Poster: Towards a Wearable Assistant to Prevent Computer Vision Syndrome

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Abstract

We propose Tiger[1], an eyeglasses-type wearable system to help users follow the 20-20-20 rule to alleviate the Computer Vision Syndrome (CVS) symptoms such as eyestrain, headaches, and dry eyes. It monitors user's screen viewing activities and provides real-time feedback to help users take appropriate actions. We present a system architecture with an initial version of hardware prototype. We also report preliminary results to assess the feasibility.

Author Keywords

Computer Vision Syndrome; 20-20-20 rule; wearable sensing; wearable system; intervention.

ACM Classification Keywords

C.3 Special-purpose and application-based systems: Real-time and embedded systems.

Introduction

Digital screens are ubiquitous, but they are like a double-edged sword in our daily lives. We benefit from them for productivity, entertainment, information, etc. At the same time, however, our eyes are hurt by them too. According to the report by the Vision Council [3], nearly 90% of Americans use digital devices for two or

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[1] Tiger is an abbreviation of "TIme to Give your Eyes a Rest".

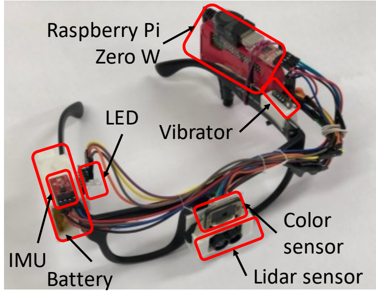


Figure 1: The prototype hardware.

more hours each day. 60% use them for five or more hours each day and 70% use two or more devices at a time. 65% of Americans experience symptoms of digital eye strain, also referred to as Computer Vision Syndrome. The prolonged use of digital screens such as smartphones causes diverse symptoms, e.g., eyestrain, headaches, dry eyes, blurred vision, and neck pain [9].

One of the recommended strategies to alleviate CVS is to follow the 20-20-20 rule [3, 9]. The rule suggests taking a 20-second break to view something 20 feet away every 20 minutes of screen use. Taking frequent breaks to look at faraway objects significantly relieves eye strain symptoms. While there are mobile or desktop applications for the rule [1, 2], they just give a notification regardless of whether a user actually views a screen for 20 minutes or not. They cannot confirm that the user takes a break seeing something 20 feet away. In addition, users need to install such applications on every device they use. Some works [5, 6, 7] address the problems of reduced blink rate and viewing distance by providing intervention upon problematic moments. However, they do not help users follow the 20-20-20 rule.

In this work, we propose Tiger, an eyeglasses-type wearable system to help users follow the 20-20-20 rule in their daily lives (See Figure 1). It monitors user's screen viewing activities and provides real-time feedback to help users take appropriate actions depending on the situations. More specifically, Tiger notifies users that they 1) take a short break if they are viewing a screen for more than 20 minutes, 2) see 20 feet away if they are looking at nearby objects during the break, and 3) return back to their previous activity if the break time reaches 20 seconds. Additionally,

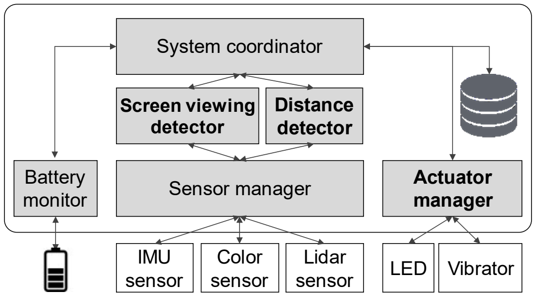


Figure 2: The system architecture.

Tiger provides a retrospective summary via an auxiliary mobile application, which shows the status of a user, e.g., how well a user follows the 20-20-20 rule.

We aim at developing Tiger as a standalone wearable system, i.e., processing sensor data and providing feedback without relying on other devices such as smartphones and personal computers. We believe this is important because Tiger should continuously run even when such devices are unavailable. More important, providing feedback via screen-equipped devices could turn user's attention into other digital contents. For example, providing a notification to a user to stop seeing a screen via a smartphone could lead her to use other mobile applications instead of taking a break for her eyes.

System Overview

Figure 2 shows the system architecture of Tiger. The key components are the screen viewing detector and distance detector that detect a user's screen viewing activity and viewing distance, respectively. To detect such situations, Tiger adopts three types of sensors, an inertial measurement unit (IMU), a color sensor, and a

Test scenarios	Accuracy
None, iPhone 6s	0.85
None, laptop	1.0
All	0.92

Table 1: Screen viewing detection accuracy; none represents the scenario without screen use. Our prototype detects the laptop-screen viewing events with nearly 100% of the accuracy when the test data includes laptop-viewing and non-screen scenarios only. However, its accuracy for iPhone 6s under iPhone 6s viewing and non-screen scenarios is 85%. It is mainly because iPhone 6s has a much smaller display than a laptop.

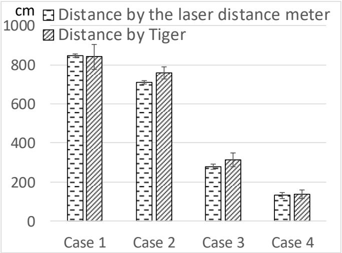


Figure 3: Distance measurement results. The bars represent the average values. We select the four cases of different distances ranging from 130cm to 850cm (Case 1: 850cm, Case 2: 700cm, Case 3: 320cm, Case 4: 130cm). Note that the posture or position of the participants could not be identical so that there is a slight variation in the distance measured by the laser distance meter. The error bar means the standard deviation.

LiDAR sensor. To provide real-time feedback, it is also equipped with two actuators, an LED and a vibrator. The system coordinator activates the whole operation upon a user's request and dynamically determines how the sensors and actuators are configured. The activation and sampling rate of the sensors are configured depending on the remaining battery which is reported by the battery monitor. The actuators are controlled based on the detection results. The sensor manager collects a series of sensor data and configures their sampling rate. The actuation manager controls the LED and vibrator. The detection results are maintained in a database and used for a retrospective summary.

Prototype Hardware

Figure 1 shows the prototype hardware. The main components include sensors, a processing unit, and actuators. We use an off-the-shelf glasses frame for the prototype. To attach the components to the frame, we custom-design 3D printed housings, each of which holds each component such as an IMU sensor and a vibrator. For screen viewing and distance detection, we currently use a TCS34725 RGB color sensor, SparkFun 9 DoF (Degree of Freedom) IMU sensor stick, TFMini micro LiDAR sensor. The color and LiDAR sensor are placed on the bridge of the glasses in order to do sensing along the direction of viewing. The color sensor allows accurate color measurements through RGB and Clear light sensing channels. The LiDAR sensor measures the distance to an object based on Time of Flight (0.3 - 12 meters). The IMU for motion sensing utilizes the LSM9DS1 including a 3-axis accelerometer, 3-axis gyroscope, and 3-axis magnetometer. For the processing unit, we use Raspberry Pi Zero W powered by a 1000 mAh battery. The Raspberry Pi collects sensor data through a GPIO interface for the color and IMU sensor and a Serial interface for the LiDAR sensor. It also controls the vibrator and LED via a GPIO interface to provide a feedback to a user.

Preliminary Results

We conduct preliminary experiments to assess the feasibility of the main components.

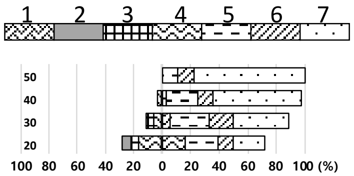
Screen Viewing Detection

Here we test an initial inference pipeline using only the color sensor to detect screen viewing events. Its main idea is to leverage 1) a characteristic of LED-backlit screens that shows an intense blue peak [4, 8] and 2) relatively fast change in objects being seen, i.e., the contents on the screen. The pipeline reads sensor data from red, blue, green, and clear light channel of the color sensor, respectively at 42 Hz, takes 5-second windowing, extracts statistical features, and uses SVM as a classifier.

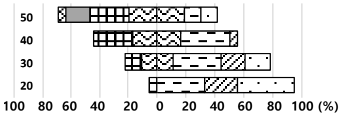
We evaluate the accuracy of detecting screen viewing events. For the feasibility test, we place our prototype on the desk and test three scenarios; one for placing iPhone 6s 40 cm ahead, another for placing a laptop 50 cm ahead, and the other without screen use. We play a YouTube video on the iPhone 6s and laptop. The experimental results show that our prototype achieves 92% of the overall accuracy. Table 1 shows the detection accuracy for different test scenarios. We expect that Tiger can achieve a higher accuracy if we incorporate IMU and LiDAR sensors into the pipeline. We leave it as a future work.

Distance Detection

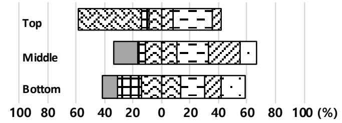
We evaluate the accuracy of measuring the distance at which an object is seen by a user. We test four



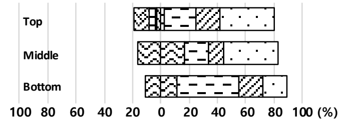
(a) Vibration perceptibility



(b) Vibration comfortability



(c) LED light perceptibility



(d) LED light comfortability

Figure 4: Feedback modality results. Three tasks are 1) taking a rest, 2) keyboard typing using a desktop monitor screen, and 3) using a smartphone. For the LED light, we test three different positions of LED; Top/middle/ bottom means that LED is placed on the top/middle/bottom right side of the right rim. For the vibration, we vary the level of vibration from weak (20) to strong (50) vibration.

scenarios including short to relatively long distance. We recruit 6 participants (all males), ranging from age 25 to 27, with a mean of 25.7. We ask the participants to wear the prototype glasses and see the spot pointed to by a laser distance meter in the lab. We compare the distance measured by the laser distance meter with that measured by the LiDAR sensor of Tiger. Figure 3 shows the results. The differences between the measurements are not large, 7-51cm. We believe that this is acceptable to the application of Tiger.

Feedback Modality

We evaluate two feedback modalities, LED light and vibration in terms of perceptibility and comfortability. We ask the same 6 participants of the previous experiment to wear the glasses and perform three different tasks, each of which lasts for 30 seconds. During the task, a feedback using LED light or vibration is given. Then, we ask them to answer two 7-point Likert scale questions regarding the perceptibility and comfortability of the feedback. For the perceptibility, 1 means never perceptible and 7 means very well perceptible. For the comfortability, 1 means very uncomfortable and 7 means never uncomfortable. Figure 4 shows the distribution of ratings under different situations. As expected, vibration is more perceptible, but could be more uncomfortable than LED light. We can see that the middle and bottom positions of LED are similar and the top position could not be a feasible option. Also, we can see that the vibration level 30 could be a balanced option for both of the metrics.

Conclusion

We propose Tiger, a wearable system to help users follow the 20-20-20 rule to alleviate the CVS symptoms. We present the system architecture with an initial hardware prototype. Our preliminary experiments evaluate the feasibility of system components.

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