# Amun-Ra Solutions: UV Photodection

Senior Design Proposal

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# **1 Introduction**

Skin cancer prevention is sure to remain a priority for the foreseeable future, but at this point there is not a ton of progress from an electronic device side to help people protect themselves. While sunscreen has become far more widely used and improved in the last few decades, the rates of skin cancer continue to rise and continues to claim lives. With our senior project, we propose a system that will allow people to understand how damaging the sun they have been exposed to is for their health. By the end of the spring semester we will have a portable device designed to clip onto clothing, equipment, etc. which monitors the amount of solar radiation received by a person. This device will then generate a signal to be sent to a mobile application on the user’s phone. The application will then allocate this data to memory and have algorithms to analyze this data for risk factors in the near and long term. We will demonstrate data collected in real time at the end of the semester as well as data collected prior to the last day to show the accumulation of data over time.

# **2 Problem Description**

Skin cancer is the most common source of cancer in the United States. In fact, skin cancer over the last three decades has had more cases than all other types of cancer combined. Treatment of skin cancer is often painful, expensive, and may leave permanent scars. Melanoma, the most advanced stage of skin cancer, claims a life every hour on average. Even worse, melanoma is the only common cancer that has an increasing rate of incidence.

The sun is far and away the largest culprit when it comes to the source of these dangerous cancers. 86% of melanoma cases are directly caused by exposure to UV radiation from the sun. Sun burns and single day exposure are not the only ways that people become at risk for these cancers. Long term effects of small exposure or large exposures that are experienced in succession can be very problematic and dangerous. Quantifying this exposure over months is a very difficult prospect for yourself or your family.\*

Enjoying sunny days should not be a source of imminent doom, so understanding your exposure risk is vital in keeping each person in control of their health in those situations. Skin cancer is considered the most preventable cancer by preventcancer.org so the fact that it has the highest incidence means that people aren’t doing nearly as good a job as they should at preventing this.

Finally, even for those who are not at high risk of skin cancer based on geography or skin tone, there are damaging ramifications of exposure. Cosmetics are a 50 billion dollar industry which is often delivering products that try to reverse the skin damage of aging. It is well known that largest reason for aged skin is the sun. For an industry that grosses over a billion dollars a year trying to reverse the effects of the sun, the ability to know how much sun you have been exposed to would be hugely sought after.

\*First two paragraphs facts according to skincancer.org

# **3 Proposed Solution**

Semiconductor devices are able to generate a flux of electrons from an incoming flux of photons through optical excitation and electric fields created in junctions. This effect is the same mechanism that allows solar cells to generate currents from light. Our goal is to use this to get an accurate real-time reading of exposure that a user can understand and take the necessary precaution to avoid sun damage. There will be a few features that allow this technology to be both useful and easy for a user who doesn’t know anything about solar radiation.

First, this device will be extremely portable and attachable to clothing, bags, umbrellas, as it will weigh nearly the same as a Bluetooth microphone and will not be much larger than one either. Second, it will interface with an app over Bluetooth to transmit data and use an in phone memory storage for the data generated on the device. This app will have the ability to track exposure over the course of the days, weeks, and years to be able to show health professionals and give the user a legitimate barometer for what their risks are and if their habits are healthy.

Since it has been shown that sun exposure when very young affects the chance of skin cancer later in life and kids are really unreliable about putting sunscreen on, this device wants to be very useful for families. The app should have the ability to track multiple profiles so that you can look at long term exposure for multiple people independently. All this data will be useful for users to take control of their risk and keep themselves safe from the harm induced by solar radiation.

# **4 Demonstrated Features**

There are a number of features to our project that we would like to demonstrate in May. The key ones are aspects that are essential to the device functionality and usability, along with some extra features that we think help make our design more marketable and user friendly.

The first thing we need to demonstrate is data collection: how the photo detector collects data about sun exposure. We will do this by exposing the board to a broad spectrum of light (including UV and visible) onto the detector and looking at the output on the app. Flooding the detector with a wide range of light frequencies will show how our photo detection system only considers rays with wavelengths that are harmful to people (<380nm). This helps prevent incorrect measurements and results on cloudy/rainy days by eliminating visible and infrared data from the signal processing aspect.

The second aspect of the project we are going to demonstrate is data transmission: how the data from the photo detection system gets transferred, via Bluetooth, to the phone application where it is stored and displayed to the user. Every time we collect data points, the information should be transferred off the board; we can show how the data is now available to be accessed from a smartphone in almost real time (some delay because there is always delay). This helps keep board small and simple with less on board memory required.

The third aspect of the project we want to demonstrate is the phone application that the user can interact with. As the main communication tool for the user, the app needs to be able to present the sun exposure data in a way that is understandable and easy to read. After we collect and transfer the data, we will implement algorithms that transform the signals to graphical and numerical representations of the information to be viewed on a smart phone. One thing to focus on is how our app will store exposure input over time and how access at later dates. Also, we want to highlight the fact that our app will be able to support multiple user profiles for different people.

Finally, we want to show that the battery we are using to power the device is rechargeable. We will show how we can recharge it using a micro USB cable. Being able to recharge the battery means the battery can be smaller and the user doesn’t have to deal with swapping it out every time it dies. This can help increase the functionality and longevity of the board.

# **5 Available Technologies**

# The main technologies of our project include the photodetection system, the signal processing system, the communication system, a battery system, and a housing system.

# The photodetection will be done with the Analog UV Light Sensor Breakout - GUVA-S12SD built by AdaFruit. The link for this technology is here: http://www.adafruit.com/products/1918?gclid=CLOWoqvap8ECFQqQaQodvGIAqg. This photodiode detects light only within the UV spectrum as shown in Figure 1, below.



**Figure 1. The photodetector response to different wavelengths of incident light**

The device is the size of a quarter and costs around $10. It outputs a voltage signal that our signal processor on our board will utilize. It will need to be soldered to the board. We may need to purchase 3-4 of these for testing and redundancy, in case we break one.

The signaling process system will be done on the PCB board, which we will design to be manufactured. As Professor Schafer indicated, this cost will be around $100.

The communication system we will utilize will be the RN41-XV Bluetooth Module - Chip Antenna. This antenna is sold by sparkfun (see weblink) <https://www.sparkfun.com/products/11600> for about $30. It is a 20 pin 2mm socket board which houses the antenna system to communicate with the cellular device and mobile app.

The battery we would use would be the Polymer Lithium Ion Battery - 1000mAh. It is a 2” wide 1” tall rechargeable battery that outputs 3.7 Volts 1000mAh, found on this webpage <http://www.robotmesh.com/polymer-lithium-ion-battery-1000mah-3717?gclid=CK2I4Z3pp8ECFQgDaQod7JMAQw>. It is a 2 terminal device that could be easily mounted to our board at about $10. This battery is rechargeable and we are going to implement a microUSB charging block on our board diagram, similar to what this webpage has listed. <http://www.adafruit.com/products/1904?gclid=CPz1-cXqp8ECFeVaMgodKmcACg>.

For our packaging system, looking at our $500 budget, and realizing that every other implementation (battery, board, photodiode, and bluetooth adaptor) will cost around $250, we are exploring printing a plastic packaging system utilizing the University’s 3-D printers. This would be a feature that we would only be able to address once we have the board size and have connected the necessary components, but until that time we are able to budget $50 for additional research in this area.

 **6 Engineering Content**

The engineering involved with the project can be broken down into five main blocks: a UV photodetection system, signal processing of the detection output signal, Bluetooth communication, mobile app development, and a powering system.

 While the physical photo detection system will be bought off the shelf, understanding the voltage output of the detection circuit will require extensive testing and analysis. To test the photodetector the group will have to expose the detector to UV light in a lab setting to understand the correlation between UV exposure and voltage. A voltage amplifier may be needed on the PCB board if the voltage signal is not substantial.

 Once the output voltage from the photodetector is understood, the team will have to create a clear and readable signal that can be reliably be characterized and measured. The signal filtering will be done with hardware on the board to create a smooth signal, which will then be analyzed and characterized via a software algorithm that will output a numeric current UV exposure index (a 0 through 5 index corresponding to current UV levels). The algorithm will have to be trained using the data acquired when testing the photodetector.

 A large portion of the engineering will revolve around the communication between the device and the mobile app. There will be significant work understanding and then implementing the protocols. The group foresees using five different Bluetooth protocols: LMP, L2CAP, SDP, HCI and RFCOMM. The group will also have to test how communication and signal strength varies as the distance from the transceiver to the phone varies.

 The project will also involve mobile app development. The app will involve the team learning a new programming language, most likely either JavaScript or PHP. The app itself will involve data storage, displaying data via a graphical user interface, and allowing user input, potentially personalized exposure profiles and, running the app while the phone is in sleep mode.

 Finally, some engineering will be involved with designing a way to power the system. Preliminarily, the group would like to use a rechargeable battery for ease of transportation. The charging and powering block will add complexity to the PCB board design, with the potential of a voltage regulator and other similar devices.

# **7 Conclusions**

The most difficult challenges we will face throughout this project are learning how Bluetooth communications function, learning how to design a web-based application, being able to design a board for the signal processing applications that we require, and being able to link all the different blocks of our system together. Another aspect of our project that will require some more research, will be the development of a metric to allow people to know if they are over exposed to ultraviolet rays. The biggest concern is expressing this metric in a way that is easy to understand for people who may not have a technical background, while allowing the metric to be informative to prevent skin damage due to harmful rays. We anticipate that this project will be well under the allotted five hundred dollar budget, while accomplishing the ultimate goal of protecting users from overexposure to sunlight.