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Smart Goggle: A Device to ascertain DES (Digital Eye Strain)

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Abstract:

Objective: This invention is very useful in the current scenario, where Digital Eye Strain (DES) is a common delinquent among people that using digital devices for more than permissible time. Theobjective behind this invention to ascertain DES at regular intervals or at an early stage so that required remedial solutions can be taken or reversals can be executed to save our eyes.

Background: The device is based on the system that will detect eye strain symptom like traceable(Eye blinking rate, Redness in eyes, eye squeezing and eye itching) and non-traceable (Eye Pain, Watery eyes, blurred vision, headache) symptoms due to continuous use of digital devices and generate an alert if these symptoms are present. The system is now installed in a device to identifythe strain. Device is called "Smart Goggle".

Method: The system is executed through various steps. Firstly, the system captures the video through camera and store in a module. The video will be divided into frames. The system will check the presence of traceable (Blink Rate, Redness, Squeezing, and Itching) factors in frames. Ifone of the traceable factor is present then system will check for another input to get non traceable(Eye Pain, Watery Eyes, Blurred vision and headache) factor from the user through input. Both the inputs are then passed into Machine Learning algorithm (Bayesian classification) to predict theeye strain. If eye strain is predicted by the classifier, then an alert is sent on user's machine to intimate about eye strain status

Application: The use of digital devices to execute their social and professional purposes is now quite normal. Due to this, occurrence of DES (Digital Eye Strain) or CVS (Computer Vision Syndrome) has increased few folds in almost all generations from the kinder garden student (whowatches rhymes and stories online) to a senior citizen (who executes its financial transactions through mobile or computer). Between these two all other generations are using digital devices for some or the other purposes. As digital devices are very popular among all ages so there is a need of this "Smart Goggle" among all age groups to detect their DES at early stage.

1. **Introduction**: Digital Eye Strain(DES) also known as CVS (Computer Vision Syndrome) is a group ofeye and vision related problems that results from prolonged use of digital devices like computer, mobiles, tablets, -readers or any other similar kind of electronic gadget that can give more than acceptable load to your eye muscles [1]. The above definition from AOA (American Optometric Association). The authors would like to examine the status of current generation in reference withdigital device interactions. The results are quite surprising but giving us the motivation to pursue our research in the current topic and further enhance it [Reference-Images:1-4].

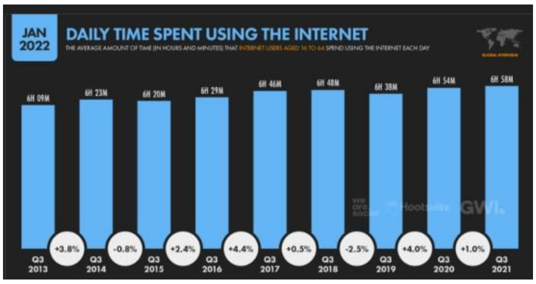

Image1:Daily time spent on Internet [2]

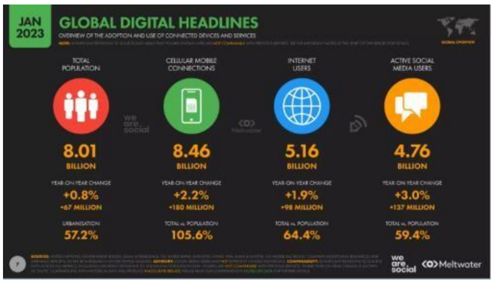

Image2:Daily time spent on Internet [2]

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Image3: Digital India Status [3]

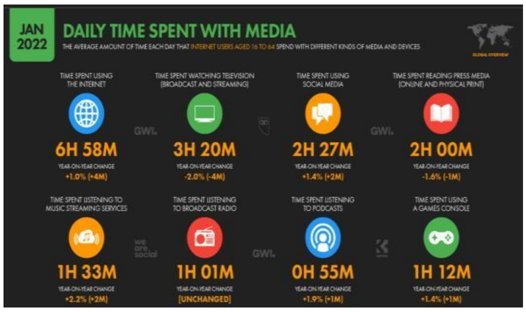

Image 4: Digital India Status [3]

There are numerous reasons that results in spear of digital media devices as daily necessity: Visionof our honorable prime minister to transform India into digitally Empowered society and knowledge economy [4]. As an execution plan of this vision, every service of government department is now delivered a through digital media, so it more and more device usages are required and screen time increases. Another spike in the use of digital devices is due to Covid - 19. Where normal interactions were restricted and people are required to complete their daily requirements through online mediums. Although pandemic is over, all most all the things are concerted to offline mode but still digital devices are still in use more than before. Along with these there are many more reasons that promotes use of more digital devices like availability of devices at economical prices, ease of using a device, all the required tasks can be completed through devices, and many more. Some of these reasons are justified and another are taking an advantage of the hour but eventually everything ends up to give an unbearable cost to our vital organ Eye. The more the devices used for day to day tasks, it gives the spike in the DES and CVS cases. As DES cases are increasing not only in India but all over the world due to some or the other reasons, so this area has gain researchers attention and they have started or intensified their workin this field. Some of the work already done in this field can be glanced in the next section:

Image 5 : Digital Eye starin status in India [4]

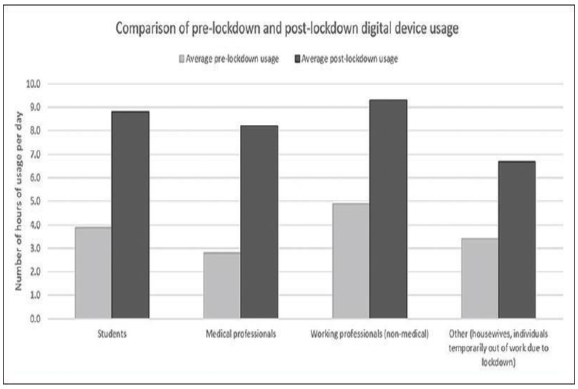

Image 6: Digital Device Usage status in India [5]

2. **Literature Review**: With an objective to add authors current work as extension to the existing work, authors have gone through the concern area. A lot of work has been done to identify the DES factors, role of profession in DES, impact on various age groups, usage duration, type of devices, geographical locations and other important information related to DES through questionnaires, personnel interactions or physical or virtual examination [6] [7] [8] [9]. One step ahead from factors, lot of manuscripts are available in the concern literature that are primarily discussing how to establish DES condition based on the presence of factors. Different researchershave adopted different strategies to establish DES condition. Like using a tool to enter data and get the result, some have used few hardware and establish the DES condition after examination, some models are also proposed that works on establish factors [10] [11] [12]. A lot of researchershave used ML and AI techniques in establishing eye strain through certain selected factors [6] [13].One such framework is also given by the authors and present work is the extension of that framework [14].

3. **Eye Strain Detection Device**: The device is named as “Smart Goggle”. It is a wearable device that can detect eye strain due to prolonged screen exposure. Machine learning, a branch of artificial Intelligence is used to detect the strain. The device collects the required information (Data that isrequired to analyze strain status of an eye). The device analyzes collected data on through ML algorithms and produce result about strain status of eyes. The device will then generate

"customized alert" through LED light blinking depending upon conditions or strain status of eye captured.

3.1. **Device Objective**: In the current scenario where a layman is having digital dependence to complete its day to day activities. A normal day tasks are completed with the help of digital devices like email to check their schedule for the day, ordering a grocery or daily needs, interacting with immediate or extended family, completing office routines, teaching and learning, getting daily updates from e-paper and much more. To complete these one is boundto stick with any of the digital devices like mobile, laptop and other digital screens. It's very obvious to get the Digital Eye Strain (DES) at some or the other point of time. Eye strain is bothering but it's not that staid, it can go off if one is relaxing and probably avoiding the activities that are prime cause of DES. The objective of the device is to ease the detection process of DES, so that people don't have to visit eye specialist every next day. If the strain is detected, user can try simple means to overcome strain and if the problem still persist thenuser can visit the Medical expert for further course of action.

3.2. **Device Assumptions**: The device is useful in detection of eye strain. The device follows few assumptions for the user (who is using the device) for appropriate detection of eye strain. These assumptions are mentioned concerning the fact that some of the factors Traceable andNon Traceable like "Redness and Watery Eyes" can be experienced by the user due to some other causes as well. So these causes are eliminated and certain assumptions are defined forthe user of the device. Device assumptions are as follows:

3.2.1. The device is useful when user is not under the impression of any alcoholic drinks.
3.2.2. The device is useful when user is not sleep deprived and due to this he/she is experiencing red or watery eyes.
3.2.3. The device is useful when user is not experiencing and mosquito / insect bite or anyother eye injury.
3.2.4. The device is useful when user is not experiencing any irritation due to dust or anyexternal element in the eyes.
3.2.5. This device is useful when user is not experiencing pink eye conjunctivitis.
3.2.6. This is device also rules out the presence of "Blepharitis" (a condition where one canfind inflammation in eyelids)
3.2.7. The device is useful when user is not experience any extreme Glaucoma condition whichmay have an adverse impact on their eyes.

3.3. **Supporting Hardware and Software Routines:** "Smart Goggle" can be considered as a systemthat comprises Hardware and Software.

3.3.1. **Hardware Components**: The specification of hardware components used in the "SmartGoggle" are explained in the Table 1

Hardware Component	**Quantity**	**Purpose**
Camera	2	For capturing the videos of both eyes
Button	5 (I orange button + 4 button withlogo)	Orange button for start and stopoperations. 4 button with logo for input of info regarding non-traceable factors.
Processing unit	1	For processing algorithms and information collected from user.
Storage unit	1	For storing the extracting frames an inputs collected from user.
LED Lights	4 (2 red and 2 green lights)	For updating the strain status of each eye. Red light will blink when strain is predicted and green light will blink if there is no strain.
Battery	1	It is used to supply energy to the processor for its working.

Table 1: Hardware components used in "Smart Goggle"

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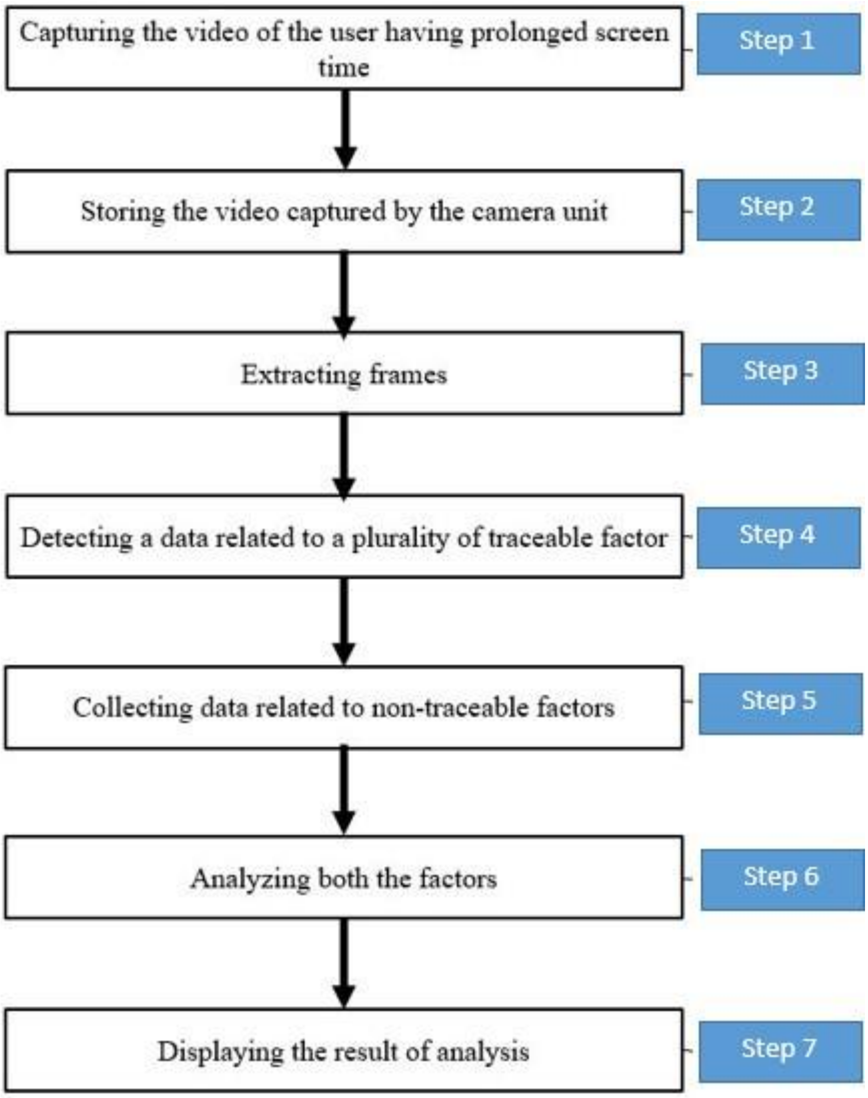
3.3.2. **Software Routines**: Software components specifications are listed in Table 2.Comprises ML (Machine Learning) algorithms for detecting eye strain, image and video processingalgorithms.

S.no	Software Components	Purpose
1.	Video Processing Algorithms	To convert video into frames
2.	OpenCV Library	To detect various traceable and non-traceable factors throughframes or videos.
3.	Machine Learning Algorithms	To detect eye strain status frominput concerning traceable and non-traceable factors

3.4. **Device Duration: Eye Strain Detection Process:** Fig 1 depicts the process of eye straindetection executed by the "Smart Goggle".



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3.5.

Figure 1: Eye Strain detection process executed through "Smart Goggle"

3.6. **Detection Basics and Progressive Execution**: The eye strain detection process is based on: Traceable and Non Traceable factors. In order to start the "Eye strain detection process", userwill wear the "smart Goggle" and press start/stop toggle button [Orange button on device left side of the device][Ref Figure 2]

Figure 1: Side view of "Smart Goggle". Button on the side view to start the process of eye strain detection.

Once the start button is pressed, the camera fit in the device will record the video of the both the eyes**[Execution of Step1 Ref fig 1]**. The recording is will automatically be stopped after 60 seconds or can be manually stopped by pressing same orange button [**Note: Orange Button is toggle Button**].

The recorded video is saved on storage device installed on the "Smart Goggle" for further processing**[Execution of Step2 Ref fig 1]**. The image and video processing algorithms saved on storage device ofthe "Smart Goggle" will convert the video into frames **[Execution of Step3 Ref fig 1]**. The ML (MachineLearning) based algorithms will try to detect following traceable factors in the frames:

[Traceable Factors: Factors that can be traced/outlined through frames extracted from recorded video or directly from recorded video]

- Blinking Rate
- Redness in eyes
- Squeezing
- Eye Itching

Factor detection process is completed using ML libraries. Various languages support such libraries, authors have used OpenCV Library of Python language. Plurality of traceable factors are recorded andfurther information about the non-traceable factors are collected through the user. Information about the following non- traceable are recorded:

[**Non-Traceable Factors: Factors that cannot be traced/outlined through frames of recorded video or directly from recorded videos. These factors are important to make analysis regarding eye strain. Input regarding such factors are collected directly from user through input mediums (Pressing a button). Input mechanism is provided on the "Smart Goggle".**]

- Eye Pain
- Headache
- Blurred vision
- Watery eyes

Figure 2: Front view of "Smart Goggle". Button to input the information regarding Non traceable factors. Four buttons are presented with an icon on each button to representing non – traceable factors.

If user is experiencing any of the non-traceable factor then respective button is pressed and presenceof the factor/s are recorded in the storage device associated with the "Smart Goggle" **[Execution of Step5 Ref fig 1]**.

Further the information of the traceable and non-traceable factors are then sent as an input to the Machine Learning algorithm for processing **[Execution of Step 6 Ref fig 1]**.

The processing output concerning strain status is updated through LED light blinking **[Execution of Step7 Ref fig 1]**.

Figure 3: Back view of "Smart Goggle". Two LED lights on each side to represent the eye strain statusof each eye. RED LED light will be blinked if eye s are strained otherwise green Led light will be blinked.

3.7. **Underlying algorithm support for "Smart Goggle"**: The execution of "Smart Goggle" primarily based on "Traceable" and "Non- Traceable" factors.

3.7.1. Traceable Factors: all the factors that can be easily noticed by observing the object in concern (Eyes). AI (Artificial Intelligence) a stream of Computer recognition and practicing offers various algorithms to notice such factors. Some of the algorithms usedin the current research for noticing these factors are:

3.7.1.1. **Blinking**: Blinking is natural reflex or an explicit act of the eyes that is performed by semi or complete closing of eyelids. A normal person blinks 10-15 times in a minute [15, 16]. This rate can be changed (increased or decreased) depending upon many factors. One such factor can be CVS or DES. The authors areconcerning this factor, keeping the subject of paper. Through **OpenCV** (Open source Computer Vision library) library of machine learning, it can be counted howmany times user blinked in a minute or any decided time frame. This library is originally for C and C++ but can also be used in java and python. Although OpenCVlibrary contains many classifiers for face and eye detection, authors have used "Haar

Cascade"to get the objective done [17].

3.7.1.2. **Redness**: An unusual eye condition when sclera (white part within eye) is abnormally red. It's a pain less and occurred due to swollen blood vessels near thesurface area [18]. To validate this property it is required to check the color statusof the eye. Hue Saturation Value (HSV) algorithm of the OpenCV library is used. HSV helps in identifying the color of the object through RGB (Red Green Blue) values. Here the object is Eye and the color of the eye sclera is identified and bloodshot eye condition is diagnosed [19].

3.7.1.3. **Squeezing**: our eye can make certain conscious and unconscious movementsdepending upon our eye status. When both the overlapping each other, we call it eye closing. When eyes are close to each other but not exactly overlapping each other then we call this condition Squeezing. In the squeezing position a person cansee through but size of his/her eye is less than its original size. The same concept is used in diagnosis of this condition. OpenCV algorithm is used to get the size of an eye. At regular intervals the size of the eye is captured and compared with original eye size to identify the squeezing or Blepharospasm medical condition.

3.7.1.4. **Eye Itching**: A medical condition Ocular Pruritus when user is experiencing some kind of itch in their eyes. Eye itching could be due to dry eyes which is againone of the symptoms of CVS or DES. When user is continuously looking at the system or any digital device and not blinking eyes frequently then our eyes water will be dry off/evaporate more quickly and we experience dry eyes. As there is nomajor change in the eyes during dry eyes or eye itching condition. So eye locations(Left eye location, Right eye Location), hand locations (Left hand location , Right8Hand Location) and their various permutations are measured and compared for atime period and then eye itching condition is concluded. For this purpose OpenCVlibrary along with Media Pipe Library is used to identify the eye and hand locations.

3.7.2. **Non Traceable Factors**: As Non Traceable factors cannot be noticed by visual appearance as does not make any change in the object in concern (Eye). These factors are rather experience by the users. Some of the non-traceable factors used in the current research are: Headache, Eye pain, watery eyes, blurred eyes. So in order to collect the information about the non-traceable factors, a usual and simple mechanismof data input is used in the current research. An input message is sent to the user for collection an information. The user is expected to select all the options he/she is currently experiencing. The user's response is saved and further processed.

4. **Conclusion and Future work**: The framework to diagnose the eye strain status is based on traceable and traceable factors. Depending upon the current eye status, information regarding both the factors are collected and processed, eye strain status is predicted and user is intimated about the same through a LED light blinking mechanism. A device for the same process is proposed and researchers are currently working to get the same device functional so thatcomplete framework can be implemented through hardware support. Individual algorithms are now practiced to get the expected outcomes and further they all will be incorporated in the hardware device.

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