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Short communication

Eye safety awareness and visual impairment prevention for computer users

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Abstract

The paper presents an etiologic approach to visual and ocular alterations caused by intensive computer usage, with the aim of carrying out the risk factors and presenting the preventive measures that are to be applied. The prevalence of computer-induced eye problems is constantly growing and will remain so as long as humanity is dependent on most activities on electronic devices. The eye care burden is exclusively in charge of the user and the multitude of intrinsic, environmental, professional, and ergonomic factors with specific preventive measures are quite difficult to manage. In more developed communities there is an emphasis on eye health education, periodic ophthalmological examinations, and ergonomic organization of the computer workspace, but an important subjective risk factor remains nevertheless uncontrolled: the proximity to the screen during work. For this matter, it is presented one solution for visual impairment prevention among computer users, consisting of a simple automated system (OptoGuard) for warning persons when working too close to the screen, exceeding the eye safety proximity interval (which is measured through the webcam). The preliminary results, obtained for the Euclidean distance measurement, as the webcam currently allows, had an average error of 4%, the warning message appearing on the screen every time the user's proximity fell below 38 cm. Further developments aim at expanding the visual area monitoring to asses several levels of the other factors that lead to computer-related health problems: posture, angle of viewing, and brightness of the screen.

Abbreviations

OOS: Occupational Overuse Syndrome; DES: Digital Eye Strain; CSV: Computer Vision Syndrome

Introduction

With the development of IT technologies and the adoption of devices to carry out current activities, people are subjected to a series of health risks that wouldn't have been aware of the associated diseases hadn't expanded so rapidly. After the Covid pandemic, during which most processes had to be carried out online, it was found that the prevalence of computer-induced health problems increased significantly [1], in all age groups. From commonly reported health problems related to intensive computer usage (OOS, musculoskeletal disorders, Carpal tunnel syndrome, psychological problems, ophthalmological diseases), visual impairments have the highest prevalence [2], the reason for which the eye diseases have recently started to be approached as a modern global epidemic [3]. Fortunately, as stated by the World Health Organization, over 80% of global visual impairment is preventable or treatable [4], so joint efforts must be directed to identifying and implementing preventive measures to reduce the overall prevalence of avoidable eye diseases. These efforts can be embodied in global action plans for eye health, educational strategies, and programs for universal access to comprehensive eye care services. Also, the safety and health plans that are to be implemented at the local and organizational levels must focus better on prevention measures.

There are two main visual conditions caused by intensive computer use: Digital Eye Strain and Computer Vision syndrome. In addition to the typical DES symptoms (dry eyes, blurred vision, itching, light sensitivity) recently included onset esotropia and vergence abnormalities. New-onset myopia along with the increased progression of existing myopia turned into the most significant ocular health complications in 2022 [5]. CVS presents more complex symptoms; in addition to ocular and visual ones, occurring non-ocular manifestations such as headache, neck, shoulders, or back pain. These arise when using a computer or visual display/screen for more than 3 hours per day or more than 30 hours per week [2]. Starting from this time restraint given by the definition, it turns out that visual alteration can occur with high probability, as long as typical daily computer exposure time is around 7 hours for office workers, 4 hours for students, and 2 hours for children (as an exception, during a pandemic, the peak time for children spending in front of a computer screen was reported at 40.3 hours per week [6]). Recent studies conducted on significant groups of students show that more than 80% have developed CSV in the last two years and to the same extent are not aware of it [7, 8]. Regarding office workers, the percentage is on average 70%, but it varies depending on the type of activity performed [2] and on the degree of regional development. It turns out that CVS extends as an occupational hazard of the modern era and is the responsibility of the user to keep under control the risk factors. In the matter of CVS treatment, at present there are no clinical guidelines to provide evidence-based advice about it, thus many remedies for CVS symptoms are marketed directly to patients [9], without clinical recommendation.

Materials and methods

Knowing the pathophysiology of these visual and ocular alterations, along with the predisposing risk factors, a series of preventive recommendations were formulated by specialists: applying the 20-20-20 rule, wearing computer glasses, using eye drops, assessing light level in the workspace, making technological adjustments (as high-resolution screens, anti-glare screens, edge-to-edge displays, blue light filters) and the most important – ensuring the correct posing and viewing distance from the monitor (Figure 1). Starting from this last demand, the research team from Technical University Gheorghe Asachi of Iasi developed a noninvasive system to help the computer user with maintaining the optimal distance from the screen during work. The OptoGuard prototype is developed based on a novel video distance measurement method based on focus positions [10], which uses the computer's webcam to asses precisely the users' proximity to the screen. The operating stages are: the webcam is calibrated in order to determine the measurement range corresponding to each position of the focus lens for which maximum clarity is obtained; the webcam remains in a fixed position on the monitor and based on the clarities related to lens positions for captured images, calculates the distance between the user and the screen; if the user exceeds the recommended optimal range of 40÷75 cm, a visual warning will appear on the screen (Figure 2). Comparable groundwork regarding proximity sensing has been conducted lately, either at the theoretical level as [11], proposing personalized measures for screen restriction triggering with distance, measured with sensors, or at an experimental level using several measurement, data processing tools, and algorithms [12].

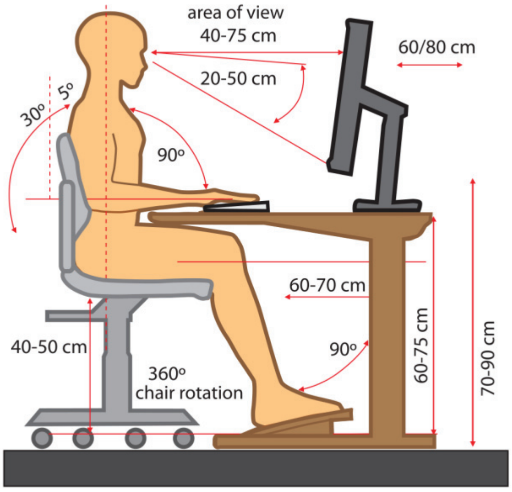

Figure 1: Recommended pose during computer work, with distances and inclinations, for eye safety (after [13]).

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The particular advantages of OptoGuard are that distance monitoring is done automatically, is no longer the responsibility of the user, and does not require additional equipment, as the monitoring is carried out through the computer peripheral. The measurement technique is based on camera focus positions and clarity and doesn't request a reference, which distinguishes it from traditional methods. Regarding the warning method, it can be customized. Firstly, the OptoGuard was tested by displaying a pop-up message that can be closed by the user and, subjectively, ignored. The system lends itself to the further development of several types of visual warnings, being considered the constrictive type - which does not allow the resumption of work until the user returns in the visual safety interval, or the type of visual warning with emotional impact.

Results and discussion

The system was preliminarily tested and the delivered results showed good precision for the measured distance. In the eye safety interval, the average relative error for webcam measurement through the passive method using three focus positions was 4.3%. For example, when the user is at a real distance of 40 cm from the screen, maximum clarity is obtained on position 10 of the lens, position 10 belonging to the range [28.6cm, 46.1cm]. These limits of the measurement domain,

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along with differences between the maximum clarity value for position 10 (0.715) and its adjacent ones (0.678 and 0.745) provide the calculated distance:

$$d = 28.6 + (46.1-28.6)*0.037/(0.037+0.03) = 38.27 \text{ cm}$$

The accuracy of proximity calculation is directly proportional to the performance of the measurement system; therefore it will be higher if the webcam presents superior performances, correlated to an increased number of lens positions. Technical details about the fundamentals and application of this video measurement method are published in [10].

In terms of prevention systems or applications, are also available and affordable viewing distance calculators depending on the screen resolution and size (more suitable for TVs). They are based on the minimum distance at which the human eye can discern the pixels from a monitor: e.g. for a ubiquitous display of 1920 x 1080 pixels resolution, the recommended viewing distance is 1.7 x screen width.

Additional attention must be paid to the blue light component emitted by the screen, because blue is the most actinic color, regardless of the viewing distance. Its photobiological effect is of shifting the circadian rhythm within 2 hours and its physiological effect is of causing cataracts, growths in the eye, or cancer because of the UV component.

Conclusion

In the last three years, there has been an increase in the frequency of computer-induced health problems, irrespective of age group. Visual-related disorders are the most commonly reported, with symptoms associated with Digital Eye Strain and Computer Vision Syndrome. Information, knowledge, awareness, and management of the causes leading to these ophthalmological disorders must be included in a plan of safety and health measures at the workplace, as most can be successfully prevented. Fortunately, technology provides for this purpose varied options, from customized glasses, specialized screens or filters, and adjustable furniture for better sitting posture, to vision training applications, screen time tracking software, and emerging applications for eye gaze monitoring in order to advise users when it's outside the visual safety area, expressly too close to the screen, below 40 cm distance. The proposed work aims to help the user while working at the computer, by providing video warnings based on proximity to the screen, in order to eliminate the risk of DES or CVS occurrence. In this early stage of the experiments, the system only measures the linear distance, in the visual plane. It fulfills its purpose of serving as a simple and embedded warden. Adding more parameters to monitor and measure (angles, luminance) increases the complexity of the system, requiring supplemental measurement and processing tools.

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