

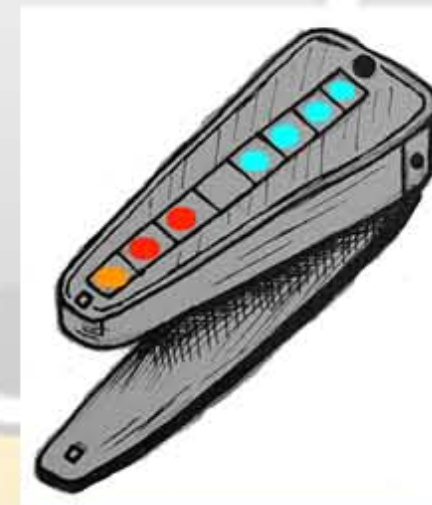
Wearable Dual Sensor Device for Measurements of Ultraviolet Index and Ultraviolet Protection Factor

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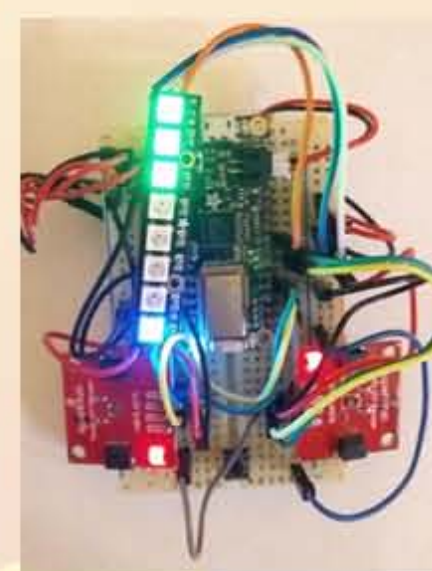
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Abstract

Medical consensus is that over-exposure to Ultraviolet (UV) radiation is dangerous. It is difficult to monitor accurate UV exposure and there is no easy way to measure and check claimed Ultraviolet Protection Factor (UPF) rating of clothing or protectiveness worn off. Handheld and portable UV Index (UVI) meters are available at various price points. However, none of them offer measurement of the protective level of clothing. We present a design of low-cost wearable device, that will give an immediate and accurate indication of both the current local UV radiation level, and the protectiveness level of clothing. The device is small enough to be clipped to clothing and is consist of microcontroller, sensors, LEDs, LCD and Bluetooth based application. The dual-sensors give immediate readings on UVI level and UPF protectiveness of clothing trough detailed quantitative measurements outputs. The calibration is achieved with publicly published weather-station data achieving acceptable accuracy.



The clip-on device



UVI	0	1	2	3	4	5	6	7	UPF
< 2.5	Green	Green	Green	Green	Green	Green	Green	Green	IV 50
2.5 < UVI < 3	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	IV 30
3 < UVI < 3.5	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	IV 20
3.5 < UVI < 5.5	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	IV 10
5.5 < UVI < 6	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	< 10
6 < UVI < 6.5	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	
6.5 < UVI < 7.5	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	
7.5 < UVI < 8	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	
8 < UVI < 8.5	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	
8.5 < UVI < 10.5	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	
10.5 < UVI < 11	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	
11 < UVI < 11.5	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	
11.5 < UVI	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	

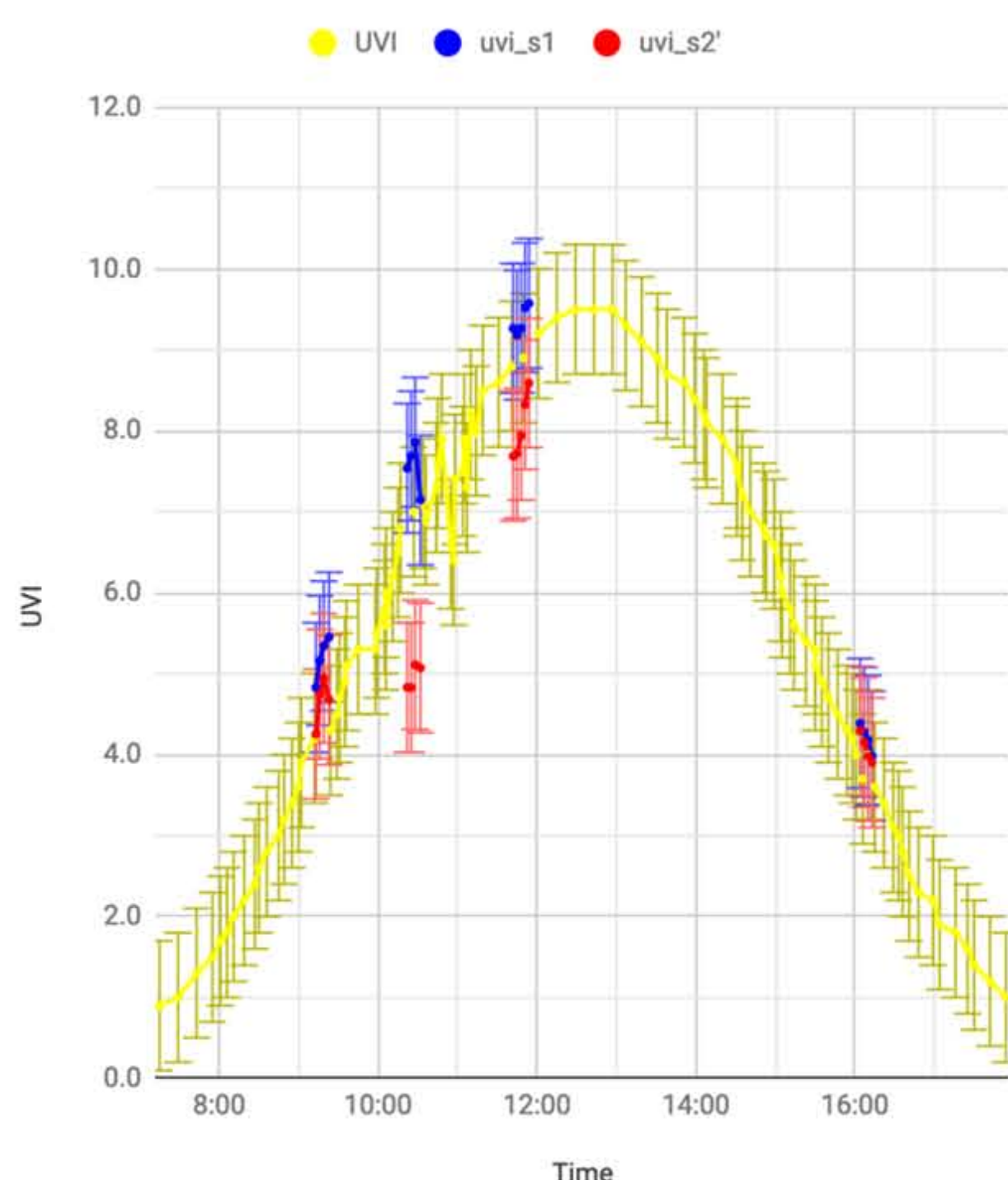
LED output scheme

Objectives

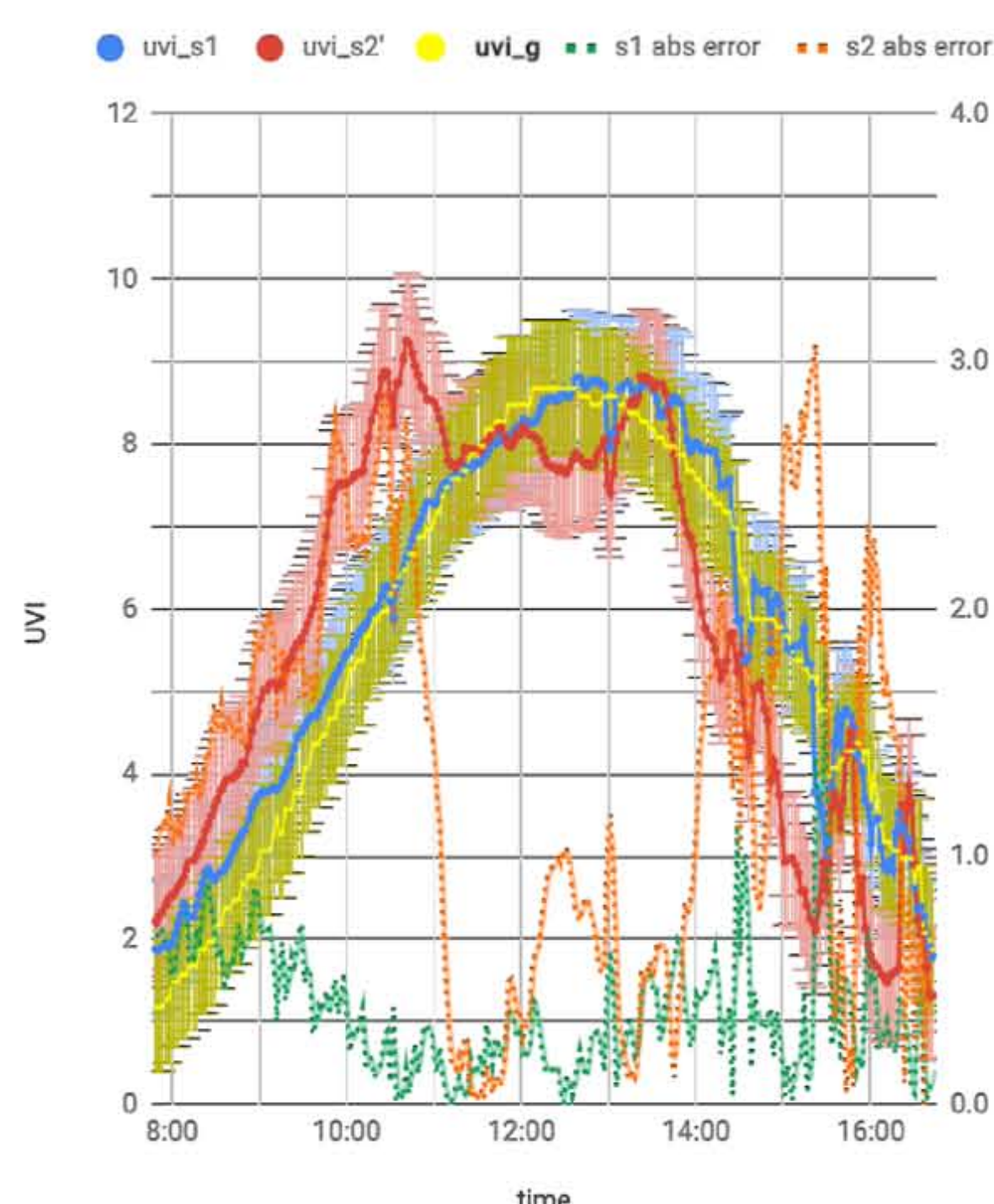
- Measurement of the protective level of clothing – UVI, UPF.
- Design of low-cost wearable UV sensor device based on a microcontroller.
- Immediate and accurate indication of local UV radiation level and protectiveness level of clothing – calibration process.
- Clipped on clothing device.
- Implement Bluetooth output/input.
- Implement LED and LCD outputs.



UV Index



UVI calibration results

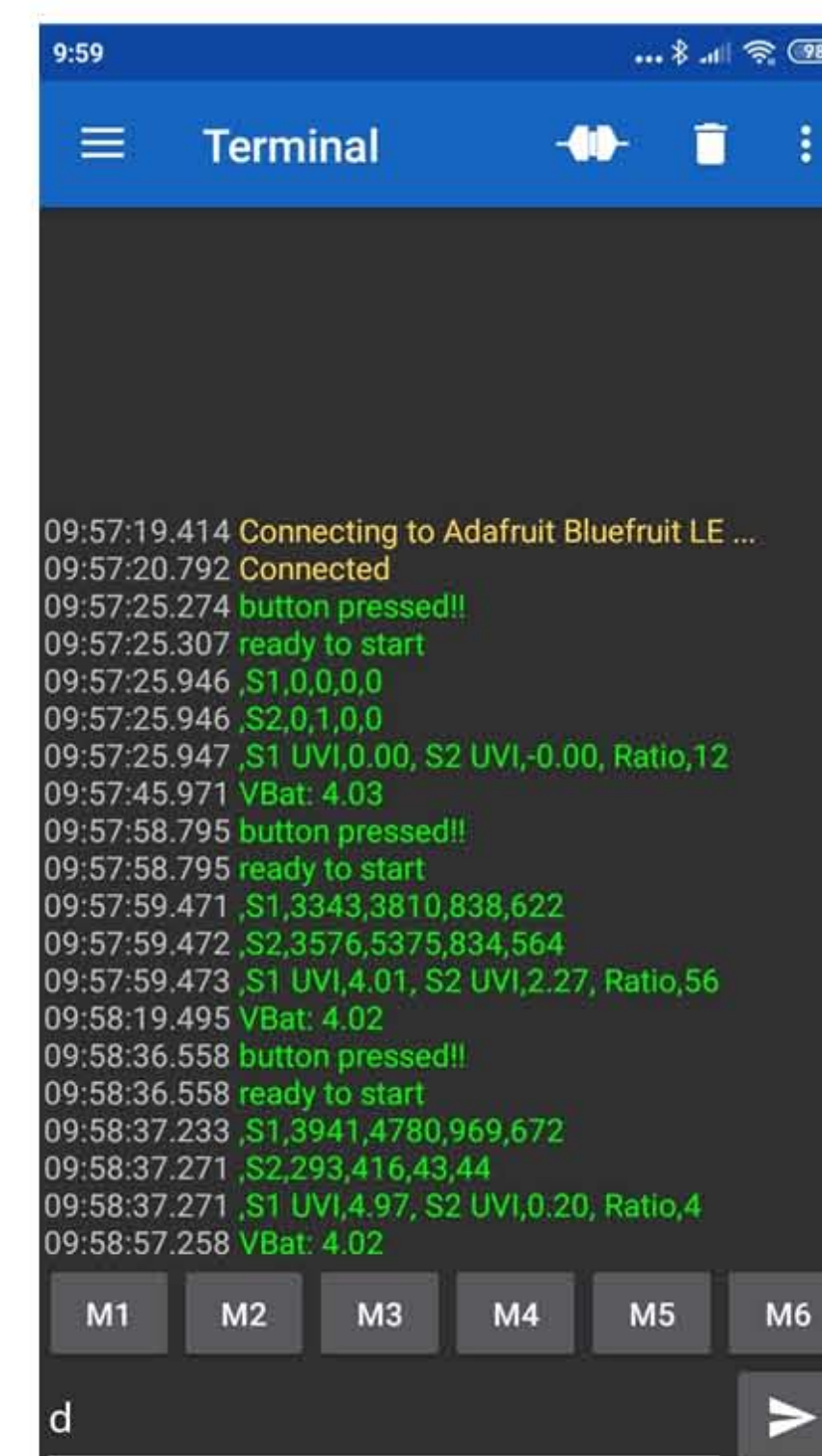


Absolute error calculations

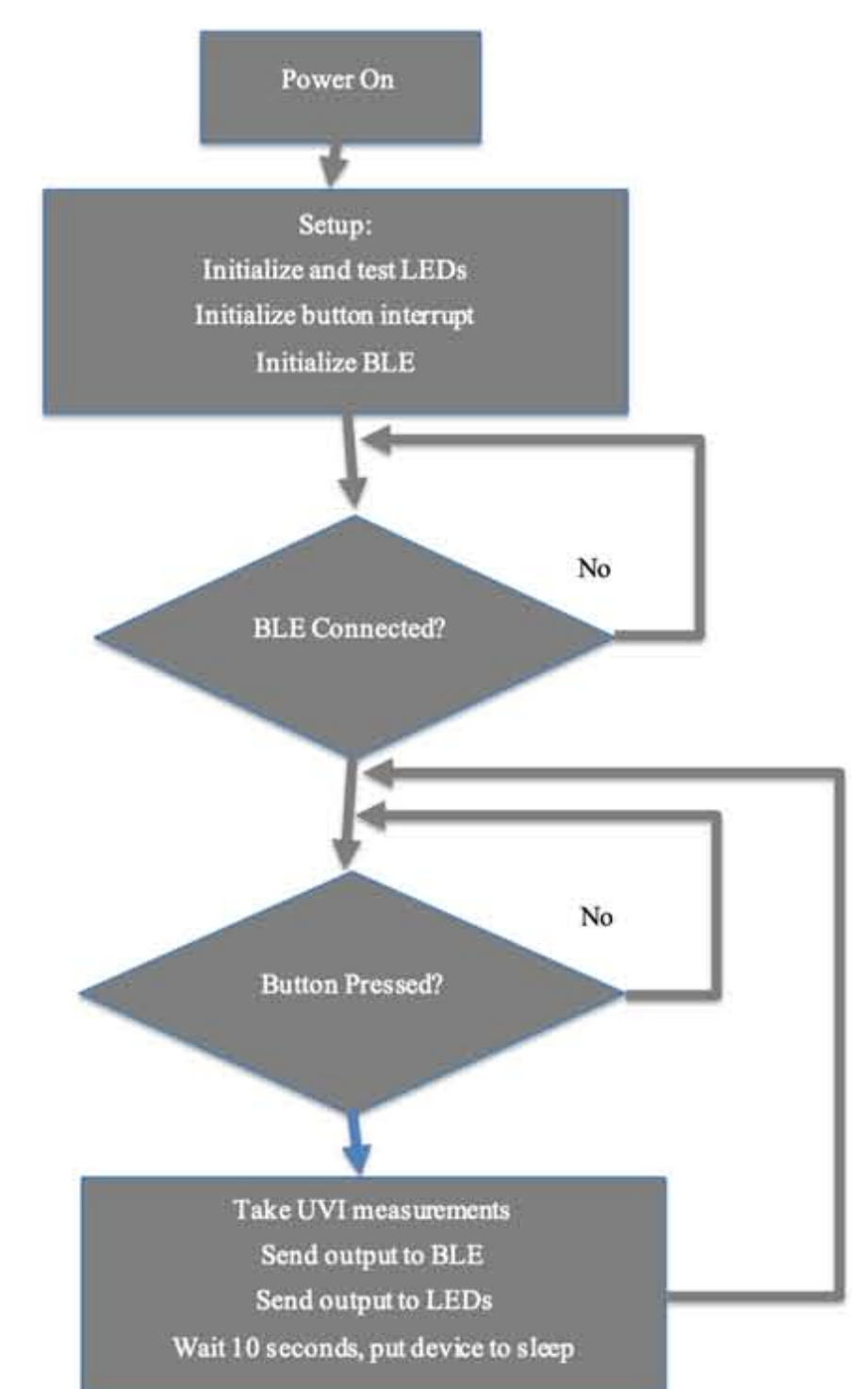
Conclusions

A prototype was successfully built using an Arduino microcontroller and Vishay VEML6075 UVI sensors. Output/Input was implemented over Bluetooth to an application, and output to a strip of LEDs.

It was found that calibration could be achieved with publicly published weather-station data, within an expected accuracy of ± 0.8 .



Prototype App



Application flowchart

References

- [1] Global solar UV index: a practical guide. World Health Organization, 2002.
- [2] H. P. Gies, C. R. Roy, G. Elliott, and W. Zongli, "Ultraviolet radiation protection factors for clothing," *Health Physics* 67(2), pp. 131–139, 1994.
- [3] C. R. Roy, H. P. Gies, and S. Toomey, "The solar UV radiation environment: measurement techniques and results," *Journal of Photochemistry and Photobiology B* 31(1-2), pp. 21–27, 1995.
- [4] G. Hustvedt and P. C. Crews, "Textile technology: the ultraviolet protection factor of naturally-pigmented cotton," *Journal of Cotton Science* 9(1), pp. 47–55, 2005.