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Real time control device for reading distance and head tilt

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ABSTRACT

The people's daily routine is characterized by an exposure to short reading distances during a long time period. This is due because of excessive reading and writing work and also because the use of mobile display screens. The human visual activity has changed a lot during last decades, demanding to the visual system (both accommodative and vergencial level) an extra effort. To correct the associated effects of working with short distances, we present a Real Time Control device "RTC device" which consists of an optical measurement system and algorithmically correction for improving working distance. The RTC device contains a head tilt measurement system that monitorizes in real time. Our main goal is to design an optical device that could improve the visual performance of people by controlling the reading distance, and thus avoiding visual-functional and postural complications since the childhood.

1. Introduction

In recent decades, our reading distance has changed notably with literacy and with the advent of new technologies. The visual system was initially prepared for the far-distance viewing (exceptionally for near vision), therefore in ancient times the incidence of myopia was less than 1% [1]. Our visual requirements have changed in recent days from looking at far distance to looking at close-intermediate distances steadily for many hours a day and the future could continue in this direction.

The accommodative or focus system is conceived and designed in its nature to make changes in focus. Furthermore, when we look at distant objects the visual system is relaxed and when we look at objects located in near vision the crystalline is contracted or stimulated. If there is not a change in the accommodative response for an extended time to perform an activity in near vision and, above all, if the distance is not adequate our visual system could suffer fatigue and visual discomfort due to some accommodative or vergence dysfunction [2], resulting in less accuracy of convergence to far distances [3]. An overstimulation of accommodation could lead to excessive accommodation or, in some cases where the system is more degraded, to accommodative spasm. In these cases, the symptoms are mostly associated with prolonged visual task in near vision, causing blurry distance vision and producing a transient myopia [4] which is much more pronounced at night.

Many studies have related an increase of myopia with an exposure for a long time at a too short distance regarding the recommendations. Moreover, this effect was seen in both children [5], as in adults [6]. Currently, the prevalence of myopia

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among young people aged between 7 and 17 years-old is higher than 30%, and this prevalence has increased considerably in the last 30 years [7], so that in some Asian countries the prevalence is much higher reaching up the 80% [8].

In childhood the prevention to early detection of visual defects is particularly important. Also, during school time it is important to have good visual ergonomics for optimal performance as an accommodative or vergence dysfunction could directly affect school performance [9] being reduced ability in reading and writing of the common causes [10].

An important factor in visual ergonomics is a correct level of ambient lighting; in fact, several studies point to the possibility of developing myopia if lighting levels are not adequate [11]. Also, whether incorrect lighting is combined with inadequate working distance (i.e., too short) it could cause changes in the vergence system [12], resulting in a visual discomfort in the subject.

Some of the following advice may help to prevent or mitigate these visual dysfunctions [13].

- To avoid reading or working with text or display screens for too short distances.
- To perform breaks for a short time after carry out near-intermediate vision tasks.
- To ward off reading or doing work when ambient light is not adequate.

In principle, these tips should not be hard to understand but, unfortunately, people usually tend to forget about them when immersed in certain tasks, such as reading books or display screens.

Our main goal is to design a device that allows real-time monitoring for working distance and the subject's head tilt. The RTC allows real time warning of inadequate postural behaviors, correcting these and preventing future visual problems.

1.1. Previous studies

Basically, most optoelectronic methods used for determining distances are using a laser type 2 or range sensors such as ultrasonic sensors for trilateration. In our case we use another emission system through infrared light-emitting diodes (LEDs), since the use of the mentioned laser could be harmful for our eyes, as outlined by the American and European Union regulations [14].

There are studies related to the estimation of distances which have been used a laser emitter and CCD sensor [15] or CCD infrared sensor for the detection and measurement of various parameters [16]. Other studies have added a real-time calculation as a precise method for calculating dimensions of objects [17].

There are systems that have incorporated devices on optical frames in order to provide various utilities; for example, some systems provide information by monitoring the different movements of the eyes (eye-tracking) [18], or other incorporate an ultrasonic sensor that records the different distances to the subject performs the tasks [19].

1.2. Justification and goals

We know of the existence of glasses incorporating LED systems, but never for the purpose of measuring distances; rather as lighting system whether in the visible or the infrared range.

The main goals of our work are:

- To develop a simple and low-cost device that may be integrated into optical frames in order to have better control of the working distance in near vision, which could avoid visual complications and allow an optimum visual performance.
- To polish and apply the different techniques and algorithms used in digital image processing to control working distance.
- To carry out tests to check the operation of the device.

2. Description and system design

The device consists of an optical frame wearing neutral ophthalmic lenses or lenses with the optical correction required (in ametropic subjects who need to wear lenses for the refractive error). At each end of the frame (over the end piece) is coupled an infrared light emitter (LED) and over the bridge of such frame is located a CCD image sensor. A Thorlabs IR filter with a cutoff wave length of 850 ± 2 nm in the emission spectra of the LED is added to CCD detector, to avoid interference from ambient light (Fig. 1).

The LEDs used are radial infrared diodes (HIRL5010) 5 mm in diameter with a peak wavelength of 850 nm and a half-intensity angle of 6° operating with a nominal current of 50 mA. To get a more precise or fine light stimulus, we redesigned the optical lens of the LED and placed with optical glue an aspheric collimating lens in front of each LED in substitution of the original lens.

The combined system of two LEDs with their respective collimating lens provides an angle of convergent projection – subtended by the two light beams – of three degrees semi angle in the working plane. The spots of light from both diodes are not overlapped when the working distance is greater than normal (farther, for example, with display screens), and are not too separated when the distance is less than normal (reading).

The predetermined distance depends on the visual needs of each person, by pre-selecting the Harmon distance (from the center of the middle knuckle to the center of the elbow measured on the outside of the arm) of the subject. In any case, the