 3. The system will roll on to execution when the webcam is in use. The system will capture live video and extract frames from the video. The no. of frames generated from the video can be customized depending upon requirement. The still frames are used to detect traceable factors (TF). Distinct algorithms are applied to detect distinct "Traceable Factors". Like for detecting an eye blinking will require to detect face, detect eye, position of the eye and other factors. On the basis of these aspects blink factors is monitored and registered. Similarly redness, squeezing and watery eyes are monitored through different algorithms. Presence of factors are registered in binary form (0 & 1).

   If at one TF is noticed in the frames the system will enter into "Stage 2: Interaction" otherwise it will go back to recording phase. In the "Interaction stage, the user is presented with a pop window and information is collected regarding Non- Traceable Factors (NTF). These factors will provide the information about the symptoms that the user is experiencing but cannot be traced through the video footage or frames [Ref Table 1]. Same like traceable factors, presence of these non-traceable factors are also monitored in binary form. Once information is collected about "Traceable" & "Non-Traceable" factor and at least one of each kind is found in the current scenario, then the system will enter into "Stage 3: Prediction".

Figure 3: Execution Sequence of CVS (Computer Vision Syndrome) Detection System



Stage 3 is utilizing the expertise of Machine Learning, a way of practicing Artificial Intelligence for prediction. Here supervised learning techniques are utilized where the algorithms build models on data that have class labels and make predictions about unknown data. In the current scenario "unknown data set"is extracted from the video footages in terms of Traceable and Non- Traceable factors. On the basis of factors present, this stage will predict an output where the user present in the video is having CVS (Computer Vision Syndrome) or not. The supervised learning algorithm practiced in the current framework is Naïve Bayes that works on the probability of each factor present. One more benefit associated with this algorithm is that it treats every factor as an independent factor which is very much similar in our framework conditions where each factor is independent of another factor. Depending upon the outcome of the algorithm system will either move to stage 4: Response or go back to video recording stage. "Response" stage will generate an indication for the user and make him aware about

the CVS. Indication is through “Text Message” and “Light Blinking”. A customized message is sent to the user and a light will blinking on “alert Device” placed on user machine.

6. **Conclusion and Future Work**: A framework is proposed to detect eyes strain among the users that has to glare to the screen more than permissible hours. Detection is based on few factors that are carefully chosen after survey, literature scan and medical guidance. Machine Learning expertise and used to make a prediction an observed user is communicated through various mechanisms about the CVS or DES. Pleasing results are obtained through machine learning algorithms but Deep learning algorithms can also be used in the same scenario to make more advance diagnosis.
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