DESIGN AND CONSTRUCTION OF AN IOT BASED MONITORING DEVICE FOR SOLAR PHOTOVOLTAIC SYSTEM

BY

AMADI-DURU CHIBUDOM MELVIN

18/ENG04/013

A FINAL YEAR PROJECT

SUBMITTED TO

THE DEPARTMENT OF ELECTRICAL/ELECTRONICS AND COMPUTER ENGINEERING, COLLEGE OF ENGINEERING, AFE BABALOLA UNIVERSITY, ADO-EKITI, NIGERIA.

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING IN ELECTRICAL/ELECTRONICS ENGINEERING.

MAY, 2023

ABSTRACT

Electricity is a vital component of our daily lives. Without the utilization of electricity, the national economy would collapse. An area that merits investment is renewable energy, particularly in light of the rising global demand for electricity. Getting renewable energy to function flawlessly is one of the problems, so a monitoring system is needed to keep track of the voltage, current, and other photovoltaic system data. In this project, a device for monitoring solar photovoltaic systems was designed and implemented. The system was developed in such a way that it can allow many users monitor of the parameters of solar photovoltaic systems in multiple locations. When connected to a solar system, the device is able to sense the voltage, current and irradiance then it uses the WIFI module to transmit the values to the central server. The values are displayed after the user logs into the online platform. This system utilizes a microcontroller, voltage sensor, current sensor and a WIFI module to route the photo-voltaic parameters to an SQL database.

Keywords: Renewable, Photovoltaic, Monitor, WIFI module, Voltage sensor, Current sensor

ACKNOWLEDGEMENTS

Firstly, I give thanks to God Almighty for giving me the opportunity to increase my level of wisdom, patience, understanding and discipline in my journey to completing this degree. A special thanks to my parents and my siblings for their constant support and love throughout my journey to completion of this project.

Special appreciation goes to my supervisor Prof.J.O. Dada and Engr. Ibitoye for dedicating their time to my development as an Engineer and their various suggestions, ideas, and comments, which helped me complete this project.

Also, I acknowledge the hard work of the Head of Department of Electrical/Electronics & Computer, Engr. Dr. M. O. Onibonoje and all the lecturers, in setting the right standard for Electrical/Electronic & Computer Engineering department, their exemplary guidance and his contribution towards the success of my project work.

Lastly my profound gratitude to my exemplary friends; Kelvin Egbuwe, Mubarak Sule, Kazie Nnenna, Chinomso Ogan, Joy bassey, Blossom Okere and my study group for their continuous support.

DEDICATION

This project is dedicated to Almighty God for his guidance and mercies. I also dedicate this project to my father, mother and siblings. Their constant encouragement and support brought this project to fruition.

CERTIFICATION

This is to certify that this research project “Design and Construction of an IOT based monitoring device for solar photovoltaic systems’’ was carried out by AMADI-DURU CHIBUDOM MELVIN (18/ENG04/013) and submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering (B.Eng.) Degree in Electrical/Electronic Engineering.

………………………………………..   ……..……………..
Prof. J. O. Dada   Date
(Project Supervisor)

………………………………………..   ……..……………..
Engr. Dr. M. O. Onibonoje   Date
(Head of Department)

DECLARATION

I, AMADI-DURU Chibudom Melvin (18/ENG04/013), hereby declare that this project work titled "Design and Construction of an IOT based monitoring device for solar photovoltaic systems", carried out under the supervision of PROF. J. O. DADA submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering (B.Eng.) Degree in Electrical/Electronic Engineering, is my original work and has not been presented for any degree elsewhere, to the best of my knowledge.

………………………………………..   ……..……………..

AMADI-DURU Chibudom Melvin   Date

Table of Contents

Table of figures

ABSTRACT

Electricity is a vital component of our daily lives. Without the utilization of electricity, the national economy would collapse. An area that merits investment is renewable energy, particularly in light of the rising global demand for electricity. Getting renewable energy to function flawlessly is one of the problems, so a monitoring system is needed to keep track of the voltage, current, and other photovoltaic system data. In this project, a device for monitoring solar photovoltaic systems was designed and implemented. The system was developed in such a way that it can allow many users monitor of the parameters of solar photovoltaic systems in multiple locations. When connected to a solar system, the device is able to sense the voltage, current and irradiance then it uses the WIFI module to transmit the values to the central server. The values are displayed after the user logs into the online platform. This system utilizes a microcontroller, voltage sensor, current sensor and a WIFI module to route the photo-voltaic parameters to an SQL database.

Keywords: Renewable, Photovoltaic, Monitor, WIFI module, Voltage sensor, Current sensor

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Electricity is a fundamental part of modern life, and it benefits us in several ways. In this day and age, we are nothing without energy. Economic growth, advancement and development in any country, as well as poverty eradication and development depend on the availability of electricity. Commerce, agriculture, the manufacturing industry, and mining are all energy-intensive productive activities. Because of the growing demand for energy, more fossil fuel is necessary, resulting in more pollution. However, with the growth of renewable energy in recent years, the amount of environmental pollution has been substantially reduced.(Oyedepo, 2012)

The necessity for affordable sustainable energy generation systems to gradually replace conventional ones necessitates the enhancement of energy supply structures based mostly on clean and renewable energy resources. Solar photovoltaic (PV) is one of the most sustainable power generating technologies, with a long history of continuous expansion due to its simplicity, low maintenance costs, lack of fuel, and lack of wear and tear due to the lack of moving components. As the requirement grows, so does the demand for monitoring the facilities involve using a wireless-based technology solution.(López et al., 2012)

By incorporating sophisticated technology and integrating digital communications into current solar photovoltaic systems, the IOT-based solar photovoltaic monitoring system has started a new revolution in the power sector. This system will be capable of rapidly assimilating, simplifying, and interpreting massive amounts of data and applying it correctly. This IOT-based system has three essential components: design and construction of the inverter that supplies the load; Designing and building a plug-and-play system that serves as a sensing and data collection unit; and Design and implementation of a web-based monitoring system that retrieves data, displays it, and stores it permanently. (López et al., 2012)

1.2 Statement of Problem

The installation of a photovoltaic (PV) plant necessitates sophisticated technologies to manage a variety of difficulties that could jeopardize the plant's functioning, such as broken solar panels, connections, and dust deposited on panels, which reduces power output. The full system performance can be observed for the purpose of analysis and decision making using remote web-based monitoring and evaluation software; primarily addressing issues such as large data management, signal interference, long-distance data transmission, and security, as some panels are installed in inaccessible locations and thus unable to be monitored from a dedicated location.

1.3 Aim and Objectives

1.3.1 Aim

The project aims to develop an IoT based system for monitoring and control of a solar plant.

1.3.2 Objectives

The objectives of the project are to:

i. design and construct an IoT based device for monitoring of solar photovoltaic power infrastructures.

ii. design and implement a device interface module for connection to the central server.

iii. evaluate the performance of the device.

iv. evaluate the performance of the platform.

1.4 Justification

The goal of this project is to remotely monitor the parameters of various photovoltaic (PV) system components. Monitoring entails data collection, processing, and storage for future use, as well as the capacity to integrate numerous systems.

Users can examine the performance of the solar plant over time. Solar PV system health should be monitored on a regular basis to optimize performance and maintenance. Remote monitoring capabilities alert users when system performance has deteriorated or is about to fail for PV systems installed in inaccessible locations.

1.5 Scope of Work

This work employed a technique that permitted remote monitoring of the characteristics of a solar PV system using an existing network infrastructure utilizing a wireless remote monitoring platform, so enabling pure integration of the physical and virtual worlds into computer-based systems, resulting in increased efficiency, accuracy, and economic gain, as well as less human interaction.

1.6 Organization of Report

The following is how this work is structured: Chapter one introduces the topic and the problem under consideration, Chapter two includes a comprehensive review of the relevant literature as well as all theoretical concepts relevant to the project under consideration, Chapter three includesa brief description of the procedure for system design, development, and evaluation, Chapter four discusses the work results, and Chapter five includes the conclusion, recommendations, and contributions.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section comprises of a thorough evaluation of the literature vital to the project topic, as well as a sufficient description of all theoretical concepts pertinent to the project at hand. This report's major purpose is to provide thorough information on the systems, properties, and associated ideas.

2.2 Remote monitoring of solar power systems

Remote monitoring in solar systems refers to the use of technology to remotely monitor and manage the performance of a solar power system. This can be done using a variety of tools, including sensors, data loggers, and software platforms that are used to track and analyze the data generated by the solar power system. With remote monitoring, it is possible to track the performance of a solar power system in real-time, including the amount of energy being produced, the efficiency of the solar panels, and the overall health of the system. This information can be used to optimize the performance of the system and identify any problems or issues that may need to be addressed.

2.3 Sensors

A sensor is a tool that detects events or alterations in its surroundings and transmits that information to other electronics, most frequently a computer processor. Physical phenomena are transformed by a sensor into a quantifiable digital signal that can be read, displayed, or processed further. (Javaid et al., 2021) The sources that can be used are numerous and include, among others, light, temperature, movement, and pressure. Sensors first capture data about the physical environment before sending and relaying information. For instance, figuring out the temperature, location, or air quality of a device, sensory devices capture data, which they then transfer to a cloud server. Your computer or mobile device will then get the information, allowing you immediate access to all tracked actions.

Types of sensors

Many sensors are routinely utilized in a variety of applications. Temperature, resistance, pressure, heat flow, and other physical parameters are used to categorize these sensors. The following is a quick rundown of the various types of sensors.

a) **Current sensors:**

Without impairing the system's functionality, the ACS712 Current Sensor as shown in Figure 2.1 is the sensor that may be used to gauge and calculate the amount of current applied to the conductor. A linear sensor IC with a Hall-effect foundation is called the ACS712 Current Sensor. This IC offers a low resistance current conductor and 2.1kV RMS voltage isolation. (Procus, 2013.)

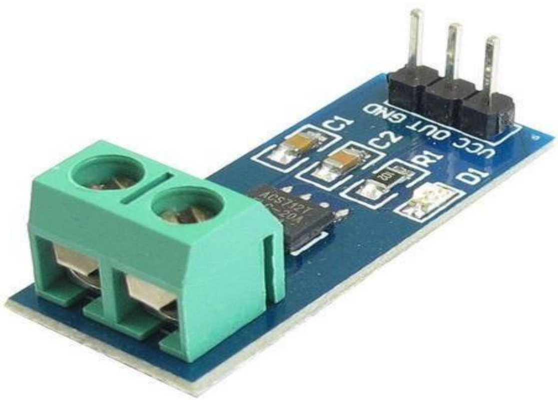


Figure 2.1: A current sensor (ACS712) (Procus, 2013)

b) Voltage sensors:

The straightforward and highly practical Voltage Detection Sensor Module shown in Figure 2.2 divides any input voltage by five using a potential divider. This enables us to monitor voltages above what a microcontroller is capable of sensing using the Analog input pin of the microcontroller. For instance, you can measure voltages up to 25V using an analog input range of 0V to 5V. For quick and secure wire connections, this module also features convenient screw terminals. (*Voltage Sensor Module Pinout, Features, Specifications & Arduino Circuit*, 2013.)

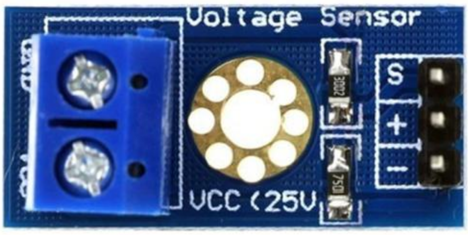


Figure 2.2: A voltage sensor . (*Voltage Sensor Module Pinout, Features, Specifications & Arduino Circuit*, 2013.)

2.4 Web Based Sensors

An application that can be accessed through HTTP is known as a web-based system. Applications that run on a web browser are typically referred to as web-based. However, it can also be used to describe programs that only load a very little portion of the solution on the client's computer. A web-based system's host server may be a local server or accessible through the internet. (Aezion, 2015.) The illustration is shown in Figure 2.3.

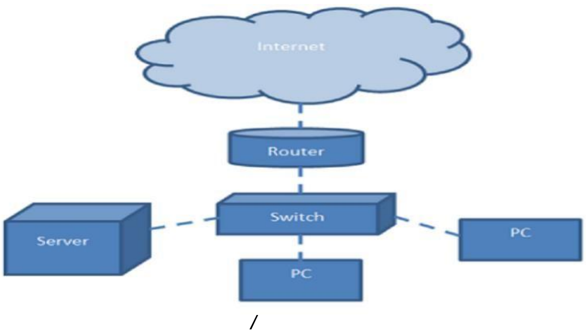


Figure 2.3: A web based sensor illustration (Aezion, 2015.)

Different types of Cloud Computing Concepts

i) **The Public Cloud**: The most popular kind of cloud deployment model is this one. A service provider makes resources online accessible to the general public in this deployment approach. You don't need to worry about the cost of maintaining local hardware or keeping it current in this situation. This offers opportunities for sharing resources and opportunities for salability that a single business would not have been able to do. The implemsentation of a blog or a web application is a typical use case scenario. The most popular public cloud service providers include IBM Cloud, Amazon Web Services, Microsoft Azure, and Google Cloud Platform. (Singh, 2016.)

ii) **The Private Cloud**: In a private cloud, one builds a cloud environment in their own data center and gives their own company self-service access to computing resources. Private cloud platforms, also known as single-tenant environments, provide resources to just one business and cannot be shared with other organizations, in contrast to public cloud, whose services can be used by numerous organizations. Private Cloud takes advantage of Public Cloud's marketability advantages, but you are completely in charge of the acquisition and upkeep of hardware and software resources. When the data cannot be stored in a public cloud for ethical or security reasons, private clouds might be used in this situation. Such restrictions may be present in any legacy or official application.

HPE, IBM, VMware, Dell EMC, and Oracle are a few of the private cloud service providers. (Singh, 2016.)

iii) **The Hybrid Cloud**: A hybrid cloud combines public and private clouds. It makes an effort to combine the advantages of both kinds of cloud computing platforms, enabling you to execute your application where it will be most effective. When some data cannot be stored in the cloud owing to legal constraints, hybrid clouds are essentially helpful. Additionally, it's helpful if you want to keep outdated hardware or systems operating locally for programs that use out-of-date hardware and can't be updated. For instance, you may install your website on a public cloud to benefit from advantages in terms of scalability and your database on a private cloud to protect the data. (Singh, 2016.) The features are shown in Figure 2.4.

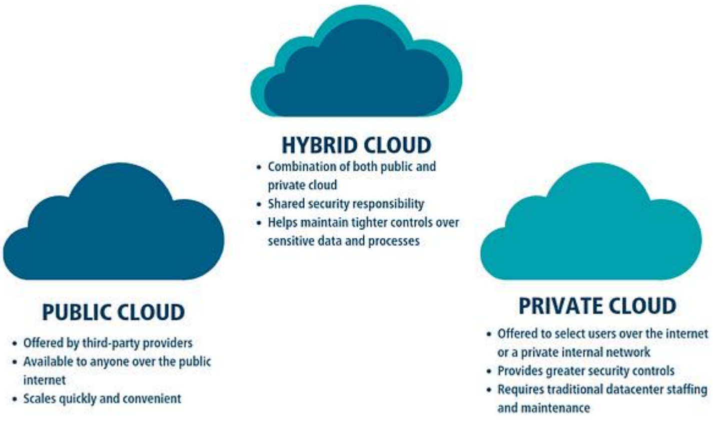


Figure 2.4: Cloud computing illustration (Singh, 2016.)

2.5 Visualization tool

Huge numbers of wireless sensor networks have emerged to monitor a variety of infrastructure in areas like healthcare, energy, transportation, smart cities, building automation, agriculture, and industry as the Internet of Things (IoT) has expanded quickly. These networks produce continuous streams of data. Big Data technologies are essential to IoT processes because they serve as visual analytics tools that produce useful knowledge in real-time to assist important decisions. (Protopsaltis et al., 2020)

Data visualization presents information in a visual setting so that others can understand its significance. The overall effort needed to manually analyze the data is reduced as a result. In order to gather insights and improve decision-making, visualization and pattern recognition within IoT generated data are crucial. Many data charts can be used in this process, with the chart or visualization chosen for each example taking the context of the visualization into consideration (Protopsaltis et al., 2020)

2.6 IOT Data Visualization Tools

By offering strong data analytics that help in the understanding of huge amounts of data received from various IoT devices, visualization tools support decision-making. IoT data visualization systems entail the development of a unique dashboard that enables the operator to explore the available raw measurements and gain understanding of the models' operation given a set of measurements collected by several geographically dispersed IoT sensors and several AI models applied to the data. Around the world, a number of IoT Data visualization technologies are utilized for solar monitoring. These implements can be either a window-based Iot platform or a Mathworks-based IoT platform. For this report and project, a window based IoT platform is used.

2.7 Review of Related Works

Effective energy yield in photovoltaic systems is a fundamental challenge in solar energy supply. A practical solution for increasing the output of solar panels is a wireless remote monitoring platform for photovoltaic systems. The design and implementation of a solar photovoltaic software for in-the-moment sensing and monitoring are detailed in this study. In order to gather and store information about the characteristics of solar energy, the system continuously monitors and assesses the components of a photovoltaic plant (PV), anticipating performance and ensuring dependable power generation.

The system's originality is its ability to transmit operation performance data to the end user location and publish data over the Internet using Web Server capabilities, enabling easy monitoring and evaluation of the performance of the entire system.

The relevant literature contains some efforts on the subject of photovoltaic (PV) monitoring systems. Throughout the preceding decade, low-cost solutions were prioritized, especially in nations like Nigeria.

A new monitoring and control method for a solar water heater was proposed by (Swart & Hertzog, 2018) The system's power consumption, the temperature inside and outside, and the time the event occurred are all included in the data it collects. It is gathered using Thing-internet Speak's server over the home's already-installed Wi-Fi network. In terms of the cheap hardware and open-source software used in system operation, the system is cost-effective.

(Adiono et al., 2017) worked on the creation of a wireless-based remote monitoring system that is quickly and directly related to the output parameters of a [PLTS]. It is done by connecting a Raspberry Pi data gathering system to a monitoring system built on an

Atmega32 microcontroller. Data readings and SPP output parameters are saved in memory and are accessible at any time.

(Nagpal et al., 2018) a system built on the Google cloud was created. The Raspberry Pi microcontroller was used to implement the system. The created system continuously logs information and data from each solar photovoltaic panel to track how well the solar panel is working. Voltage, current, and thermocouple sensors are all installed in every solar photovoltaic panel. The system developed is effective in capturing data from solar PV systems, according to the results of the performance evaluation.

(Neeraja et al., n.d.) evaluated the numerous methods that can be used to achieve solar panel monitoring. It was advised to use an IoT open-source cloud-based setup (Thing-Speak) that made use of sensors and microcontrollers like Arduino and Raspberry Pi. This technique is thought to be both affordable and effective for gathering comprehensive energy conversations.

(Sankaran et al., 2021) built a health monitoring, control, and tracking system based on solar and IoT. The system's three main functions—health monitoring, control, and tracking—were accomplished with the use of sensors and a PIC 18F452 microcontroller. The PIC 18F452 processed data from a GPS, body warmer, and heartbeat detection before sending it to an LCD and a GSM for display. A GPS module is being used to determine the location. A solar array powers the entire system and charges the battery at the same time.

According to the work of (Vijayakumar et al., 2019), the primary objective of a PV monitoring system is to offer a practical solution that continuously displays remote energy yields and performance on a computer or via smart phones. The proposed system was evaluated with a 125-watt solar module to measure string voltage, string current, temperature, and irradiance. A smart Wi-Fi capable CC3200 microcontroller with the most recent ARM

Processor integrated was used to implement this cost-effective technique. It communicates with the cloud platform and uploads data via the Blynk application. The result indicates that a wireless monitoring system maximizes a PV system's operational reliability while requiring the least amount of system resources.

(Tellawar & Chamat, 2019) created a data logger and monitoring system based on the Blynk App for the management and monitoring of Pico solar photovoltaic systems. The data logger uses an ESP 32 microcontroller to store all the monitoring parameters collected from the Arduino in a micro-SD card, together with four sensors connected to an Arduino IDE. These settings are shown on the Blynk application. The outcome demonstrates that IOT-based monitoring increases system energy efficiency, cuts down on supervision time, and makes network management easier.

(Hara et al., 2019) used MIT App Inventor for mobile devices and Thing-speak cloud-based technologies for web-based accessibility to construct a solar photovoltaic monitoring system. Temperature, current, and voltage were used by the system. Sensor attached to an Arduino microcontroller (ATMega2560). Using a wireless transceiver called NodeMCU; the Arduino captured the data and posted it to the internet (ESP8266). As long as an internet connection was available, the system made use of Thing-speak and MIT App Inventor to save all of the sensor data and display it graphically. This allowed the user to watch the data remotely. The outcome demonstrated both the system's performance efficiency and the devices' accuracy.

(Mangayarkarasi et al., 2019) used an economical technique based on IoT (Thing-speak) to remotely monitor a solar plant in order to assess its performance. To make accurate decisions based on real-time data, sensors like voltage and current sensors were employed to gather information. An Arduino Uno microcontroller was used to collect the power level and production data, and a Wi-Fi module was used to transmit the data to cloud-based monitoring tools (ESP8266). This technique worked well for monitoring plant faults in real time, facilitating preventive maintenance, and keeping an eye on solar panel dust while observing peak power.

The Internet of Things was used by (Vaishnav & Palkar, 2022) to create a solar power monitoring system. The system uses a 20W solar panel's output to power several sensors, including voltage, current, and temperature sensors. The analog signal obtained from the solar panel is read using these sensors. The Node-MCU ESP8266 microcontroller received the output. A built-in Wi-Fi module in the microcontroller made it simple to access digital signals from the device. OLEDs were used to display the parameter's information. The data was also stored on a memory card so that it could be recovered at any moment.

A cloud-based Blynk-app was used to create a solar tracking system in (Samuel & Rajagopal, 2021). Three components make up the system: data processing, data storage, and data display. The microcontroller's numerous sensors that were attached to them provided the information, which included information on the temperature, humidity, voltage, and current produced by the PV. Microcontrollers were used to process data, and a NodeMCU and Ethernet shield were used to send the data to the cloud (web server). With pre-built widgets in the Blynk application, users may view real-time solar tracking data from the IoT monitoring app.

The previous related works engaged direct monitoring, which didn't encourage remote monitoring. The proposed work will use various techniques that will enable the monitoring of the parameters of the solar PV systems remotely over an existing network infrastructure using a wireless remote monitoring platform, providing opportunities for pure integration of the physical world into computer-based systems and improving efficiency, accuracy, and economic benefits.

CHAPTER THREE
METHODOLOGY

3.1 Introduction

In this chapter, a high-level grasp of the research is given in this succinct description of the study. Additionally, a thorough explanation of the system design, development, and evaluation process is given, providing insights into the all-encompassing strategy used to accomplish the study objectives.

3.2 System Overview

The solar system consists of a solar panel and a solar charge controller incorporated in an inverter which has regulated AC and DC output, and the third unit in the existing solar system is the battery. The developed system utilizes an Arduino Nano microcontroller to automate voltage sensor and current sensor for an effective performance. It communicates with the central server using a WIFI module (ESP8266). The developed system made use of an Arduino Uno to automate the system, a voltage sensor module (KR-SR0087) to measure the voltage produced by the solar system, and a current sensor (ACS712) to measure the battery charging current. The WIFI module was used to route the data obtained from the voltage and current sensors to the SQL database. Figure 3.1 shows the overview of the system.

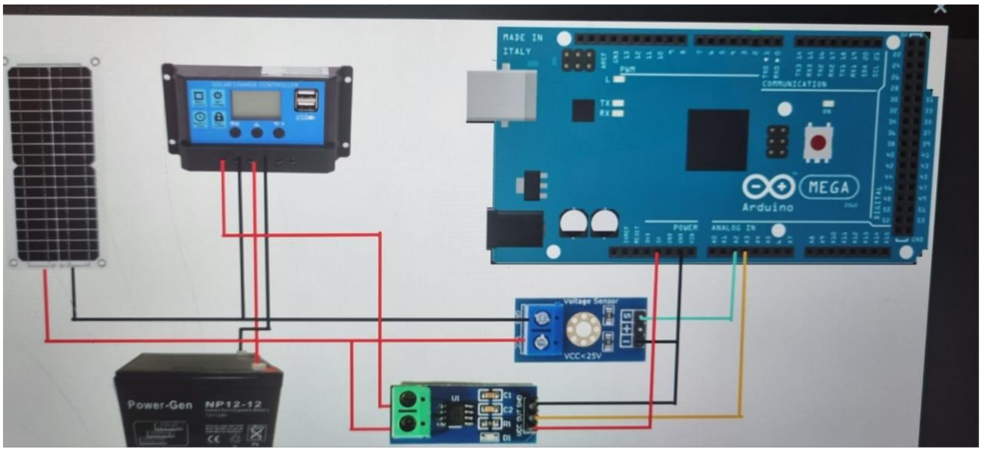
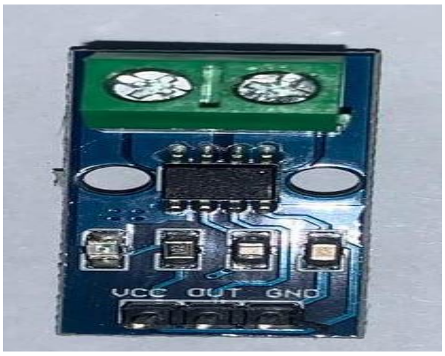


Figure 3.1: Overview of system

3.3 Components of System

Current Sensor (ACS712): The current sensor (ACS712) shown in Figure 3.2 was specifically chosen for this project because it makes use of the well-known ACS712 IC to detect current utilizing the Hall Effect theory. It has benefits such as cheap cost, accurate AC or DC current sensing solutions, an isolated current measuring sensor, and a broad variety of applications. It is extremely easy to connect the ACS712 module to any microcontroller since it can measure AC or DC current in the range of +5A to -5A, +20A to -20A, and +30A to -30A and output Analog voltage of (0-5V) based on the current passing through the wire.

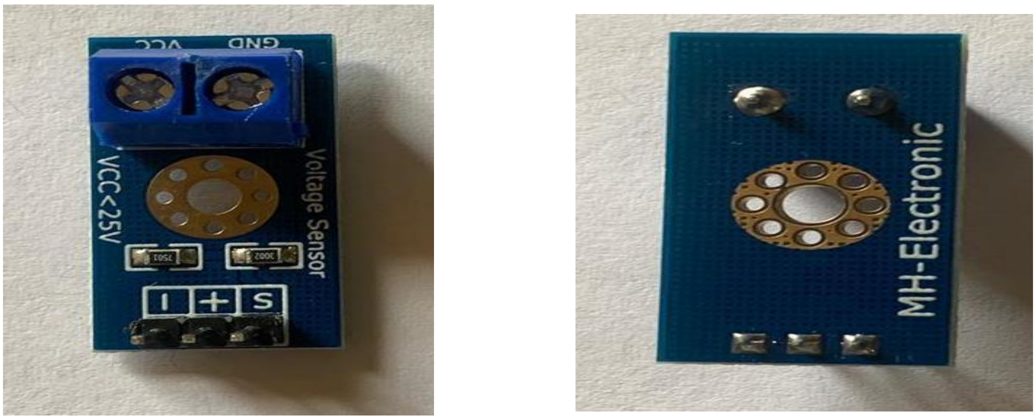


FRONT VIEW

BACK VIEW

Figure 3.2: A current sensor(ACS712)(Procus, 2013)

Voltage Sensor Module (KR-SR0087): The voltage sensor module (KR-SR0087) shown in Figure 3.3 was especially chosen for this project's needs because of its simplicity, control effectiveness, and efficient performance when used with Arduino boards, i.e., it makes it simpler to detect battery voltage.



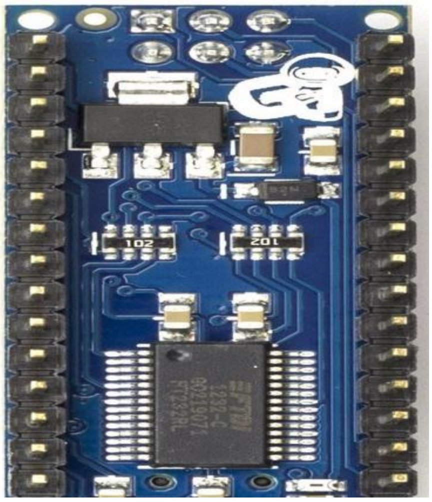
FRONT VIEW BACK VIEW

Figure 3.3: A voltage sensor (KR-SR0087) (*Voltage Sensor Module Pinout, Features, Specifications & Arduino Circuit*, 2013.)

With a voltage input range of DC 0-25 V, a voltage detection range of DC0.02445 V-25 V, and a voltage analog resolution of 0.00489 V, this module is based on the resistive divider design concept. It consists of a DC input and output interface. The DC input interface includes a red terminal that is positive with VCC and a red terminal that is negative with GND. The output interface contains a "+" terminal that is linked to 5/3.3V, a "-" terminal that is connected to GND, and a "s" terminal that is available to connect to the Arduino AD pins.

Arduino Nano: The microcontroller board used in this project, the ATmega328-based Arduino Nano shown in Figure 3.4, was chosen for its adaptability and breadboard-friendliness (datasheet). It contains eight analog inputs, a 16 MHz resonator, a USB connection, a reset button, and an ICSP header among its 22 digital I/O pins. It also has a 16

MHz resonator. The Arduino board's microcontroller is configured to transform the analog sensor output to digital form. The LCD shows the digital temperature and humidity readings. The digital data is then transmitted to the GSM module, which is connected to the Arduino Nano, after that.



FRONT VIEW BACK VIEW

Figure 3.4: An Arduino Nano (Procus, 2016)

Arduino WIFI module: A WIFI module shown in Figure 3.5 has been incorporated into the Arduino Uno to create the Arduino Uno WIFI. The ESP8266WiFi Module is built inside the ATmega328P-based circuit board. The ESP8266WiFi Module is an independent SoC with a built-in TCP/IP protocol stack that allows access to your WIFI network (or the device can function as an access point). Support for OTA (over-the-air) programming, whether for the transmission of Arduino sketches or WIFI firmware, is a handy feature of the Uno WIFI.

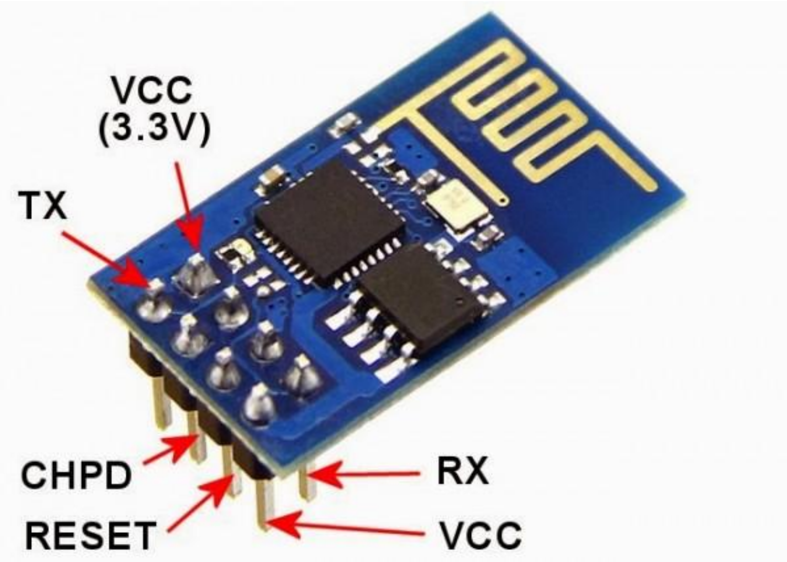


Figure 3.5: An Arduino WIFI module (Instructables, 2019)

Transformerless Inverter: A power inverter known as a transformerless inverter does not employ a transformer to transfer DC electricity into AC voltage. Instead, it turns the DC voltage on and off at high frequencies to produce an AC waveform using semiconductors like MOSFETs or IGBTs. A transformerless inverter has the benefit of generally being more compact and lightweight than a conventional inverter with a transformer. This makes it ideal for applications with limited space, including electric vehicles or solar power systems. The transformerless inverter is shown in Figure 3.6.

Figure 3.6: A transformerless inverter (Instructables, 2019)

3.3.1 Interfacing the WIFI module with the SQL Database

The project's integration of an Arduino WIFI module with a SQL database enables seamless data storage and retrieval between the Arduino microcontroller and the database. First off, a stable and dependable connection is made by properly configuring and attaching the Arduino WiFi module to the Arduino board. The required libraries, including "WiFi.h" and "MySQL Connector/Arduino," are installed to make it easier for the Arduino and the SQL database to communicate. The Arduino uses the WIFI library to create a WIFI connection to start the connection. To ensure effective authentication and connectivity, the needed credentials, such as the SSID and password, are given. The MySQL Connector/Arduino library is then used to establish the connection to the SQL database. To establish a successful connection, the Arduino transmits the necessary information, such as the database server address, username, password, and database name. The required SQL statements are prepared in order to communicate with the SQL database. These statements comprise queries for getting data from the database tables as well as ones for adding new records, altering existing records, and deleting data. The SQL statements' syntax and structure are carefully considered to guarantee that they are compatible with the database schema. The MySQL Connector/Arduino library's appropriate functions are used to execute the prepared SQL statements. This enables the Arduino to do the necessary SQL database operations. The monitored parameters are sent to the SQL database and are displayed on the web based monitoring system. Figure 3.7 shows the interface between the Arduino and the WIFI module.

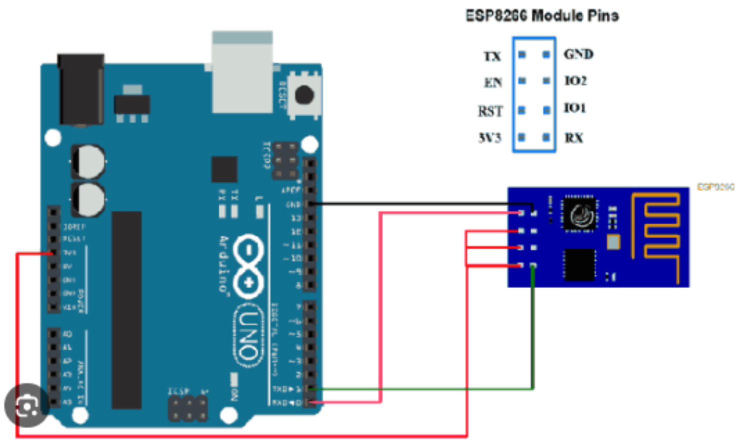


Figure 3.7: Interface of WIFI Module with Arduino (Instructables, 2019)

3.3.2 Solar module specifications

The design of the solar monitoring system was made to handle a maximum of 500Watts of power. This was taken into account when acquiring materials. In light of the efficiency and price of solar modules on the market, the mono-crystalline type being the most appropriate for this project, three panels were used to analyze the system. The PV modules typically come already without any need for further improvement aside from maintenance like regular cleaning. The panel used for testing is 100/24 Watts/Volts and the battery is of a powerful 40AH capacity. The transformerless inverter is 1000Watts. With this combination for testing it should be able to power a 500W room and the monitoring system can adequately measure the parameters seamlessly.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

The results of the project are thoroughly and in-depth explained in this chapter, with an emphasis on important details and perceptive interpretations of the results. It includes a comprehensive analysis of the data gathered, highlighting major findings and trends that surfaced throughout the investigation. The conclusions presented in the chapter highlight the significance and potential effects of the project's findings. This chapter makes a significant addition to the overall knowledge and relevance of the research project by giving a thorough explanation of the study's results.

4.2 Results

These are the various results obtained from tests performed on the hardware of the system.

4.3 Installation and internal circuitry of the solar monitor

Figure 4.1 to Figure 4.4 is the internal circuitry of the monitoring system. The breadboard was used as the platform for inserting the components. The WIFI module here is interfaced with the Arduino Nano. The sensors feed the data into the Nano and the WIFI module is used to interface with the central server database. For the testing, a 5v battery was connected to the monitoring device; below in the diagram are the values it read. The project was initially meant to be designed with a GSM module but with the interfacing issues we faced, the WIFI module was the better alternative.

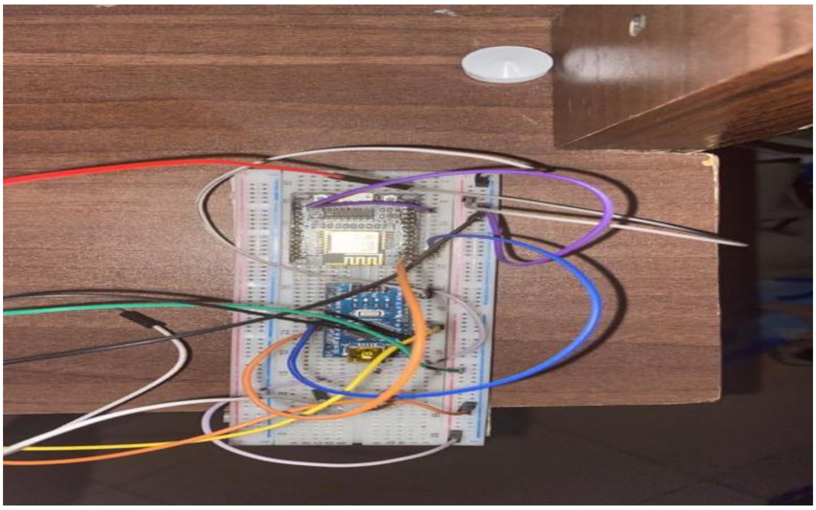


Figure 4.1: Top view of the connection between WIFI module and Nano

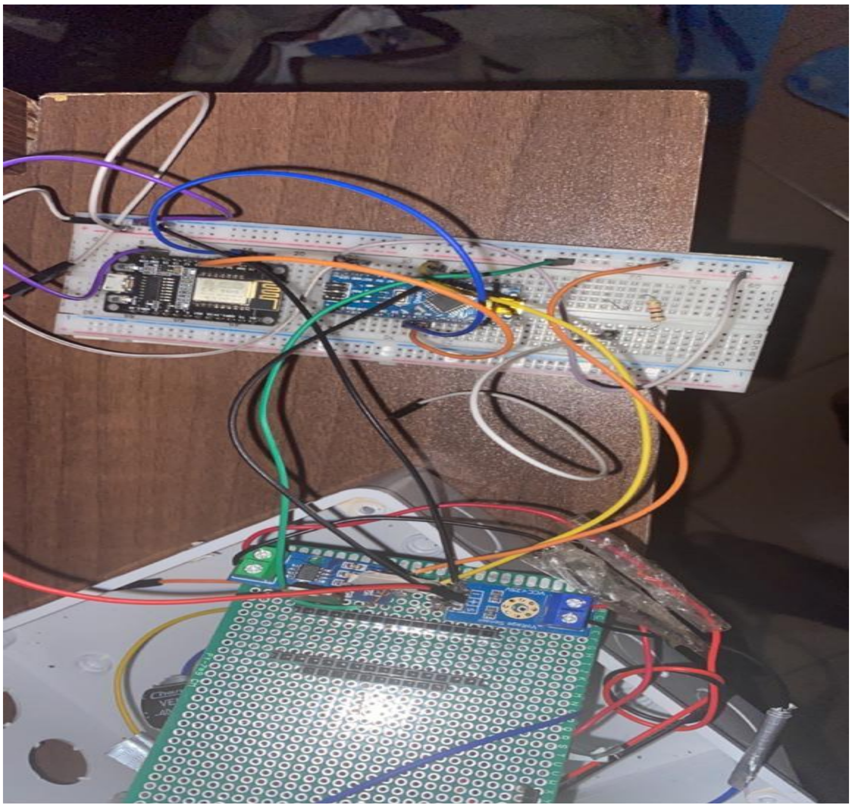


Figure 4.2: View with the current and voltage sensor

Figure 4.3: The LED display

Figure 4.4: The LED display with test values

4.2.1 Continuity test

Continuity test results showed that continuity was achieved in all the components and the overall system, so electrical connection exists and current flows through the system.

4.2.2 Charging and discharging rate test

Results showed that the solar panel would take approximately 10 hours to charge the 40AH battery. In an ideal situation it should be around this value but taking into account efficiency losses, weather conditions and variations in charging current it should not take more than 15 hours. The discharge rate depends on the load connected to it.

4.3 Results obtained from the web-based monitoring platform

4.3.1 User login page

Figure 4.5 below shows the login page of the solar monitoring webpage developed by my project partner. This is where users can login with their username and passwords and access their solar monitoring parameters.

Figure 4.5: User Login Page

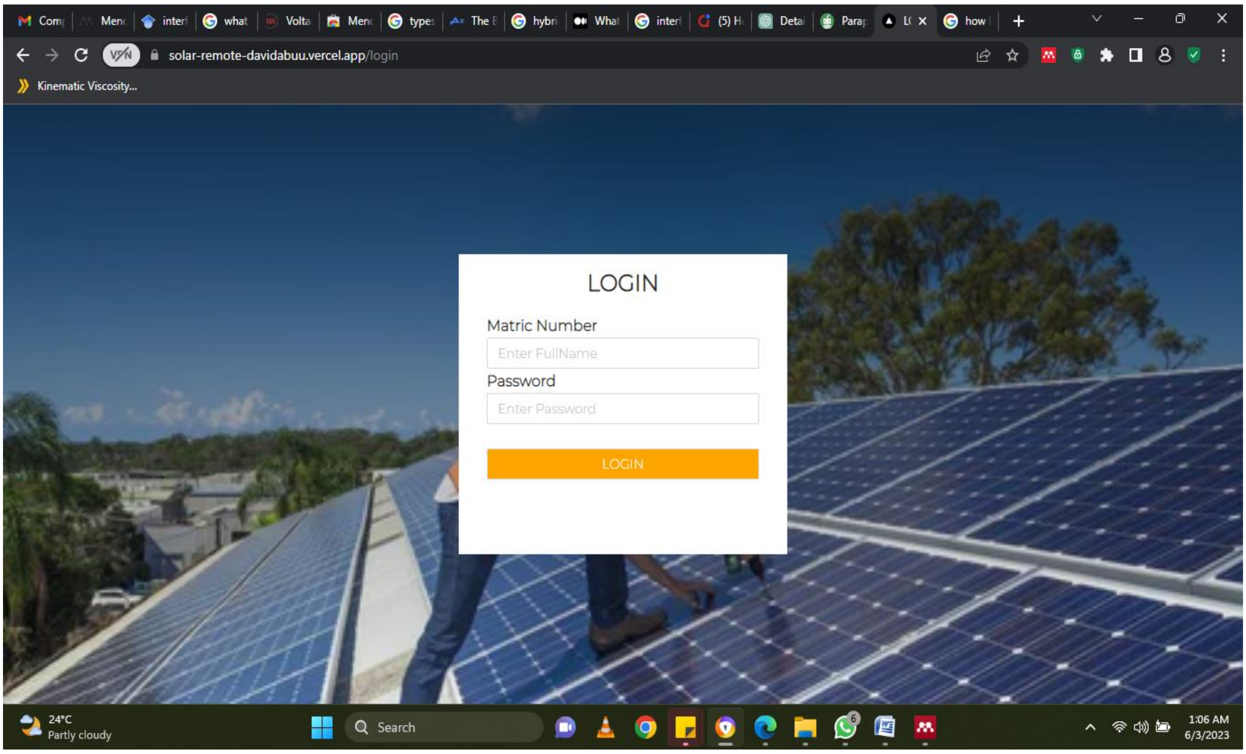


Figure 4.5: User Login Page details insert

4.3.2 Solar parameters

The solar parameters are displayed on the webpage as shown in Figure 4.6 and the values are refreshed every 5 minutes.

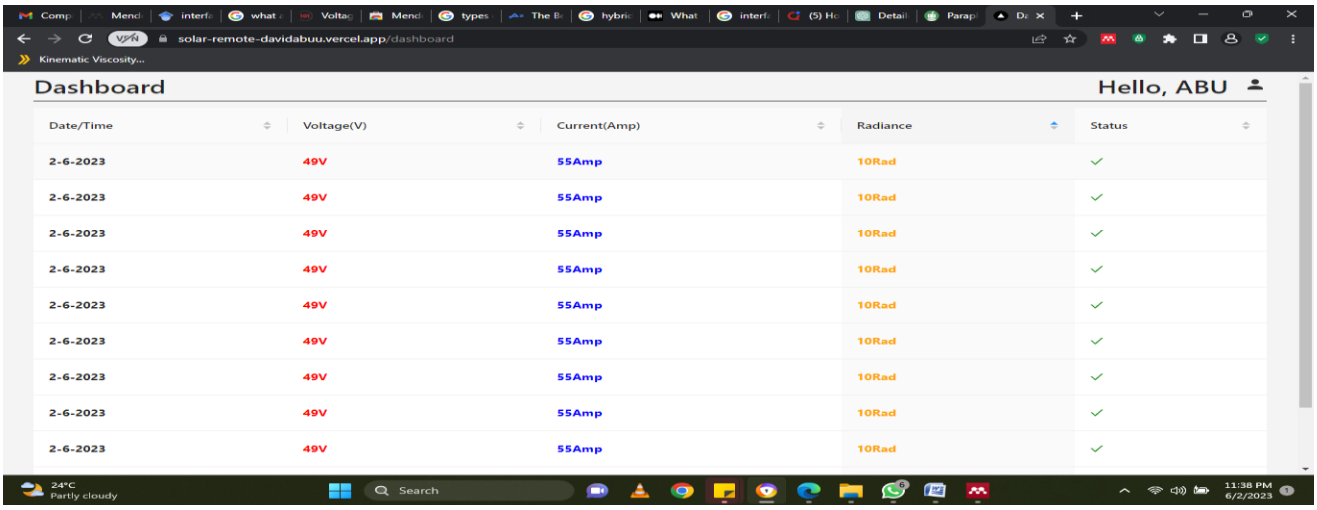


Figure 4.6: Solar parameter page

4.4 Arduino and WIFI module code for configuration of devices

The following are the codes used for the interface of the WIFI module and Arduino to the SQL database

The WIFI module code

```
void setup() {
// Open serial communications and wait for port to open:
Serial.begin(9600);
while (!Serial) {
; // wait for serial port to connect. Needed for native USB port only
}
}

void loop() { // run over and over
if (Serial.available()) {
Serial.write(Serial.read());
}
}
```

The code sets up the Arduino program by initiating serial communication with a baud rate of 9600. It waits for the serial port to connect, which is deemed necessary for native USB ports. In the loop function, it continuously runs in a loop and checks if there is any available data on the serial port. If there is data available, it reads the data and writes it back using the Serial.write() function. Essentially, the code acts as a passthrough, receiving data from the serial port and immediately sending it back.

The Arduino Code

```
#include <SoftwareSerial.h>
#define VIN A3 // define the Arduino pin A0 as voltage input (V in)
const float VCC   = 5;// supply voltage is from 4.5 to 5.5V. Normally 5V.
const int model = 2;   // enter the model number (see below)



float cutOffLimit =0.5;// set the current which below that value, doesn't matter. Or set 0.5
int offset = 20;// set the correction offset value

float sensitivity[] ={
        0.185,// for ACS712ELCTR-05B-T
        0.100,// for ACS712ELCTR-20A-T
        0.066// for ACS712ELCTR-30A-T

       };
```

```
const float QOV =   0.5 * VCC;// set quiescent Output voltage of 0.5V
float voltage;// internal variable for voltage
SoftwareSerial espSerial(5, 6);
String str;

void setup() {
    //Robojax.com ACS712 Current Sensor
    Serial.begin(9600);// initialize serial monitor
    espSerial.begin(9600);
    Serial.println("Robojax Tutorial");
    Serial.println("ACS712 Current Sensor");

     delay(2000);


}
void loop() {
  int volt = analogRead(A1);// read the input
  double voltage = map(volt, 0, 1023, 0, 2500) + offset; // map 0-1023 to 0-2500 and add
correction offset

  voltage /= 100; // divide by 100 to get the decimal values
  Serial.print("Voltage: ");
  Serial.print(voltage); //print the voltge
  Serial.println(" V");

  //Robojax.com ACS712 Current Sensor with LCD1601
  float voltage_raw =   (5.0 / 1023.0)* analogRead(VIN);// Read the voltage from sensor
  voltage =  voltage_raw - QOV + 0.012 ;// 0.000 is a value to make voltage zero when there
is no current
  float current = voltage / sensitivity[model];

 // if(abs(current) > cutOffLimit ){
    Serial.print("V: ");
    Serial.print(voltage,3);// print voltage with 3 decimal places
    Serial.print("V, I: ");
    Serial.print(current,2); // print the current with 2 decimal places
    Serial.println("A");


  str =String("coming from arduino: ")+String("v= ")+String(voltage)+String("I=
")+String(current);
espSerial.println(str);
  delay(500);

  }
```

The code utilizes the SoftwareSerial library and defines constants and variables for reading voltage and current values through an ACS712 current sensor in an Arduino setup.

During initialization, the code establishes serial communication at a baud rate of 9600 for both the hardware serial monitor and the espSerial SoftwareSerial instance. It also displays initial messages on the serial monitor.

In the main loop, the code reads an analog value from pin A1 to determine the voltage input. This value is then mapped and corrected to obtain the accurate voltage, which is printed to the serial monitor. Another analog value is acquired from pin A3, representing the voltage from the current sensor. By subtracting the quiescent output voltage (QOV) and applying a slight correction, the actual voltage is computed. The current is subsequently calculated by dividing the voltage by the corresponding sensitivity value for the chosen model. The obtained voltage and current values are displayed on the serial monitor. Furthermore, the values are converted into a string and transmitted to the espSerial instance for communication with an external device which is the WIFI module in this case. The loop continues after a delay of 500 milliseconds.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This project successfully designed and implemented a device aimed at monitoring solar photovoltaic systems. The system's development focused on providing the capability for multiple users to monitor their system parameters conveniently. When connected to a solar system, the device effectively senses vital parameters such as voltage, current, and irradiance, subsequently transmitting these values to a designated database through the integration of a WIFI module. Upon logging into the online platform, users can readily access and view the displayed parameter values. The system's core components include a microcontroller, voltage sensor, current sensor, and WIFI module, working in harmony to facilitate the seamless routing of photovoltaic parameters to an SQL database. This project successfully showcases the potential of utilizing advanced technologies to enable efficient monitoring and management of solar energy systems.

5.2 Contribution to knowledge

This project successfully designed and implemented a fully functional remote monitoring software platform specifically tailored for Solar PV systems in a convenient plug-and-play format. The platform's versatility allows for seamless compatibility with various types of solar PV systems and arrays (provided it is within the ranges of the monitoring device). The outcomes of this study lay a solid foundation for future research and further advancements in the field.

5.3 Recommendations

i. The Monitoring Device should not be used for industrial solar power systems. It is designed to handle a maximum panel wattage of 500W, anything more than this will cause inaccuracy or the device will malfunction.

ii. Arduino microcontrollers and IoT is the future of modern day engineering, the most time consuming part of this project was used to learn and understand how microcontroller and IoT work. Many errors were encountered during the learning stage. Students should be introduced to these technologies at the lower levels to reduce the learning curve during the execution of their final year projects.

iii. Moreover, it is recommended that students be enlightened on new areas of technology that are yet to be addressed to bring the solution to the various problems man faces in his day-to-day activities.

REFERENCES

Adiono, T., Marthensa, R., Muttaqin, R., Fuada, S., Harimurti, S., & Adijarto, W. (2017). Design of database and secure communication protocols for Internet-of-things-based smart home system. *IEEE Region 10 Annual International Conference, Proceedings/TENCON*, *2017-December*, 1273–1278. https://doi.org/10.1109/TENCON.2017.8228053

Aezion. (n.d.). *The Benefits of Web-Based Systems for Business - Aezion*. Retrieved June 2, 2023, from https://www.aezion.com/blogs/the-benefits-of-web-based-systems-for-business/

Hara, K., Akitomi, M., Masuda, A., -, al, Tiwari, A., Agarwal, R., Priharti, W., K Rosmawati, A. F., & D Wibawa, I. P. (2019). IoT based photovoltaic monitoring system application. *Journal of Physics: Conference Series*, *1367*(1), 012069. https://doi.org/10.1088/1742-6596/1367/1/012069

Instructables. (2019). *Arduino UNO + ESP8266 WiFi Module : 3 Steps - Instructables*. https://www.instructables.com/Arduino-UNO-ESP8266-WiFi-Module/

Javaid, M., Haleem, A., Rab, S., Pratap Singh, R., & Suman, R. (2021). Sensors for daily life: A review. *Sensors International*, *2*, 100121. https://doi.org/10.1016/J.SINTL.2021.100121

López, M. E. A., Mantiñan, F. J. G., & Molina, M. G. (2012). Implementation of wireless remote monitoring and control of solar photovoltaic (PV) system. *2012 Sixth IEEE/PES Transmission and Distribution: Latin America Conference and Exposition (T&D-LA)*, 1–6. https://doi.org/10.1109/TDC-LA.2012.6319050

Mangayarkarasi, N., Raghuraman, G., & Kavitha, S. (2019). Influence of computer vision and IoT for pipeline inspection-a review. *ICCIDS 2019 - 2nd International Conference on Computational Intelligence in Data Science, Proceedings*. https://doi.org/10.1109/ICCIDS.2019.8862109

Nagpal, G. S., Singh, G., Singh, J., & Yadav, N. (2018). Facial Detection and Recognition using OpenCV on Raspberry Pi Zero. *Proceedings - IEEE 2018 International Conference on Advances in Computing, Communication Control and Networking, ICACCCN 2018*, 945–950. https://doi.org/10.1109/ICACCCN.2018.8748389

Neeraja, M. Y., Susritha, D., Kalpana, J., Subhasri, K., & Students, D. L. (n.d.). *AN ADVANCED BRAILLE SYSTEM-COMMUNICATION DEVICE FOR BLIND-DEAF PEOPLE*.

Oyedepo, S. O. (2012). Energy and sustainable development in Nigeria: the way forward. *Energy, Sustainability and Society*, *2*(1), 1–17.

Procus, E. (n.d.). *ACS712 Current Sensor - Working Principle and Applications*. Retrieved June 2, 2023, from https://www.elprocus.com/acs712-current-sensor-working-and-applications/

Protopsaltis, A., Sarigiannidis, P., Margounakis, D., & Lytos, A. (2020). Data visualization in internet of things: Tools, methodologies, and challenges. *ACM International Conference Proceeding Series*. https://doi.org/10.1145/3407023.3409228

Samuel, J., & Rajagopal, D. (2021). IoT Based Solar Panel Monitoring and Control. *NVEO - NATURAL VOLATILES & ESSENTIAL OILS Journal | NVEO*, *8*(5), 7609–7618. https://www.nveo.org/index.php/journal/article/view/2051

Sankaran, S., Thiyagarajan, A. P., Kannan, A. D., Karnan, K., & Krishnan, S. R. (2021). Design and Development of Smart Airbag Suit for Elderly with Protection and Notification System. *Proceedings of the 6th International Conference on Communication and Electronics Systems, ICCES 2021*, 1273–1278.

https://doi.org/10.1109/ICCES51350.2021.9488972
Singh, K. (n.d.). *What is the difference between Public, Private and Hybrid Cloud? | by Karan Singh | Medium*. Retrieved June 2, 2023, from https://karansinghreen.medium.com/what-is-the-difference-between-public-private-and-hybrid-cloud-a41bba631479

Swart, A. J., & Hertzog, P. E. (2018). LED's as viable power loads for experimental purposes relating to PV modules in pico-solar systems. *4th IEEE International Conference on Engineering Technologies and Applied Sciences, ICETAS 2017*, *2018-January*, 1–6. https://doi.org/10.1109/ICETAS.2017.8277861

Tellawar, M. P., & Chamat, N. (n.d.). *An IOT based Smart Solar Photovoltaic Remote Monitoring System*. Retrieved June 2, 2023, from www.ijert.org

Vaishnav, K. N., & Palkar, R. R. (2022). An Assessment of GHG Emission Reduction by Using Renewable Energy and Energy Efficient Processes. *Environmental Science and Engineering*, 393–402. https://doi.org/10.1007/978-3-030-96554-9_26/COVER

Vijayakumar, V., Malathi, D., Subramaniyaswamy, V., Saravanan, P., & Logesh, R. (2019). Fog computing-based intelligent healthcare system for the detection and prevention of mosquito-borne diseases. *Computers in Human Behavior*, *100*, 275–285. https://doi.org/10.1016/J.CHB.2018.12.009

Voltage Sensor Module Pinout, Features, Specifications & Arduino Circuit. (n.d.). Retrieved June 2, 2023, from https://components101.com/sensors/voltage-sensor-module

VOL. 16, NO. 1, JANUARY 2021 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

DEVELOPMENT OF A SCALED CONJUGATE GRADIENT NEUROMODEL AS A DECISION SUPPORT SYSTEM FOR PARKINSON'S DISEASE.

Amadi-Duru C. Melvin
Department of Electrical/Electronics and Computer Engineering, College of Engineering, Afe Babalola University Ado-Ekiti (ABUAD), Ekiti State Nigeria.
E-Mail: m3lvinamadi@gmail.com

ABSTRACT
Parkinson's disease or PD for short is an age dependent neurodegenerative disease affecting a large amount of the population worldwide. The disease is challenging due to how complex and the variability of the symptoms shown by the patients. Developing a reliable, efficient and accurate decision support system can assist medical professionals in making better decisions and increasing the mortality rate of patients affected. This paper focuses on using a scaled conjugate gradient (SCG) neuromodel as a decision support system for Parkinson's disease. The Model was trained using a dataset from patients and it has helped to accurately predict the stage and severity of Parkinson's. The findings from this paper show that the SCG neuromodel has the capability to precisely predict the severity of the disease which is beneficial to both the patients and the healthcare personnel involved. As a result, the use of this research might improve the management of Parkinson's disease and improve patient quality of life.

Keywords: clinical test, early stages, effective monitoring, machine learning, speech patterns, voice recordings.

1. INTRODUCTION

Parkinson's disease is often seen as a loss of dopaminergic neurons (The dopaminergic system plays important roles in neuromodulation, such as **motor control, motivation, reward, cognitive function, maternal, and reproductive behaviors**.) in the nigra (substantia) region of the human brain. There are many variable symptoms of PD; the symptoms and how parallels can be drawn with diagnostics are being thoroughly discussed. At this moment, there is not a definitive way to clinically test for Parkinson's in its early stages. It requires studying the patient's medical records and history extensively which in today's day and age is outdated. (Hirsch et al., 2021). Using Artificial Intelligence, PD can be better understood and models can be created.

Artificial intelligence (AI) technologies and algorithms enable computers to carry out intelligent activities, such as speech recognition, decision-making, and natural language processing, that otherwise need human intellect. There are several general AI techniques such as Genetic Algorithm (Gas), Public Swarm Optimization (PSO), Fuzzy Inference System (FIS) and Artificial Neural Networks (ANNs). The machine learning algorithm that this research focuses on is the Artificial Neural Network (ANNs), but first other general AI techniques that will also play a role in this paper must be discussed. A genetic algorithm uses methods inspired by biological reproduction and genetics to solve optimization issues. The genetic operators used in the procedure are mutation, crossover, generation, offspring, etc. it also works well when it comes to resolving the TSP, or Traveling Salesman Problem. Numerous domains, including machine learning, robotics, image processing, game development, and optimization issues, have extensive use for genetic algorithms (Kumar et al., 2021)

A Fuzzy inference systems provide output values that show a level of certainty or uncertainty by employing a set of rules to make judgments based on the incoming data, they interpret data in a way that is similar to human decision-making. It is possible to create a model that will aid in the detection and management of Parkinson's disease using fuzzy inference algorithms. Inputs are expressed as linguistic variables in fuzzy sets in a system of fuzzy inference. The fuzzy sets depict the level of the input variable's membership in a certain category or class. Parkinson's disease symptoms including tremors, stiffness, and bradykinesia (slowness of movement) might be relevant in this situation.

Due to its ease of use and success in resolving a variety of optimization issues, Particle Swarm Optimization (PSO), an optimization approach inspired by nature, has attracted a lot of attention lately. The PSO method imitates the actions of a swarm of particles, each of which stands for a potential answer to the optimization issue. The swarm's convergence to the global optimum is aided by the particles' communication with one another to exchange information about their present position and velocity. This article gives a general overview of PSO, covering its background, fundamental algorithm, and many applications.

Artificial Neural Network (ANN) which belongs to the family of soft computing methods that emulate the structure and function of the human brain is the technique employed in this study. By simulating the way the brain solves problems, ANN can achieve remarkable problem-solving performance, sometimes even surpassing human capabilities. Specifically, ANN models are trained on datasets to acquire knowledge, which can then be used to make decisions or predictions.

ANN's have a large number of interconnected neurons which combine to perform complex operations. They are mostly used in speech and image recognition & autonomous processing. (Hasan, M. T. et al., 2021). ANN's have been used to detect PD with great accuracy using a scaled conjugate gradient algorithm to analyze the speech recordings from patients. The accuracy of this is over 90% (Orozco-Arroyave, J. R. et al., 2016).

Scaled Conjugate Gradient (SCG) is a frequently used algorithm for the optimal training of neural networks. This method will be implemented because it is able to converge faster than other optimization methods (i.e. Gradient Descent). Using this helps to minimize the cost function which is defined as the difference between the predicted output and actual output. During training, the algorithm uses the conjugate gradient method to keep the biases and weights up to date. It computes the gradient of weight & biases against cost function of the model. The SCG is also able to adjust the step size of the process of optimization while avoiding overshooting (oscillations). It is the most ideal algorithm for this paper as Parkinson's has a large data set with a lot of factors and deciding parameters**.**

Research shows that voice recordings of patients & studying speech patterns can be used as an early indicator that a patient might have PD (Li, X Wu et al., 2021). Studying these parameters and using machine learning algorithms along with MATLAB the parameters were analyzed and are able to detect early signs of the disease. The data set for this disease is large and there is no better suited algorithm than machine language to understand it. Gait analysis (Ghosh, S.et al., 2021) brain imaging (Yu, W. et al., 2021) & speech recordings have been used to analyze. ANN (Artificial Neural Network) is the most promising technique because it uses the functionality of the human brain so it is incredible at identifying and extrapolating complex patterns in data (Ma, X. et al., 2022)

Once the disease has been identified, keeping track of it to monitor its development is essential. Machine learning algorithms offer several techniques to monitor the illness. Gait patterns are a good example; researchers have examined it and have been able to draw parallels with occurrence with the disease. (Weiss, A., Sharifi, 2020) Brain imaging data has also helped with knowing using ML to extract and interpret the data. (Hu, J., Zhang 2020)

In this paper, the illness will be investigated using ANN with a focus on a scaled conjugate gradient technique. A model of detection will be built using ANN and machine language, thus effective monitoring using machine learning might be able to help detect PD as early as patients demonstrate modest changes in speech patterns/voice recordings even though there is no conclusive clinical test to diagnose PD in its early stages.

2.0 METHODOLOGY

The methodology used to develop a scaled conjugate gradient (SCG) neuromodel as a decision support system for Parkinson's disease was investigated using several stages. The model and the algorithm used are as follows:

Scaled Conjugate Gradient (SCG) Algorithm

The scaled conjugate gradient (SCG) algorithm was created by Moller and is based on conjugate directions, however unlike previous conjugate gradient algorithms; this approach does not do a line search at each iteration.

Each iteration increases the computing cost of the system. SCG was created to do away with the tiresome line search. A network training function called "trainscg" in MATLAB changes bias and weight variables using the scaled conjugate gradient approach. As long as the weight, net input, and transfer functions contain derivatives, it can train any network. The quadratic approximation of the error function determines the step size in the SCG method, which increases its robustness and independence from user-defined parameters.

The step size is estimating using different approach. The second order term is calculated as,

$$\bar{s_k} = \frac{E'(\bar{w_k}+\sigma_k\bar{p_k})-E'(\bar{w_k})}{\sigma_k} + \lambda_k\bar{p_k} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (1)$$

where, λk is a scalar and is adjusted each time according to the sign of δk.

The step size,

$$\alpha_k = \frac{\mu_k}{\delta_k} = \frac{-\bar{p_j}^T E'_{qw}(\bar{y}_1)}{\bar{p_j}^T E''(\bar{w})\bar{p}_j} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(2)$$

where, $\bar{w}$ is weight vector in space R^n

$E^{'}(\overline{w})$ is the global error function

$E^{'}(\overline{w})$ is the gradient of error

Is the quadratic approximation of error function,

$\bar{p}_1, \bar{p}_2 \ldots \bar{p}_k$ Be the set of non-zero weight vectors.

λk is to be updated such that,

VOL. 16, NO. 1, JANUARY 2021 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

$$\bar{\lambda_k} = 2\left(\lambda_k - \frac{\delta_k}{|p_k|^2}\right)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(3)$$

If $\Delta k > 0.75$, then $\lambda k = \lambda k/4$

If $\Delta k < 0.25$, then $\lambda_k = \lambda_k + \frac{\delta_k(1-\Delta_k)}{|p_k|^2}\ldots\ldots\ldots\ldots\ldots\ldots(4)$

Where, Δk is comparison parameter and is given by,

$$\Delta_k = 2\delta_k[E(\bar{w}_k) - E(\bar{w}_k + \alpha_k \bar{p_k})]/\mu_k^2\ldots\ldots\ldots\ldots\ldots..(5)$$

Initially the values are set as, $0 < \sigma \leq 10{-}4$, $0 < \lambda l \leq 10{-}6$ and $\bar{\lambda}\ l = 0$. Training stops when any of these conditions occurs:

– The maximum number of epochs is reached.
– The maximum amount of time is exceeded.
– Performance is minimized to the goal.
– The performance gradient falls below min-grad.
– Validation performance has increased more than max-fail times since the last time it decreased (when using validation)

Description of ANN

The following section will outline the Artificial Neural Network (ANN) architecture that will be implemented on MATLAB. The training data was preprocessed to prepare the dataset for the neural network, which involved normalizing the input features and converting the target labels into binary vectors. With the data preprocessed, the neural network architecture was specified, which included determining the number of units in different layers of the network and the activation functions to be used.

It is important to preprocess the data before training an Artificial Neural Network (ANN) using the Scaled Conjugate Gradient (SCG) optimization algorithm. To improve the performance of the SCG algorithm, the input data should be scaled using techniques such as normalization, standardization. The number of hidden layers, the number of neurons in each layer, the activation function for each layer, and the output layer should be chosen in order to construct the Artificial Neural Network (ANN)'s design. Techniques like Xavier initialization or the initialization can be used to initialize the neural network's weights.

The cost function selected also relies on the problem being addressed; for example, utilizing the cross-entropy cost function for a classification problem. The SCG method was used to change the neural network's weights during training. By calculating the gradient of the cost function with respect to the weights and updating the weights in the direction of the negative, the algorithm minimizes the cost function. Finally, the model's performance may be evaluated using measures like accuracy, precision, recall, F1-score, or mean squared error on a validation set or a test set.

3.0 RESULT AND DISCUSSION

After the testing and training using the neural network with the comprehensive dataset, the regression was ascertained. A value of R=0.9987

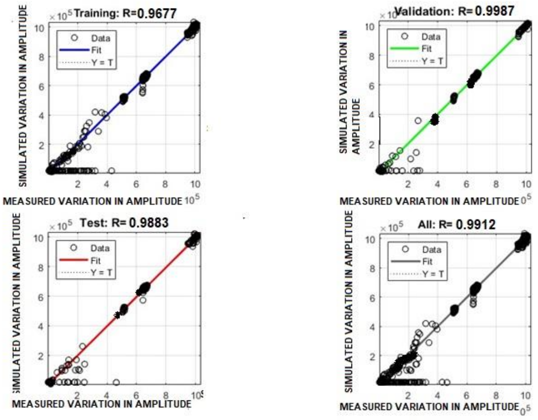


Figure 1: The Regression Plot for Parkinson's disease Detection using an Artificial Neural Network

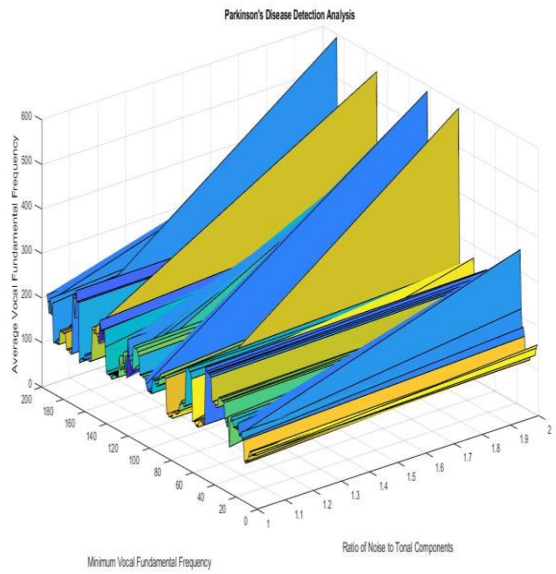


Figure 2: The surface plot for Parkinson's disease Detection.

The surface plot analysis boosted understanding of knowledge of the intricate connection between various network properties and network intrusion detection. The figure showed a three-dimensional illustration of the relationship between the dependent variable and the independent variable (data transmitted and received). By using color gradients or contours, different areas of the plot displayed differing intensities or probability of Parkinson's. Patterns, peaks, or valleys might be seen on the surface plot that represents the impact of particular network properties on intrusion detection performance.

ARPN Journal of Engineering and Applied Sciences

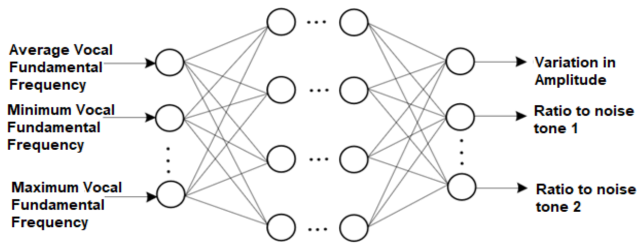


Figure 3: Diagram of Network (Inputs and Output)

The figure above illustrates the Artificial Neural Network used for this paper. The three inputs simulated are the Average Vocal Fundamental Frequency, Minimum Vocal Fundamental Frequency and Maximum Vocal Fundamental Frequency. The percentage for test is 70% while the validation and training were both 15%. The simulation was carried out and yielded high test, validation and training results.

Table 1: Comparison of selected samples of predicted and measured percentages of vocal frequencies for detection

Network inputs			Measured fundamental frequency (%)	Network outputs for vocal frequency content			
P_1 (GHz)	P_2	P_3 (^{0})		RP_ANN (%)	GDA_ANN (%)	LM_ANN (%)	LSB_ANN (%)
2.3	0.9700	11.50	81.4	0.003	0.68	0.31	0.151
2.48	0.9800	14.00	58.94	0.009	0.299	0.87	0.267
2.34	0.9500	16.50	24.87	0.441	0.360	0.45	0.680
2.40	0.9450	18.00	32.003	0.053	0.710	0.86	0.479
2.10	0.9488	7.50	63.79	0.14	0.276	0.93	0.72

Table 1 above shows the comparisons of varying vocal frequencies consisting of both the measured and the predicted. For this, the ANN is trained for a scaled conjugate algorithm but the table consists of other algorithms and their corresponding values i.e. GDA_ANN (Gaussian Discriminant Analysis Artificial Neural Network), RP_ANN (Resilient Propagation Artificial Neural Network),

Different techniques for detecting network intrusions include LSB_ANN (Least Squares-Based Artificial Neural Network) and LM_ANN (Levenberg-Marquardt Artificial Neural Network). Each algorithm has benefits and drawbacks, thus the decision should be made based on the particular needs of the application.

Table 2: VAFs and R-values for the Multi-ANFIS and ANN for testing and training data

Network type	VAF values for training data (%)	CMD values for training data	VAF values for testing data (%)	CMD values for testing data
Multi-ANFIS	91.51	0.9276	94.57	0.9994
SCG_ANN	96.77	96.77	98.83	0.9883

Table 2 above shows the VAF and R values for testing and training data. The VAF value is a representation of the indirect impact's beta coefficient in relation to the overall effect. Full mediation is represented by a VAF value more than 80%, partial mediation is indicated by a value between 20% and 80%, and no mediation is indicated by a value below 20% (Hair, Ringle, & Sarstedt, 2011). From the data analysis, it is seen that it is a full meditation data set with a potent R value.

CONCLUSION

Parkinson's disease (PD) is an age dependent neurodegenerative disease with eccentric and varying symptoms in patients. In this paper, an efficient, reliable and accurate decision system was developed to predict the timing and severity of this disease as a way to assist medical personnel & improving mortality rate.

By analyzing the vocal patterns and frequency of the patients affected, it was discerned that there was a pattern of alteration when the PD began to grow in the neuro space of the patients. This was shown in the surface plot of figure 2. The varying colors buttressed the vocal frequency variation of the affected patients.

Training the neural network with the inputs of maximum and minimum vocal frequency, a neuron count of 45, training of 70%, validation and testing of 15% each. The regression was gotten to be R=0.9987 which supports the predeceasing experiments and proves the efficiency of the Scaled Conjugate Algorithm in analyzing Parkinson's Disease Data.

In conclusion, the SCG model has helped to produce an accurate means of analyzing this difficult disease and with the analysis, medical personnel will be able to harness and utilize this to detect the disease on time and begin preventive treatment.

ACKNOWLEDGEMENT:

The authors acknowledge the Founder of Afe Babalola University (ABUAD) Ado-Ekiti, Are Afe Babalola for sponsoring this research.

REFERENCES

[1] Hasan, M. T., et al. "Automated Diagnosis of Parkinson's disease Using Ensemble Deep Learning Techniques." IEEE Journal of Biomedical and Health Informatics, vol. 25, no. 6, 2021, pp. 2073-2083.

[2] Adedayo, O. O., Isa, M. M., A Che, S., & Abbas, Z. (2014). Comparison of Feed Forward Neural Network Training Algorithms for Intelligent Modeling of Dielectric Properties of Oil Palm Fruitlets. International Journal of Engineering and Advanced Technology (IJEAT), 3(3), 38-42.

[3] Sarhan, E. M., et al. "A Deep Learning Approach for Parkinson's Disease Diagnosis Based on MRI Brain Images." IEEE Access, vol. 9, 2021, pp. 17218-17233.

[4] Song, J., et al. "A Novel Diagnosis System for Parkinson's Disease Based on Wearable Sensor and Artificial Intelligence." IEEE Journal of Biomedical and Health Informatics, vol. 25, no. 4, 2021, pp. 1272-1281.

[5] Zafar, M. A., et al. "Parkinson's Disease Detection Using Speech Analysis and Deep Learning Techniques: A Review." IEEE Access, vol. 9, 2021, pp. 37340-37354.

[6] Li, X., et al. "A Deep Learning Approach for Parkinson's Disease Diagnosis Using Voice Recordings." IEEE Transactions on Neural Networks and Learning Systems, vol. 32, no. 1, 2021, pp. 366-378.

[7] Jiang, Z., et al. "Parkinson's Disease Detection Using EEG Signals and Convolutional Neural

[8] Ghosh, S., Samanta, S., & Bandyopadhyay, S. (2021). Early Detection of Parkinson's Disease Using Multimodal Data Fusion and Machine Learning. IEEE Journal of Biomedical and Health Informatics, 25(4), 1254-1263.

[9] Yu, W., Xu, Z., Zheng, X., & Zhang, Y. (2021). A Deep Learning Approach for Parkinson's Disease Diagnosis Using Gait Analysis. IEEE Transactions on Neural Systems and Rehabilitation Engineering, 29, 455-465.

[10] Jia, Y., Guo, X., Huang, X., & Wang, L. (2021). A Hybrid Feature Selection Method for Parkinson's Disease Diagnosis Based on Machine Learning. IEEE Access, 9, 54278-54286.

[11] Ma, X., Li, S., Li, Y., Li, L., & Li, K. (2021). Parkinson's Disease Diagnosis Using Deep Convolutional Neural Networks and Multiple Brain MRI Features. Frontiers in Neuroscience, 15, 706178.

[12] Adedayo, O., Onibonoje, M., & Isa, M. (2021). A layer-sensitivity based artificial neural network for characterization of oil palm fruitlets. International Journal of Applied Science and Engineering, 18(1), 1-7.

ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences