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Implementation of Ultraviolet Sensor in Low Cost Weather Stations

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Abstract. Ultraviolet solar radiation while offers great risks for the human being, is also an essential compound for health. What determines the malefic and benefic effects are the time of exposure and intensity of radiation. Monitoring the radiation has a high cost of implementation in meteorologic stations. This article presents a monitoring system in real time for the ultraviolet indexes based on a Atmega328P microcontroller to be coupled with in a meteorological station. The proposed system is simple and low cost. The device is made of a sensor connected to the microcontroller with an internet web interface, which allows verifying the measuring in real time.

Keywords. Database, meteorologic stations, ultraviolet indexes, microcontroller.

1 Introduction

The ultraviolet (UV) solar radiation is one of the main causes of erythema and skin cancer in human beings, which is supported by enough experimental and epidemic evidences [1, 2]. Recently, the decrease of stratospheric ozone raised the ultraviolet radiation on the Earth's surface [3]. A decrease of 10% on ozone may lead to a raise of 15-20% on the UV exposure. Studies show that the raise of solar spectro that reaches the Earth's surface through the decrease of stratospheric ozone may increase incidence the skin damage [4, 5].

About 60 thousand premature deaths were assigned to UV radiation exposure on year 2000. In the past decades, a great rise on skin cancer was observed in light-skinned population, as in Austria and New Zealand presenting the higher incidence rates. [6].

The skin cancer is widely avoidable when the appropriate action of solar protection. Unlike the visible light or heat, the UV radiation cant be directly seen. To overcome this

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problem, in 1995, the World Health Organization (WHO), along with several organizations, released the Global Index Solar UV (Ultraviolet Index - UVI) as a vehicle to view the amount of UV radiation reaching the Earths surface [7]. The UVI values vary on a 0 to 11 scale, values higher than 11 are rarely found in some regions. The UV Index is expressed numerically as a result of the multiplication of the average value in the time of effective irradiance (W/m^2) for 40. Example: An effective irradiance of $0.2W/m^2$ corresponds to a 8,0 UVI value.

Based on a UVI scale, the WHO defines five categories of exposure, varying from low to extreme. The UV Index lower than 2, is considered low; 3 to 5, moderate; 6 to 7, high; 8 to 10, very high; and above 11, extreme. As bigger the value as, bigger the risk of health damage. Besides, some protection actions of solar protection are recommended, as: using sunscreen, protective clothes, hats, shelter with shadows at noon [8].

It is possible, however, to take advantage of some benefits of the ultraviolet rays. For example, the vitamin D is only synthesized in our organism when theres skin exposure to the rays. Which is essential for calcium and phosphorus to metabolize in the human organism. However, it requires caution: the exposure to sun must be moderate and always in times of lower incidence- before 10a.m. and after 4p.m. [9].

Since V century b.C., the benefits of solar radiation were already known to prevent rickets and wound healing. This treatment was named heliotherapy. Besides that, the solar radiation has an antidepressive principle, once in light solar exposure is capable of release serotonin, a neurotransmitter responsible for the pleasure and well-being sensation. Psychiatrists affirm that light solar exposure is efficient in seasonal depression (SAD-Seasonal Affective Disorders) treatment [10].

Considering the importance of UVI movement, several commercial systems are available to perform such as monitoring, as for field applications as for research. This system presents high cost of implementation. This article proposes the development of a UVI measuring device that can be attached to any meteorologic station. The system is based on an opened code, simple, low cost, which the performance is similar to the commerce systems. The project is composed by a sensor connected to an internet web interface, which allows to visualize and data storage collected in real time.

2 Materials and Methods

To build the UVI monitoring device, a microcontroller atmega328 [11], a shield Ethernet board [12] and a GUVA-S12SD [13] was used. All the collected data were stored in a database that may be accessed remotely. The Figure 1 shows the project modules flowchart.

2.1 Sensor UV

The reading of the UVI index has been performed using the GUVA-S12SD sensor [13]. It has a wavelength measuring range from 220 nm to 380 nm. The sensor output is connected to the microcontroller's $A/D-01$ port. In the Figure 2, it is possible to observe the voltage variation curve (mV) as a function of the UV index. To determine the voltage

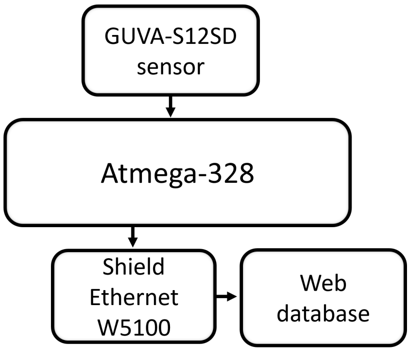

Figure 1: System's flowchart.

(mV) of the pin A/D obtained, the reading value is multiplied by 5 (microcontroller maximum voltage level) and then divided by 1023 (10-bit readout of microcontroller). The result of this equation is multiplied by 1000, the final value (converted to voltage) compared to the ranges of analog variations corresponding to the different UV index values, as shown in Table 1. The electronic circuit of the sensor was coupled to a plastic housing, leaving only the sensor exposed. Silicone glue was used for the seal.

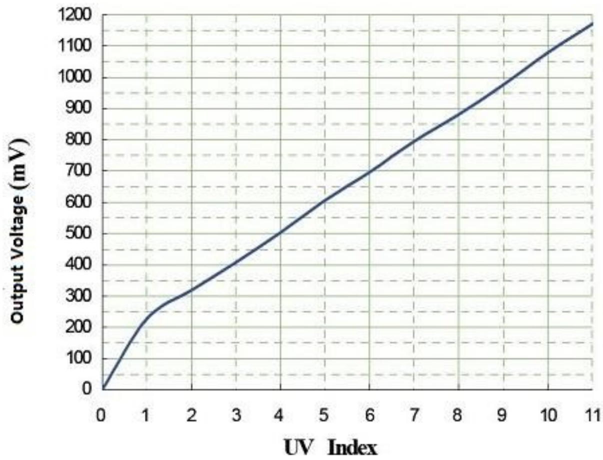

Figure 2: UV sensor characteristic curve adapted [13].

2.2 Communication Server and Database

The server used was the one at School of Technology (*FT-UNICAMP*). The advantage of being web is the real-time monitoring of UVI during the day. PHP-MySQL was the interface used, which is responsible for receiving data, running calculation and storing information. The MySQL database was chosen because it is free to use and also has a good integration with PHP language.

Table 1: UV Index Conversion adapted [13].

Output Analog.	Vout (mV)	Index (UV)
≤ 10	≤ 50	0
46	227	1
65	318	2
83	408	3
103	503	4
124	606	5
142	696	6
162	795	7
180	881	8
200	976	9
221	1079	10
240	1170+	11

The display interface was developed using PHP with Javascript programming languages. It offers search options (separated by date and time) from the completed collections. The page has a button to download the date from the chosen date in *CSV* (*Comma-separated values*) spreadsheet. The access to the interface is available at: $http://www.ft.unicamp.br/labse/Ad/interface.html$.

3 Results and Discussion

For the validation of the developed project, the data of the system collected with a database of Climatempo were available in: $www.climatempo.com.br/previsao-do-tempo/cidade/478/limeira-sp$. The Figure 3 shows system validation.

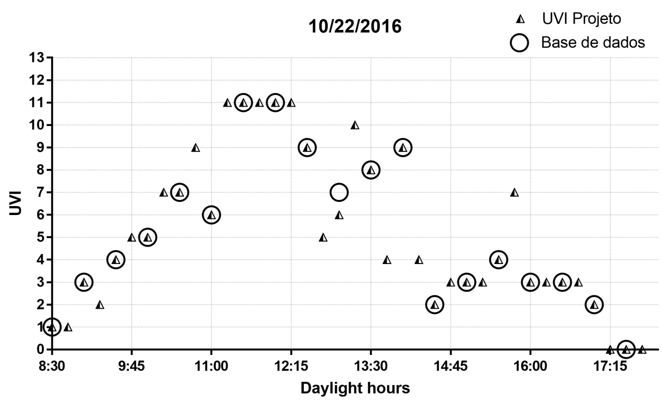

Figure 3: Index UV of October 22, 2016.

It is possible to verify that the values measured in the proposed system are in agreement with the values provided by Climatempo database. The values given were approximately every half hour. The developed system has an autonomy of reading the sensor from minute to minute and the values were sampled every fifteen minutes.

The Figure 4 shows UVI graph at noon, in the period from October 22, 2016 to March 1, 2017, once the half day time represents the peak of solar radiation. During this monitoring period it was observed that some days reached extreme values of UVI. The days that presented low or zero values of UVI indicate cloudy or rainy days.

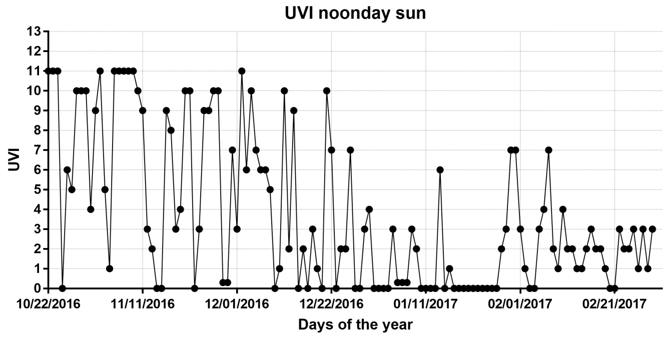

Figure 4: Ultraviolet index at noon.

The Figure 5 shows the monitoring of UVI throughout the day (December 14, 2016). It can be observed that in the first hours the incidence of solar radiation that reaches the Earth's surface presents low intensity. As the hours progress, the UVI values increase, reaching a maximum level of UVI between 11a.m. and 1p.m. After this, it is observed that the levels of radiation decrease as the sun sets.

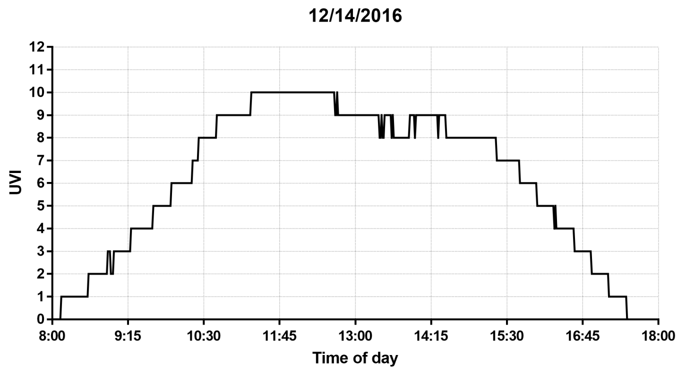

Figure 5: Monitoring of a full day UVI.

4 Conclusion

Given the importance of UVI monitoring, the project presented an efficient device for such purpose, with low implementation costs, using easily and accessible components. It has a web interface that allows you to view and store the data in real time. The validation of the collected data was done using as source the database of *Climatempo*. Considering the threshold between the benefits and the harmful effects of solar radiation, the developed tool would be very useful in monitoring the UVI in the meteorological stations, which would imply low cost in the implementation.

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References

[1] IARC, Solar and Ultraviolet Radiation, International Agency for Research on Cancer (Monographs on the Evaluation of Carcinogenic Risks to Humans), Lyon, vol. 55, 1992.

[2] P. F. Urbach, J.H. Epstein, P. D. Forbes, Ultraviolet carcinogenesis: experimental, global and genetic aspects, in: M.A. Pathak, L.C. Harber, M. Seiji, A. Kukita (Eds.), Sunlight and Man Normal and Abnormal Photobiological Responses, University of Tokyo Press, Tokyo, 1974, pp. 259283.

[3] WHO/UNEP/IRPA, Ultraviolet Radiation, Environmental Health Criteria 14, World Health Organization, United Nations Environment Programme, WHO, Geneva, 1979.

[4] D. S. Berger, F. Urbach, A climatology of sunburning ultraviolet radiation, Photochem. Photobiol. 35 (1982) 187192.

[5] O. Klepp, K. Magnus, Some environmental and bodily characteristics ofmelanoma patients. A case-control study, Int. J. Cancer 23 (1979) 482486.

[6] A. Kricker, B. K. Armstrong, D. English, P.J. Heenan, P.L. Randell, A case-control study of non-melanocytic skin cancer and sun exposure in Western Australia (abstract No. III, P2), Cancer Res. Clin. Oncol. 117 (Suppl. II) (1991) S75.

[7] World Health Organization, World Meteorological Organization, United Nations Environment Programme, International Commission on Non-Ionizing Radiation Protection, Global Solar UV Index: A Practical Guide, 2002Geneva, SwitzerlandWorld Health Organization.

[8] Lemus-Deschamps L, Gies P, Rikus L, et al., UV Index: Forecast and Media Weather Reports. avaliable in: $http://www.niwa.co.nz/data/assets/pdf_file/0012/41250/Lemus - Deschamps.pdf$. Accessed em: 7 junho 2017.

[9] O. Engelsen, The relationship between ultraviolet radiation exposure and vitamin D status Nutrients, 2 (2010), pp. 482495.

[10] R. L. $McKenzie$, J. B. Liley, L. O. Björn UV radiation: balancing risks and benefits Photochem Photobiol, 85 2009, pp. 8898.

[11] Arduino UNO - Overview, avaliable in: $https://www.arduino.cc/en/Main/ArduinoBoardUno$. Accessed em: 20/08/2016.

[12] Arduino shield Ethernet, avaliable in: $https://www.arduino.cc/en/Main/shield-Ethernet$. Accessed 20/08/2016.

[13] GUVA-S12SD [datasheet]. Roithner LaserTechnik -Austria.