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SELF-SERVICE KIOSK FOR TESTING SUNGLASSES

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ABSTRACT

Sunglasses users may only be assured on their ultraviolet protection by purchasing certified products, however they are not able to check if sunglasses are still ultraviolet (UV) protected as they age, unless they resort themselves to a professional who is qualified for using a spectrophotometer and is acknowledged on the standards for providing a report for the user. Current literature establishes safe limits on the exposure of the eyes relatively to the ultraviolet radiation exposure for the UVA and UVB ranges (280 nm – 400 nm). The UV protection is category dependent. Sunglasses are categorized from 0 to 4 and the categories are determined by the lenses transmission's percentage on the visible range (380 nm – 780 nm).

Methods: In order to overcome inaccessibility of such measurements on sunglasses, a prototype for testing ultraviolet protection on sunglasses, according to Brazilian Standards, has been developed for amateur use. The system consists of assembling UVA and UVB light sources and two UV responsive photodiode sensors, with Erythema action response for measuring UV protection; for categories measurements, combination of white light and LEDs were used for the visible range, as well as a light sensor having spectral response similar to the human eye. Electronics has been developed for controlling the measurements and software has been implemented for providing the report as well as for the user's interface.

Results: All the system was embedded as a self-service touch screen kiosk and provides transmittance measurements that are within the deviation limit required by NBR15111, i.e., 0.25%. Measurements were performed in over 45 sunglasses and compared to CARY 5000 – VARIAN spectrophotometer and present a good correlation for the measurements of transmittance in the visible spectral range (r^2 = 0.9999) and in the ultraviolet range (r^2 = 0.9997).

Conclusions: The prototype identifies the UV protection, for non-corrective sunglasses, according to category of the lens and is available for the public. In addition to educating the population about the importance of wearing protected sunglasses, the prototype has also allowed the public to have access to information about the quality of protection of their own sunglasses in an easy and free testing method.

I. LITERATURE REVIEW

Sunglasses are world widely used, whether for glamour, visual comfort and particularly for ocular protection, for those who are aware that excessive ultraviolet radiation may harm the eye if lenses are not properly protected [6,7]. Global standards specify mechanical and optical for sunglasses and sun glare filters of nonprescription lenses, which are intended for protection against solar radiation for social and domestic purposes such as road use and driving. All the system was embedded as a self-service touch screen kiosk and provides transmittance measurements that are within the deviation limit of 0.25%.

Transmittance measures include ultraviolet radiation (UVR) for an effective protection test of spectacles against eye diseases [6,7] infrared radiation, and traffic signal light radiation, so that minimum thresholds required for traffic signs visibility and visible radiation can be established. These measures ensure the minimum safety requirements to the population, indicating excessively dark lenses, which can limit the ability to identify objects in shadows while driving, extremely colored lenses, which can affect the detection and recognition of colors, and filter protection against harmful UV radiation.

The American Standard [8] and British and European Standard [9] require UV protection on the 280 nm – 380 nm range. Brazilian Standard [10] and The Australian/New Zealand Standard [11] have an extended UVA protection, thus the wavelength range for safety is from 280 nm – 400 nm.

It is still controversial in literature the harms of UV radiation for each component of the ocular media. The corneal epithelium absorbs UV-A and UV-B radiation, avoiding inner eye components from extreme radiation, but severe exposure to UV radiation may induce corneal changes [1,2]. Yet, a number of ocular diseases in the internal structures of the eye are related to UV radiation exposure, such as cataract [3]. Sunglasses can attenuate ocular exposure, but unprotected sunglasses and its incorrect use, may interfere on this attenuation [4]. Sunglasses can increase UV exposure of the crystalline lens and corneal limbus by disabling the eyes' natural mechanisms of lid closure and pupil constriction [5].

II.INTRODUCTION

Measurements of the UVA and UVB protection for sunglasses are categories of sun-glasses reliant. Categories of sunglasses are labelled based on the percentage of visible light transmitted through the spectacles. Visible light transmittance is proportionally to the response of the human eye for the different wavelengths within this range.

Fashion spectacles are categorized by the amount of visible light – 380 nm 780 nm - allowed to pass through the lens. Category rating, ranging from 0 - 4, is given to deter-mine how light or dark sunglasses lenses are, the higher the number, the darker the lens colour. The labelling requirements for sunglasses are based on the transmittance values, given by Table 1.

Table 1 Transmittance for sun glare filters for general use of NBR15111(2013) [10]

	Requirements			
	Ultraviolet spectral range		Visible spectral range	
Filter category	Maximum value of spectral transmittance $\tau_F(\lambda)$ 280-315 nm	Maximum value of solar UVA transmittance $\tau_{SUVA}(\lambda)$ > 315-400 nm	Range of luminous transmittance (380-780 nm) τ_V	
			From over %	To %
0			80.0	100
1		τ_V	43.0	80.0
2	$0.1 \cdot \tau_V$		18.0	43.0
3		$0.5 \cdot \tau_V$	8.0	18.0
4			3.0	8.0

III. PROPOSED METHOD

As an interface software routine, the user places the sunglasses in an appropriate compartment of the kiosk and the category of the sunglasses is measured in one of the lenses as well as the UV protection on the other lens, as shown on the chart in Figure 2. The data is stored and the user is asked to replace the sunglasses in such a way that the category and UV protection measurements are performed for a second time, but now on the opposite lenses than previously done, and finally the report provided to the user is based on both measurements data for each pair of lenses.

For the category measurements, we have used as illuminating sources a combination of LEDs, with band peaks at the 405 nm; 450 nm; 550 nm; 565 nm; 610 nm and 680 nm and sensors. For the UV measurements we have used two sensors and lamp as the illuminating source; One acts as the reference sensor and the other as the measuring sensor [15,16].

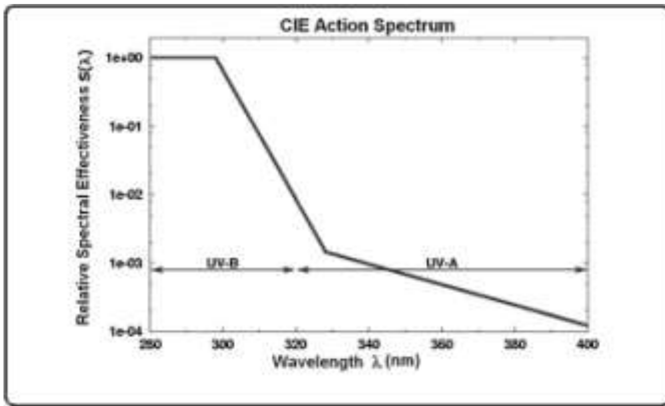

Figure 1 Graphical representation of the spectral effectiveness

IV. SOFTWARES

The embedded software was programmed using C language. It performs calibration of the system and controls the sequence for the transmittance measurements on the ultraviolet (280 – 400 nm) and visible (380 – 780 nm) ranges, providing the final report by comparing the data with boundary conditions of Table 1.

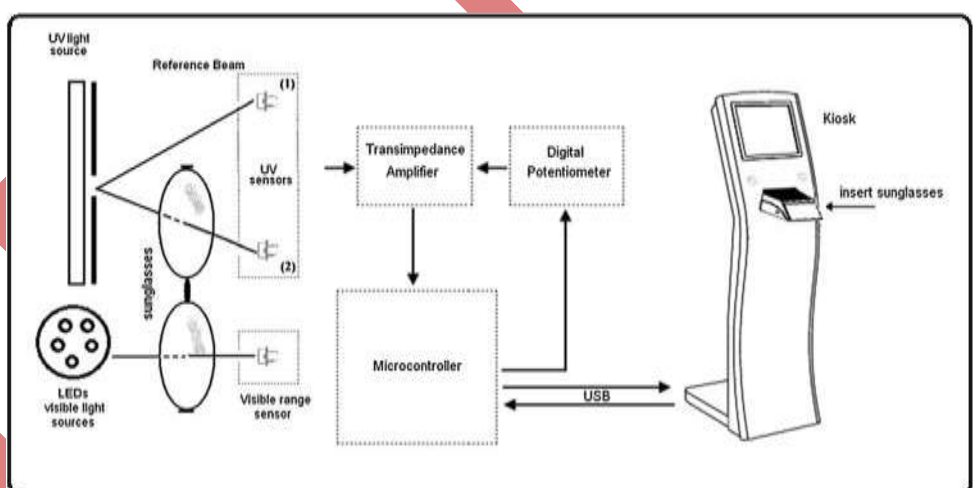

Figure 2 System's block diagram

The software also establishes a communication with the microcontroller, sending commands to turn ON and turn OFF the lamp; calibrating the system; and performing the measurements. The block diagram of the embedded software is shown in Figure 3.

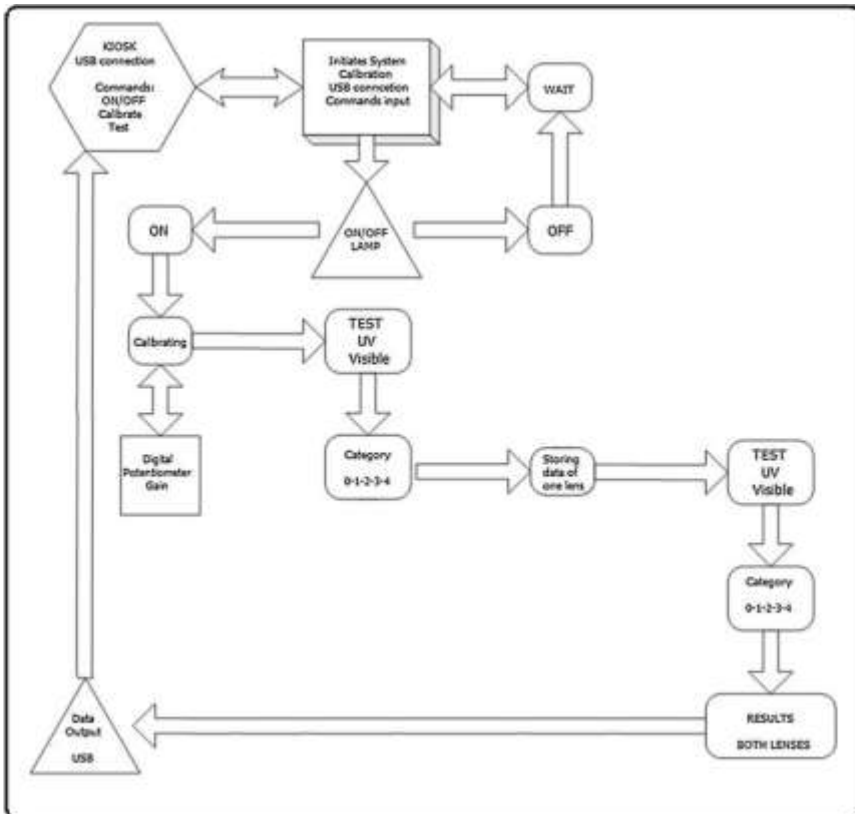

Figure 3 Block diagram of embedded software.

Figure 4 Inviting screen for calling public attention for sunglasses UV protection self-testing

The sequenced interface screens guide the user for testing the sunglasses, as well as provide them information about each item to be tested. It also states previously to the tests that the machine is for sunglasses testing purposes only.

V. RESULTS

The outcome of this system is a self-service sunglasses testing kiosk, which is presented in Figure 5. It shows the prototype - kiosk - and in detail, the slot to place the sunglasses for testing.

To test the system, its repeatability and accuracy, measurements were performed as described below.

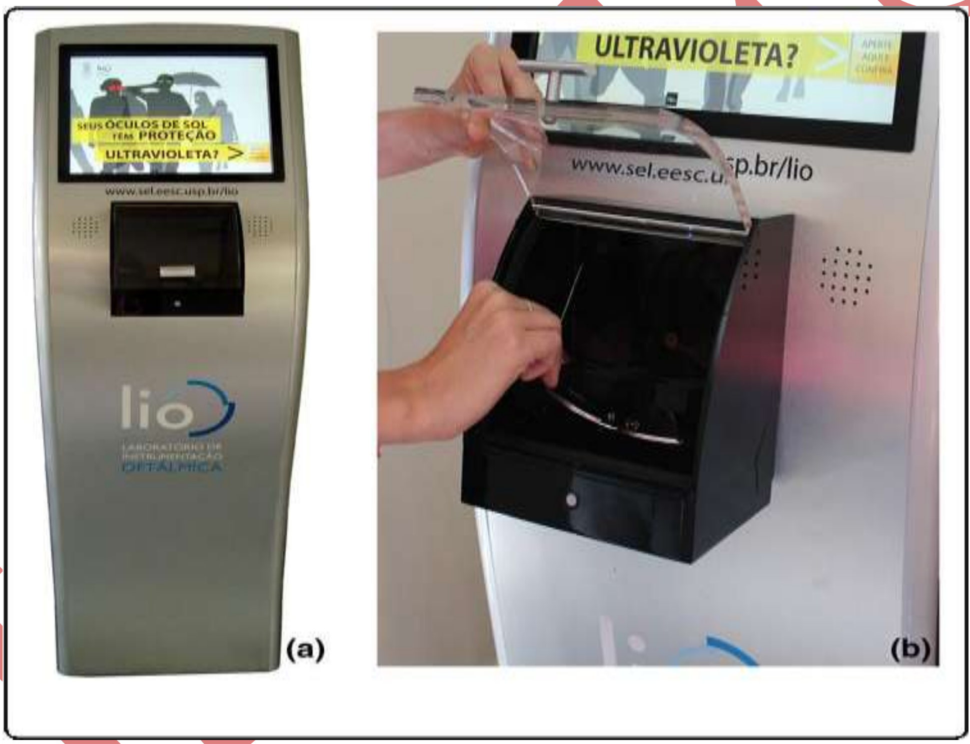

Figure 5 Picture of the available system for the public. (a) The self-service sunglasses testing kiosk; (b); inserting sunglasses for testing.

Repeatability

The test consisted of performing repeated measurements of transmittance at different positions and angles within the device, for 10 different sunglasses (05 from ABIÓP-TICA and 05 from the signature companies). Figure 6 shows the results obtained for visible light transmittance, emphasizing the values of maxima and minima obtained by the average transmittance values. The maximum difference obtained from the mean value for these measures was 3%. For UV transmittance, the sunglasses measures showed practically all 0% UV transmittance, and the maximum difference was 1% from the mean value.

Benchmarking tests

Two tests were performed on each of the 20 lenses from 10 sunglasses in the developed equipment and the results were compared to spectrophotometric measurements.

Figure 7 shows the Bland-Altman plot for sunglasses tested on the prototype and on the spectrophotometer in the visible range. The transmittances of the UV range wavelengths for all the lenses were below 1%. The limit deviation for

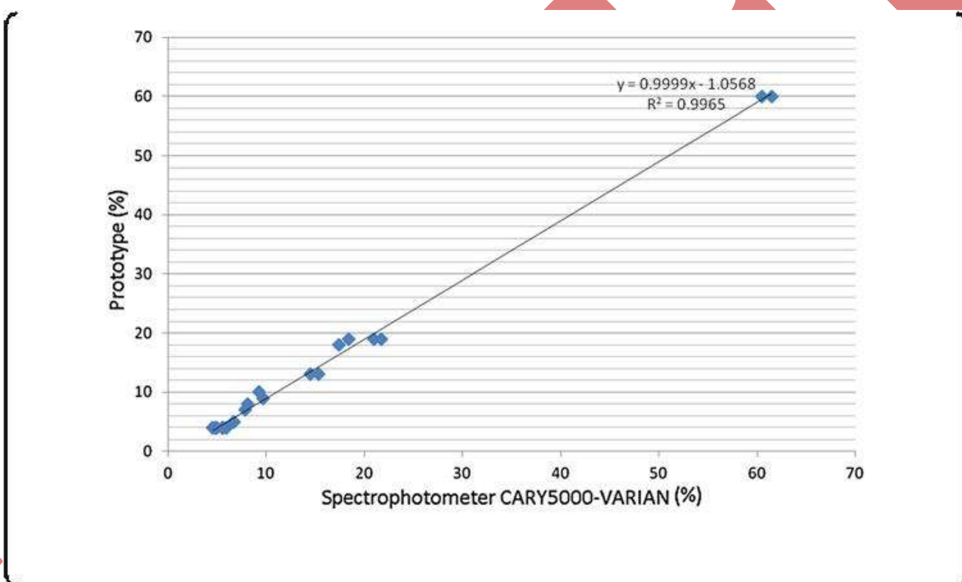

Figure 6 Repeatability measurements comparing the maximum and minimum values of different transmittances for the visible range.

transmittance measurements shall be ± 3% absolute for the transmittance values of categories 0 to 3 and ± 30% relative to the stated value for the transmittance values of cat-egory 4 [10]. We have used the 3% limit in Figure 7 to determine the proximity between the two methods.

Furthermore, 45 additional sunglasses (35 from ABIÓPTICA and 10 from signature companies) - 90 lenses - have been tested and results show that there is a good correlation for the measurements of transmittance in the visible spectral range (r^2 = 0.9999) and in the ultraviolet range (r^2 = 0.9997).

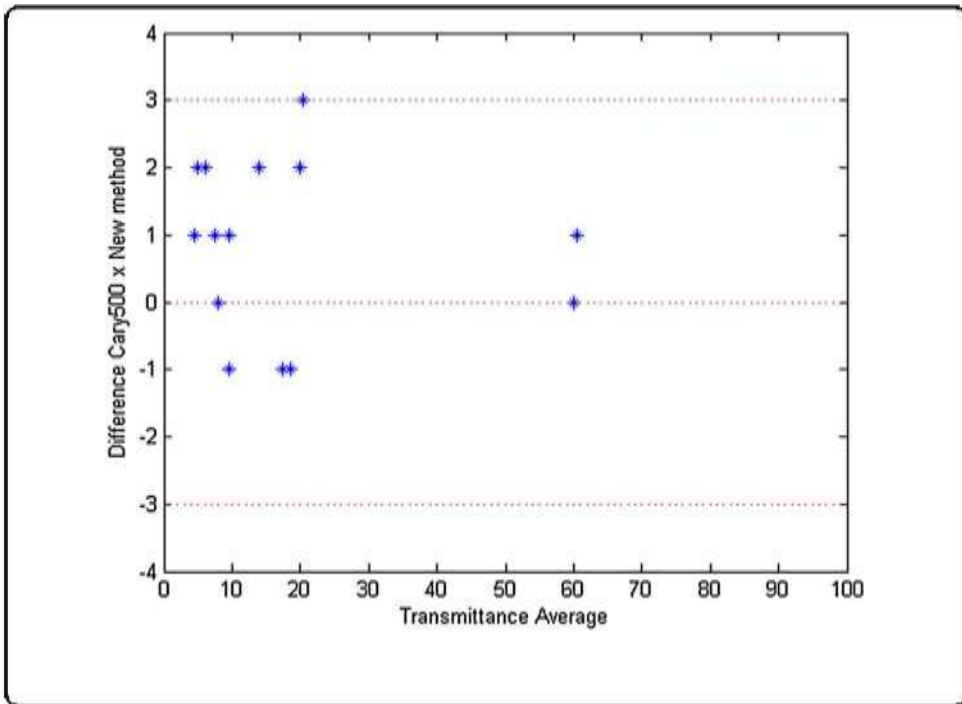

Figure 7 Bland-Altman plot measurements of sunglasses tested on the prototype and on the spectrophotometer (visible range).

VI. CONCLUSIONS

A prototype has been built and it identifies the UV protection, for non-corrective sunglasses according to the category of the lens, performing measurements of average light transmittance in the visible spectral region - 380 nm – 780 nm - and ultraviolet range - 280 – 400 nm.

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