Behind the Lens: Exploring UV Reflection

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Abstract: Current UV protection regulations mainly center on sunglass lenses' light passage, using quantitative criteria based on sunglass categories. Yet, studies, including this one, stress the necessity to enhance and adjust these norms. Our findings underscore aligning standards, notably the Brazilian ISO NBR 12312-1, with ICNIRP guidelines. Environmental radiation dispersion where sunglasses are worn can impact eye safety despite dark lenses, potentially harming protection due to pupil dilation. This project marks a pivotal step in UV protection analysis, crafting a methodology to measure light entering the eyes as UV rays penetrate sunglass lenses. We devised an apparatus with LEDs, sensors, and a mannequin to gauge eye-reaching radiation. Preliminary results reveal 10 to 15% of this wavelength's light penetrates the eyes, varying based on lens characteristics like material and curvature. However, these initial tests only validated the system with red LEDs, limiting their scope. Validating this research urges adapting existing norms to assess UV radiation reaching the eyes and establish effective protection methods.

1 INTRODUCTION

Exposure to ultraviolet (UV) solar radiation poses a significant threat to human health and well-being, particularly concerning ocular health. The use of sunglasses is of paramount importance as the primary protective measure against this radiation, especially in regions such as Brazil, characterized by high levels of UV radiation (VENTURA et al, 2022). However, the effectiveness of conventional dark lenses in safeguarding against UV radiation warrants careful examination.

These lenses, lacking adequate UV protection, may hinder the natural movement of the pupil, resulting in increased UV exposure and potentially intensifying adverse ocular consequences. While existing regulations, such as ISO 12312-1:2022 (ABNT, 2014), are crucial for overseeing sunglass standards and ensuring ocular safety, they currently overlook a crucial aspect: the interaction of UV rays reflected within the lenses and their impact on ocular health.

This oversight becomes particularly pertinent when contrasted with criteria established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) (ICNIRP, 2004), which delineates limits for UV radiation exposure. The ISO standardizes sunglass UV protection solely in terms of lens 'darkening' (DIFFEY, 2002), neglecting the incorporation of structural geometry in ocular safety considerations and failing to encompass the impact of UV radiation diffused in the environment, which can potentially harm the eyes. Consequently, these disparities underscore the need for a broader scope of considerations within sunglass standards to ensure comprehensive ocular protection (MASILI, 2015).

The primary focus of this study was to develop a prototype that quantifies the incident UV radiation reaching the eyes due to the internal reflection of the lenses.

2 STATE-OF-THE-ART

Human visual perception is a complex interplay between light and the visual system. As light enters the human eye, it undergoes a series of processes that culminate in the formation of a conscious visual

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impression. However, light represents just a portion of the electromagnetic spectrum, typically associated with visible light. Figure 01 depicts the electromagnetic spectrum, housing Ultraviolet Radiation (UV), the focus of this study, transmitted by the sun. The incidence of this radiation until it reaches the atmosphere undergoes several phenomena, including reflection and backscattering. Reflection is the primary physical phenomenon enabling human visual perception (HALLIDAY, 2012).

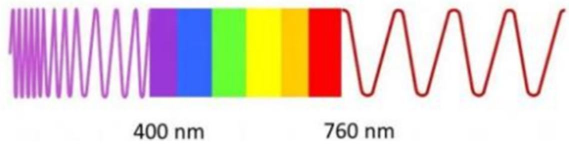

Figure 1: Electromagnetic Spectrum.

2.1 Albedo

Albedo, in essence, denotes the reflective property of surfaces and materials, directly impacting how they interact with incoming radiation. Its responsiveness varies according to the wavelength of radiation, implying that different wavelengths of light provoke distinct levels of reflection from surfaces. Specifically concerning ultraviolet (UV) radiation, materials exhibit diverse albedo values, signifying their capacity to reflect UV light (MISILI, 2018).

Here are some examples of common materials and their respective albedos in relation to UV radiation:

- Fresh snow: 80-90%
- Sand: 20-30%
- Concrete: 15-25%
- Grass: 5-10%
- Asphalt: 5-10%
- Clean water: 3-10%

These values may fluctuate based on specific conditions such as surface texture, impurities, and other influencing factors.

2.2 Standards and Regulations

The international standard ISO 12312-1, alongside itsBrazilian translation, the NBR ISO 12312-1, recognizesultraviolet radiation (UV) as composed of three distinct subregions within the electromagnetic spectrum: UV-A (320–400 nm), UV-B (280–320 nm),and UV-C (100–280 nm).[7] In the context of protection against ultravioletradiation (UV), addressing normative discrepancies betweenthe international standard ISO 12312-1 and its nationalcounterparts, such as ISO NBR 12312-1 in Brazil, incomparison to guidelines established by the InternationalCommission on Non-Ionizing Radiation Protection (ICNIRP), is essential. One of the main discrepancies lies in the definitionof the wavelength range of UV radiation (ICNIRP, 2004). This division is essential to understanding the effects of UV radiation on objects and organisms, including humans.

3 MATERIALS AND METHODS

The following methodology outlines the development of a prototype aimed at measuring the contribution of internal reflection of UV radiation occurring within the lenses of sunglasses and reaching the eyes. To obtain this measurement, several parameters and components need standardization for increased result accuracy.

In this study, the primary focus will be measuring the intensity of ultraviolet radiation that occurs through reflections from sunglass lenses and reaches the eyes, specifically targeting UV radiation in the range of 380 – 400 nm. The system setup primarily involves the utilization of emitting sources and detectors within this spectral range.

To validate the proposed issue and identify if there is a reflection coming from the sunglasses lenses, a preliminary system was assembled using red LEDs in the 640 nm range and visible sensors to collect light values reaching the eyes originating from their reflection. The developed configuration is illustrated in Figure 02 below.


Figure 2: Proposed Experimental Setup.

3.1 Data Acquisition

Practically, the aim is to calculate and measure the amount of radiation reaching the eyes from reflections acquired withs sunglasses. To identify this reflection parameter as a percentage, determining the maximum experimental measurement without the glasses and identifying all influencing parameters are crucial for obtaining accurate results. The initial methodology adopted is as follows:

- Nominal Measure 100% (NM100)

To establish the nominal 100% system, direct solar radiation incidence needs to be obtained without sunglass interference. Experimentally, two sensors (OPT101 model) representing the mannequin's eyes and two fixed red LEDs are used—one simulating total reflection (LED1) and the other imitating reflections from albedos and surfaces (LED2). The three contributing factors to the collected result involve:

  - Direct Incidence (DI): Radiation directly incident on the sensor, from LED1.
  - LED1 Noise (N1): Contributing radiation from above and laterally due to LED1's opening, adding to the result.
  - LED2 Noise (N2): Radiation reflected by ambient surfaces reaching the sensor, from LED2.

Mathematically:

$$NM100 = DI + N1 + N2$$

- Measure with Sunglasses (MWS)

Adding sunglasses to the equation introduces new parameters. Experimentally, sunglasses with the lens covered on the external side were used to maintain transmittance, and LED2 was activated (Figure 18). Results collected are contributions from:

  - LED2 Noise (N2): Ambient-reflected radiation reaching the sensor.
  - Radiation Reflected by the Lens (RL): The main value of interest in this study, representing UV radiation reaching the eyes due to sunglasses.

Mathematically:

$$MWS = N2 + RL$$

To isolate ambient radiation values (AR) from MD100 and MWS, a measure was taken to establish a 0% baseline for this system.

- Measure of LED2 0% (ML2_0)

To determine only the fraction of radiation reflected by the environment (AR), only LED2 was turned on without the glasses, and the calculated baseline value was observed.

To calculate the contribution of lens reflection to the total percentage of solar incidence in nominal conditions, the following steps are taken: First, calculate only the lens reflection contribution inside:

$$RL = MWS - N2$$

Then, eliminate noise values from NM100:

$$DI = NM100 - N1 - N2$$

Finally, to obtain the desired parameter as a percentage:

$$Lens\ Reflection\ \% = RL\ /\ DI$$

3.2 Electronic Components

To achieve the proposed data acquisition, the system requires suitable and efficient components. The activation of the project's main components involved the following elements and connections:

1. Red LEDs (640 nm): Light-emitting diodes that emit red light at a wavelength of 760 nanometers.
2. High-Power Resistor (10W): A resistor designed to handle high power, in this case, rated for 10 watts of power dissipation.
3. OPT101 Sensor: An analog photodiode sensor used for precision light measurement, converting light intensity into an electrical signal.
4. Conversion Board with LM358: A board utilizing the LM358 operational amplifier for signal amplification or conditioning, often used in sensor interfaces.
5. Low Pass Filter: An electronic filter that allows low frequency signals to pass through while attenuating higher frequencies, often used to eliminate noise or unwanted high-frequency components.
6. Resistive Divider: A circuit consisting of resistors used to create a fraction of an input voltage, commonly employed for voltage scaling or level shifting.
7. ADS115 Analog-to-Digital Converter: An ADC (Analog-to-Digital Converter) used to convert analog signals (like voltage) into digital data for processing by a microcontroller or computer.
8. Arduino NANO: A small, versatile microcontroller board based on the ATmega328P chip, commonly used in various electronic projects for control and data acquisition.
9. Micro SD Card Adapter: An adapter allowing a micro-SD card to be used with devices designed for standard SD cards, enabling storage or data logging capabilities.

These components were utilized and interconnected to facilitate the functioning and data acquisition process as part of the project's electronic setup. The diagram in Figure 03 shows this connection.

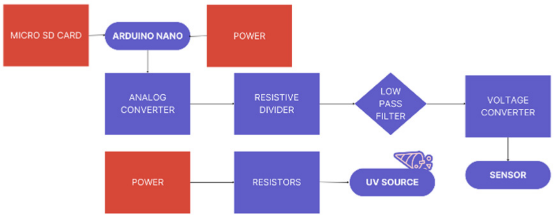

Figure 3: Electronic system diagram.

4 RESULTS

The experiment utilized three different sunglass samples, depicted in Figure 04. Two of these samples (Sample 1 and 2) shared similar physical and visual characteristics, a similarity reflected in the obtained data respectively. The samples were identified as follows: 1 – n°9, Lot 23; 2 – n°50, Lot 13; 3 – n°22, Lot 23.

Figure 4: Samples used for testing.

Implementing the proposed methodology for data treatment, collecting values at 100% and 0%, yielded the following results presented in Table 01, based on the samples from Figure 04, with 10 test runs conducted. The standard LED power supply for all tests remained at 10V.

Table 1: Preliminary results of reflection.

SAMPLE	100%	0%(R1)	0% (R2)	MEASURED VALUE	R (%)
1	79.2	1.2	0.1	7.5	9.61
2	79.1	1.1	0	7.8	10
3	79.2	1.1	0	10.2	13.06

Table 01 provides preliminary results using illumination and detection in the red spectral region. These findings indicate the feasibility of the experimental setup, here employing an LED with a peak wavelength of 640 nm. It's noteworthy that the final prototype aims to operate in the ultraviolet region, around 390 nm, and is currently under development at the Ophthalmic Instrumentation Laboratory at USP São Carlos.

5 CONCLUSIONS

The study highlights the need for a significantly high-intensity LED source, presenting challenges in achieving a saturated 100% signal, particularly affecting commonly used sensors. The validation emphasizes the reflection of UV radiation in sunglass lenses, despite being at low levels, which may interfere with long-term vision. This work represents an ongoing refinement process to quantify UV radiation reaching the eyes, requiring the acquisition and testing of robust components. There is a substantial need for this study and adaptations in standards to address these considerations. Future work aims to develop a more complex prototype for measuring the quality of lenses regarding UV reflection, validating the research's importance by revealing significant reflection indices.

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