



Learning About Reflection of Light Based Ultraviolet Detection System Using Raspberry Pi

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ABSTRACT

Ultraviolet light is an electromagnetic radiation that has range of wavelengths between 100nm to 400nm. This wavelength can be identified by the ultraviolet index, where at this wavelength ultraviolet light has an impact to human health. Ultraviolet light with ultraviolet index green to yellow is beneficial for human health. Meanwhile, ultraviolet rays with red to purple ultraviolet index are harmful to human health. Ultraviolet rays that are harmful to humans can pass the surface of the earth caused by many factors, one of which is global warming. Therefore, this research was conducted to create an ultraviolet light detection system using Raspberry Pi as a sensor data reader and aims to learn about how much light reflected on the surface of the earth. The data obtained will be processed using the python programming language and presented using an LCD touchscreen. From this research, the values of the ultraviolet index from zero to six were obtained based on the ultraviolet index value from the BMKG indicate the categories of ultraviolet light associated with light reflection on the surface of the earth are known. So it can be concluded that the less ultraviolet light on the surface of the earth will be reflected easily by the earth, and the more ultraviolet light on the surface of the earth will be difficult to reflect.

Keywords: Light Reflection, Raspberry Pi, Python, Ultraviolet

INTRODUCTION

Sunlight is one of the largest and most important sources of energy in the life of living things on the earth. Sunlight has many benefits for the survival of living things on earth, such as photosynthesis in plants (Tirtana et al, 2014). Talking about sunlight, it is no stranger to solar radiation, namely ultraviolet rays or UV rays. According to the BMKG, ultraviolet light is an electromagnetic wave from solar radiation which have a wavelength between 100nm to 400nm. Ultraviolet light is divided into three parts, namely UV A with a wavelength of 315-400nm, UV B with a wavelength of 280-325nm, and UV C with a wavelength of 100-280nm (BMKG, 2020). Based on the type of UV light and its wavelength, exposure to ultraviolet radiation is related to how much light is reflected on the earth's surface which has an influence on the life of living things on earth. Ultraviolet light has a number without units that can explain the level of exposure to ultraviolet radiation for the survival of living things on earth which is

called the UV Index. The UV index is useful for monitoring the level of ultraviolet light, both beneficial and harmful to living things on earth (BMKG, 2020).

The Ultraviolet light that is harmful to living things on earth is caused by many factors, one of which is global warming. Basically, global warming is one of the phenomena of increasing the average temperature of the atmosphere globally, either at sea or on Earth's land (Yulianto et al, 2019). Meanwhile, according to researchers from CIFOR (Center for International Forestry Research) global warming is an event of trapping of long-wave solar radiation emitted to the earth by greenhouse gases (2). Greenhouse gases have six types, namely Carbon Dioxide (CO), Methane (CH₄), Nitrous Oxide (N₂O) Hydro perfluorocarbons (HFCs), Perfluorocarbons (CFCs), and Sulfur Hexafluoride (SF₆), the six gases are naturally present in the atmosphere. The trapping of the sun's heat in the earth's atmosphere is called the Greenhouse Effect. In addition, the depletion of the ozone layer can also heat up the earth's temperature. Because, the thinner top layers of the atmosphere will make ultraviolet rays more freely emit radiation entering the earth, so that more and more ultraviolet rays will pass through the earth's surface and light cannot be reflected on the earth's surface. The less ultraviolet light on the surface of the earth, the light will be reflected easily by the Earth, while the more ultraviolet rays on the surface of the earth, the light will be difficult to be reflected (Vivi, 2008).

In this research, exposure to ultraviolet radiation hitting the earth will be detected by an ultraviolet detection system using Raspberry Pi which is useful as a sensor data reader. Raspberry Pi is a single-board circuit (SBC) or a single board computer the size of a credit card developed by the Raspberry Pi Foundation and has a Debian GNU / LINUX-based operating system that has been optimized to become Rasbian (Pramono et al, 2019). Raspberry Pi has quite complete parts like computers in general, such as a processor, RAM, hardware port, GPIO Pin, and SD Card as a boot system and data storage. Like hardware in general, the Raspberry Pi also has several types, one of which is the Raspberry Pi3 model B + with several additional features that support the Raspberry Pi work process such as the Bluetooth 4.2 / BLE feature which can be used to process data on the Raspberry Pi with Android (Perkasa et al, 2014). However, on this occasion, data processing from the Raspberry Pi uses the Python programming language and the results of the data will be displayed with an LCD touchscreen (Rahman et al, 2017) . Many previous ultraviolet detection systems have been made using ZnO or *Zinc Oxide* which is deposited on plain with paper. ZnO, which has a character similar to a UV sensor, was created by performing an analysis using quantum chemical methods to explain the possibility of explaining the conductivity changes observed on the ZnO surface due to doping interactions with interstitial hydrogen and doping depletion caused by oxygen adsorption (Gimenez et al, 2011). However, this ultraviolet detection system using ZnO as a UV sensor can only be used once, so we created an ultraviolet detection system using a UV sensor with the GUVA-S12SD type and Raspberry Pi as a sensor reading that can be used multiple times (Gimenez et al, 2011).

Problem of Research

The Ultraviolet light that is harmful to living things on earth is caused by many factors, one of which is global warming. Basically, global warming is one of the phenomena of increasing the average temperature of the atmosphere globally, either at sea or on Earth's land. So that we can find out the harmful UV index in every human activity by using this UV detection system. This is in accordance with the research conducted by Gimenez JA, Yanez-Limon JM, and Seminario JM (2011) which makes UV sensors from ZnO.

Research Focus

This research aims to create an ultraviolet light detection system using the Raspberry Pi as a sensor data reader. The results of this research can be used as a medium of learning about one of the properties of light, namely the reflection of light on the surface of the earth.

METHODOLOGY OF RESEARCH

General Background of Research

This approach used in this research is quantitative and descriptive approaches. In this research, using two approaches because the researcher want to describe about light reflection on the surfaces of the earth. Where the reflection of light is the process of changing the direction of light propagation to the original medium after hitting different sides of the medium. This research was conducted in two different locations. The first location is the hall of the Department of Physics, State University of Malang. The location was chosen because the development of the tool was carried out in the same place, so it was done to check the equipment as well as to collect data. The second location is at the Mount Kawi, because it has a different altitude from the first location. Data collection was only carried out in two locations, because the COVID-19 lockdown was still being implemented so it was quite difficult to retrieve data from many different places. Another reason for data collection was only in two locations because this tool is still a prototype and is still in the development stage, but it is planned to collect data from more locations.

Subject of Research

The research subjects in this study were in the morning to noon, from 06.30 a.m until 10.45 a.m and also in a closed location. The data collection time was made because it was adjusted to existing conditions, where data collection was carried out in May, which at that time was often cloudy and even rainy during the day, so data collection with blue skies at that time could only be done in the morning.

Instrument and Procedures

A research instrument is a tool used by researchers in collecting data during research. The design of this ultraviolet light detection system is using by several tools, first is microprocessor called Raspberry Pi, the UV sensor system and a LCD touchscreen as an

output. by using phyton language programing system, we acuire the data (Kadarina, et al., 2019). The detection system design chart is shown in Figure 1:

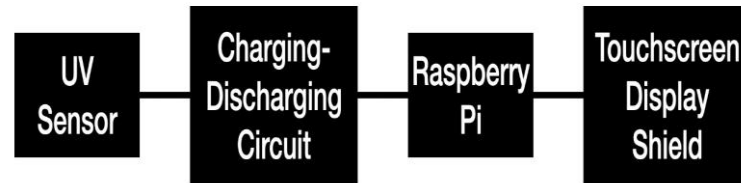


Figure 1. Design chart of an ultraviolet detection system

GUVA-S12SD is a Gallium Nitride material based Schottky-type photodiode, optimized for photovoltaic mode operation (Roithner Lasertechnik, 2011).

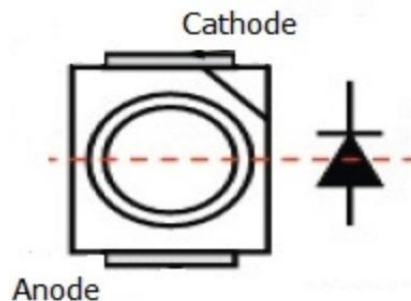


Figure 2. UV sensor type GUVA-S12SD

AnGUVA-S12SD Ultraviolet sensor is connected to a ChargingDischarging circuit as an Analog to Digital Converter (ADC). Charging-Discharging Circuit is used in this method because the UV sensor used is an analog sensor and the Raspberry Pi itself does not have an internal ADC circuit like other devices. After that two thing are connected, the Raspberry Pi as a sensor data reader will get the data results from the UV sensor and will be displayed on the LCD touchscreen. The following is a picture of the series of tools used:

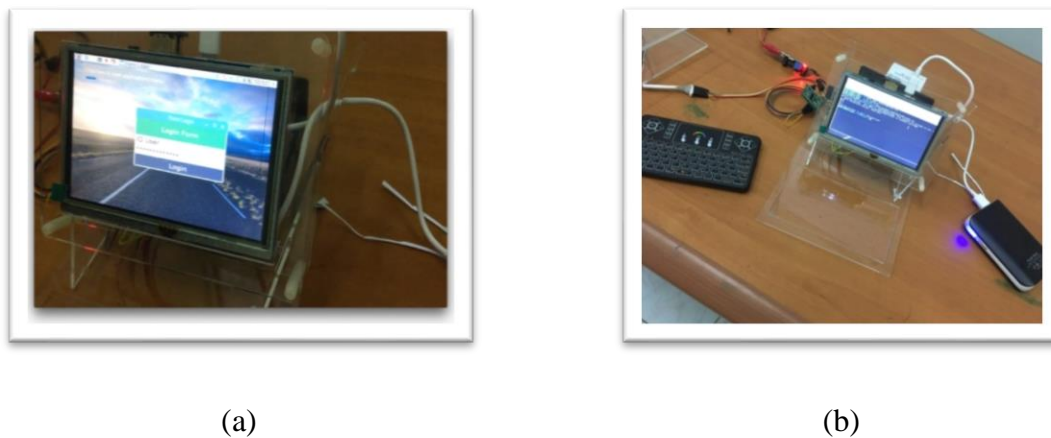


Figure 3. Range of Raspberry Pi tools, UV sensors, and LCD touchscreen

The data obtained from the UV sensor will be processed by using the python programming language. Data processing is done by including the RPI library into python code with the following program code:

```
import RPi.GPIO as GPIO
import time

GPIO.setmode(GPIO.BCM)
```

Furthermore, defining the GPIO by using two different variables, namely

```
a_pin = 18
b_pin = 23
```

Then, we created a releasing function to read the data obtained from the series of tools used and created a time function to capture the calculated value from the analog UV sensor with a program code as below:

```
def discharge():
    GPIO.setup(a_pin, GPIO.IN)
    GPIO.setup(b_pin, GPIO.OUT)
    GPIO.output(b_pin, False)
    time.sleep(0.005)

def charge_time():
    GPIO.setup(b_pin, GPIO.IN)
    GPIO.setup(a_pin, GPIO.OUT)
    count = 0
    GPIO.output(a_pin, True)
    while not GPIO.output(b_pin):
        count = count + 1
    return count
```

After that, we made an analog function to read charging and discharging data from the UV sensor which is used to generate the UV Index. After the UV sensor is read by the Raspberry Pi, the UV sensor with a voltage value is converted to millivolts with the following program code:

```
def analog_read():
    discharge()
    return charge_time()

def readSensor():
    UVIndex = "00"
    sensorValue = 0
```

```

sensorValue = analogRead(0);
voltage = (sensorValue * (5.0/1023.0))*1000;
if(voltage<50):
    UVIndex = "00"
elif: (voltage>50 && voltage<=227):
    UVIndex = "00"
elif (voltage>227 && voltage<=318):
    UVIndex = "01"
elif (voltage>318 && voltage<=408):
    UVIndex = "02"
elif (voltage>408 && voltage<=503):
    UVIndex = "03"
elif (voltage>503 && voltage<=606):
    UVIndex = "04"
elif (voltage>606 && voltage<=696):
    UVIndex = "05"
elif (voltage>696 && voltage<=795):
    UVIndex = "06"
elif (voltage>795 && voltage<=881):
    UVIndex = "07"
elif (voltage>881 && voltage<=976):
    UVIndex = "08"
elif (voltage>976 && voltage<=1079):
    UVIndex = "09"
elif (voltage>1079 && voltage<=1170):
    UVIndex = "10"
elif (voltage>1170):
    UVIndex = "11"
returnUVIndex

```

The value of the amount of analog UV Index data generated will be displayed on the LCD touchscreen with the program code as follows:

```

While True:
    print('UV Index: ', readSensor())
    time.sleep(1)

```

This program code will sent data from the UV sensor to the charging and discharging circuit as an external ADC circuit for the Raspberry Pi. After that, the data will be read by the Raspberry Pi and the results of the data will be displayed on the LCD touchscreen.

The output voltage from the UV sensor that the Raspberry Pi will read is obtained from the equation below:

$$V_o = 4.3 * Diode - Current - in - uA \tag{1}$$

Then, the voltage (V_o) is converted into a UV index using the equation:

$$Index = V_o / 0.1V \tag{2}$$

Data Analysis

The UV index data obtained in this study will be compared with the UV index data table from the BMKG to determine the category of ultraviolet light in each UV index obtained. The following is the UV index data from BMKG:

Table 1. UV Index Scale From BMKG

Color	UV Index	Category
Green	0-2	Low
Yellow	3-5	Moderate
Orange	6-7	High
Red	8-10	Very High
Purple	>11	Extreme

RESULTS AND DISCUSSION

Based on the design, tool design, and data processing obtained using the python programming language, the UV index results obtained from testing at two different locations as in the table below:

Table 2. UV Index Data Results Obtained

Time	UV Index		
	A	B	Indoor
06.30 a.m	1	0	0
07.15 a.m	2	1	0
08.44 a.m	4	3	0
10.00 a.m	5	5	0
10.45 a.m	6	6	0

From these results, it is known that the two locations have inequality in the UV index obtained. From 06.30 a.m to 07.15 a.m it is known that the UV index at both locations is still in the low category with the UV index value being 0 to 2. Ultraviolet rays at 08.44 a.m to 10.00 a.m at location A and location B have UV index values being at numbers 3 to 5, so it is in the moderate category. Meanwhile, at 10.45 a.m the index of ultraviolet light at both locations has the same value, which is 6, so it can be seen that the category of ultraviolet light at 10.45 a.m in both locations is high. The data collection time was made because it was adjusted to existing conditions, where data collection was carried out in May, which at that time was often cloudy and even rainy during the day, so data collection with blue skies at that time could only be done

in the morning. From the timing for data collection, we obtained the types of categories on the UV index as described above, where these categories were derived from the BMKG UV index data in table 1. We also used the UV index data from BMKG as a comparison to the UV index results we obtained.

In addition for outdoor locations, called location A and location B, we also conducted research in closed locations. At that location, the resulted UV index is 0, this means that ultraviolet rays have a low category. The 0 number on the UV index is not due to the absence of ultraviolet rays at that location. This is due to the rounding in equation:

$$Index = Vo / 0.1V \quad (2)$$

The numbers 0 to 0.99 are considered indexed 0, so there can be no UV rays and there can be UV rays, but it hasn't reached number 1, so the index is 0.

The difference in the UV index results at the two locations was caused by several factors, named locations, the surrounding environment such as buildings or trees, and weather such as cloudy skies so that they gave different readings. However, these factors can be minimized by ensuring that the ultraviolet sensors get direct sunlight. So, that ultraviolet sensor used can get the appropriate results. When compared with UV sensors made of ZnO, it can be seen that the UV index results obtained in this study are quite appropriate and the ultraviolet detection system in this study can also be used many times.

From these results, it means that ultraviolet rays that reach the earth's surface can be reflected even though they are not too perfect, because the ultraviolet rays are in the high category at 10.45 a.m which means they can be in the very high even extreme category if it is more than 10.45 a.m. This means that the ozone layer on the earth's surface is damaged and depleted quite severely, so that ultraviolet rays can reach the earth and are dangerous for the survival of living things on earth.

CONCLUSIONS

Based on the results of research to detect ultraviolet light using raspberry pi for learning about reflections on the surface of the earth it was found that the category of the UV index of ultraviolet light that reaches the earth during the daytime is quite dangerous, this is because the ozone layer on the surface of the earth is damaged and depleted quite severely so that ultraviolet light that reach the earth's surface are difficult to reflect and can have an impact on the life of living things on earth. These results are following the UV index data from BMKG with a note that the placement of the UV index measuring instrument is exposed to the sun directly. The UV index obtained in this study comes from the prototype calibration after programming in python using equation

$$Vo = 4.3 * Diode - Current - in - uA \quad (1)$$

and

$$Index = Vo / 0.1V \quad (2)$$

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