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Solar Based Grass Cutting Robot with Leaf Disease Detection

Bhagyalakshmi V[1]; Sunil Moorti Naik[2]; Apoorva B N[3]; Gowthami M[4]; Preethi N[5]

[1]Assistant Professor, [2,3,4,5] Student

[1,2,3,4,5] Department of Electronics and Communication Engineering Maharaja Institute of Technology, Thandavapura (MITT) Mysuru, India

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Abstract: This project is about developing a grass cutting machine that runs on solar power instead of electricity or fuel. The main idea is to make a simple, eco-friendly, and cost-effective solution for cutting grass in gardens, parks, and small farms. The machine uses a solar panel to collect energy from the sun, which is then stored in a rechargeable battery. This stored energy is used to power the motor and blades of the grass cutter. Since it uses solar energy, it helps reduce pollution and does not rely on fossil fuels or electricity from the grid. It also saves money in the long run, as there is no need to buy petrol or pay electricity bills. The machine is easy to operate, lightweight, and can be used in rural or remote areas where power supply may be limited. The main goal of this project is to promote the use of renewable energy and provide a practical tool for maintaining green spaces in an environment-friendly way.Grapes are a globally cultivated fruit crop, but their productivity is significantly affected by various leaf diseases. Early detection and accurate classification of these diseases are essential for effective management and prevention. This project presents an intelligent system for automated grape leaf disease classification using deep learning techniques.

Keywords: *Solar Energy; Grass Cutting Machine; Renewable Energy; Eco-friendly Technolog; Deep Learning; Grape Leaf Disease; Image Classification; Smart Agriculture*.

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I. INTRODUCTION

This project is based on using solar energy to power a grass cutting machine. The main purpose of this project is to reduce the use of fuel and electricity while providing a clean and green method for cutting grass. A solar panel is attached to the machine, which absorbs sunlight and converts it into electrical energy.This energy is stored in a rechargeable battery and used to run the motor that turns the blades for cutting grass. The machine can work for a good amount of time when the battery is fully charged. This makes it useful in places where electricity is not available or where fuel costs are high. It is also much quieter and safer for the environment compared to traditional grass cutters that use petrol or diesel.Agriculture plays a vital role in sustaining the globaleconomy, and grape cultivation is one of the most significant segments of the horticulture industry. Grapes are highly valued for their use in fresh consumption, winemaking, and other food products. However, grapevines are prone to a variety of leaf diseases such as Black rot, Esca (Black Measles), and Leaf Blight (Isariopsis Leaf Spot), which can severely affect crop yield and quality if not identified and treated in time.

Traditional methods of disease identification often rely on visual inspection by agricultural experts, which can be time- consuming, error-prone, and not always accessible to farmers in remote areas. With the advancement of artificial intelligence and deep learning, it is now possible to develop automated and accurate plant disease detection systems that assist in early diagnosis and intervention.In this project, we present an automated solution for classifying grape leaf diseases using a Convolutional Neural Network (CNN) based on the VGG16 architecture. The model is trained on a dataset containing images of healthy and diseased grape leaves categorized into four classes. The goal is to accurately identify the type of disease affecting a grape leaf based on image inputs.

II. METHODOLOGY

The methodology for developing the grass cutting using the Aurduino Uno R4 microcontroller involves several key steps, including system design, hardware integration, software development, and testing. The system design phase involves defining the requirements and selecting the appropriate components, such as the Aurduino

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microcontroller, DHT11 sensor, I2C LCD display, Bluetooth module (HC-05), Power divider, Solor Panal, and relays.

The hardware integration phase involves connecting these components to the Aurduino microcontroller and ensuring that they function correctly together. The software development phase involves writing the code for the Aurduino microcontroller to read data from the DHT11 sensor, display it on the I2C LCD, communicate with the Bluetooth module, and control the relays based on the comparison between the measured and set temperature and humidity values. The testing phase involves verifying that the system operates as intended and making any necessary adjustments to ensure optimal performance. The development of the grape leaf disease classification system follows a structured methodology comprising several key phases, from data preparation to model deployment. The overall process is outlined as follows:

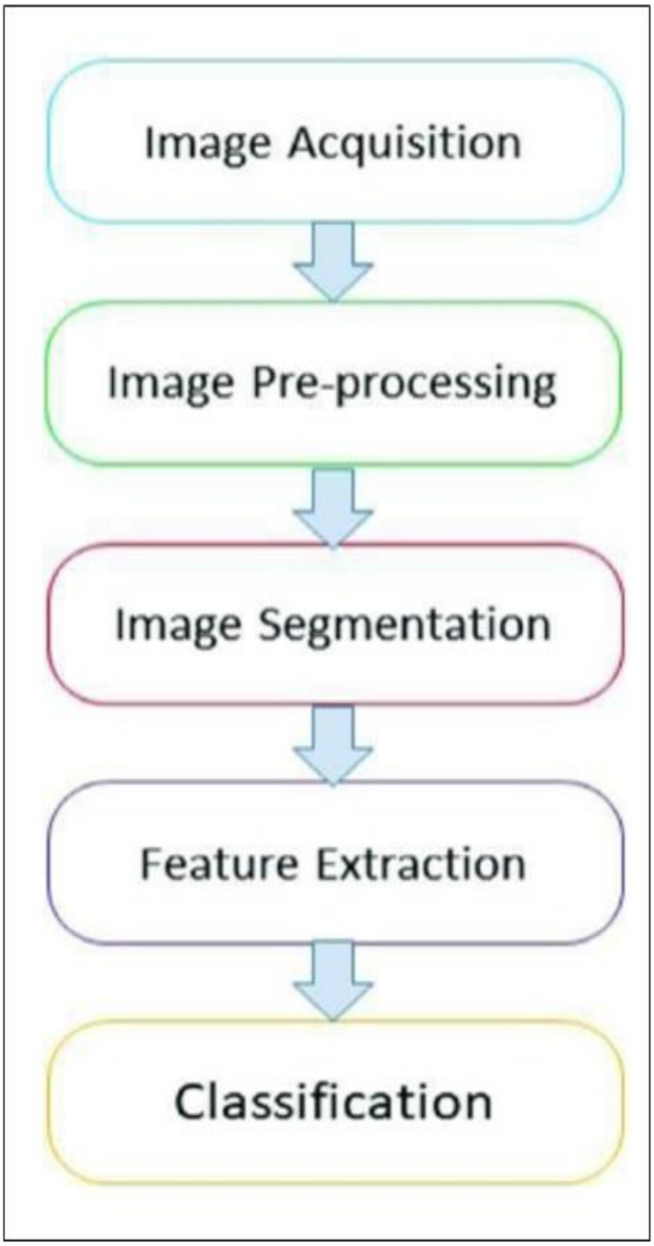

Fig 1 Flowchart

The dataset used in this project is sourced from the Plant Village repository, specifically focusing on grape leaves affected by different diseases—*Black rot*, *Esca (Black Measles)*, *Leaf Blight (Isariopsis Leaf Spot)*, and *Healthy* leaves. Each image is labeled accordingly and stored in separate folders. The images are preprocessed by resizing them to a uniform input size compatible with the VGG16 model (typically 224x224 pixels), normalizing pixel values, and applying data augmentation techniques such as rotation, flipping, and zooming to improve the model's robustness and prevent overfitting.The pre-trained **VGG16** model is used as the base for classification due to its proven performance in image recognition tasks. The top layers of the original VGG16 model are removed and replaced with custom dense layers suitable for the four-class classification task. Transfer learning is employed, where the weights of the base layers are frozen, and the newly added layers are trained using the grape leaf dataset. The model is trained using categorical cross-entropy as the loss function and an optimizer like Adam to update the weights. The training process includes validation to monitor accuracy and loss metrics. After training, the model is evaluated on a separate test set to measure its accuracy, precision, recall, and F1-score. Once the model achieves satisfactory performance, it is saved in HDF5 (.h5) format using Keras for integration into the web application.

A user-friendly Flask-based web application is developed to serve the trained model. The application includes user authentication, an image upload feature, and a backend that handles model loading and prediction. Upon uploading a grape leaf image, the Flask backend preprocesses the image, feeds it into the trained VGG16 model, and returns the predicted class (disease type or healthy). applications. In this project, the R4 board is housed in the disk-shaped rescue module that is lowered into the bore well. Its main responsibility is to control the servo motor that drives the robotic arm designed for rescuing the trapped child. The robotic arm is equipped with soft gripping brushes to ensure a gentle and secure hold on the child during the rescue. The Arduino Uno R4 WiFi reads commands and precisely positions the servo motor to open or close the gripper based on real-time visual feedback provided by the ESP32-CAM. The board is either powered by a 5V battery or a wired connection from the top module. Its processing capability and wireless communication features make it ideal for managing critical actions in confined, remote conditions, increasing both efficiency and safety in life-saving operations.

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III. MODULES AND ITS IMPLEMENTATION

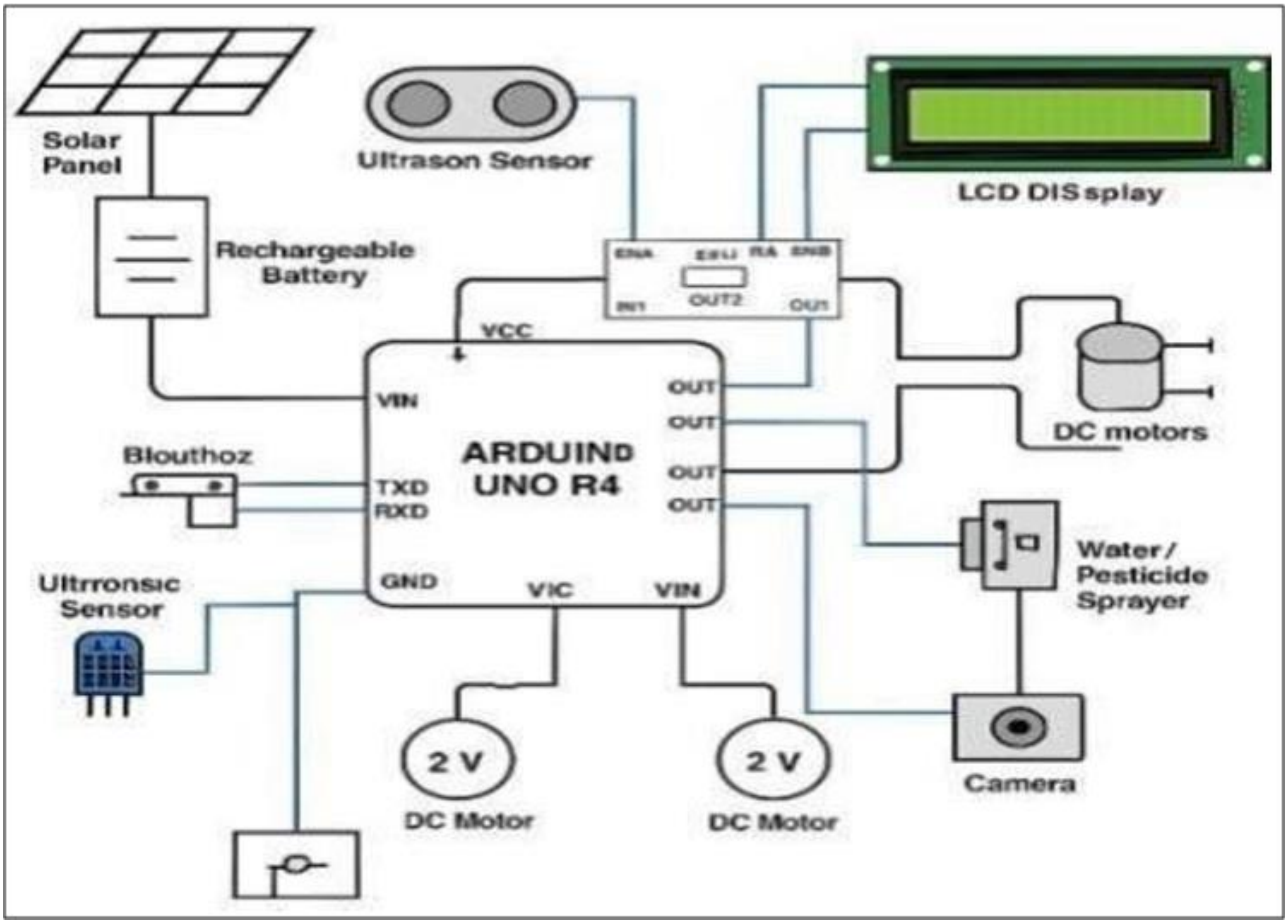

Fig 2 Block diagram

The Arduino UNO R4 WiFi combines the processing power and exciting new peripherals of the RA4M1 microcontroller from Renesas with the wireless connectivity power of the ESP32-S3 from Espress if. On top of this, the UNO R4 WiFi offers an on-board 12x8 LED matrix, Qwiic connector, VRTC, and OFF pin, covering all potential needs makers will have for their next project.With the UNO R4 WiFi, you can easily upgrade your project and add wireless connectivity to expand the reach of your current setup. If this is your first project, this board has everything you need to spark your creativity.

DC A DC motor operates based on the Lorentz force, which states that when a current- carrying conductor is placed in a magnetic field, it experiences a force that makes it move. In a DC motor, this conductor is the armature (rotating part of the motor), and the magnetic field is generated by either permanent magnets or electromagnets

A 100 RPM DC motor is a direct current motor designed to rotate at a speed of 100 revolutions per minute (RPM) under normal operating conditions. It is commonly used in various applications where low-speed, high-torque operation is required.

Solar panels are usually made from silicon, or another semiconductor material installed in a metal panel frame with a glass casing. When this material is exposed to photons of sunlight (very small packets of energy) it releases electrons and produces an electric charge

HC-06 is the popular Bluetooth module. This HC06 module is slave mode only. It's very easy to add wireless serial connectivity for your device with this module. Examples for Arduino and other boards are available. Once you pair with other Bluetooth devices you work like with normal UART to exchange data.

This module has built-in 3.3V voltage regulator and helps to break out the important pins (Vcc, Gnd, Txd, Rxd). Based on CSR BC4 chip, Bluetooth V2.0 + EDR. You can set the baud rate, name and pair password by AT commands when there is no Bluetooth connection. This module is a slave- it can be paired with Computer- Bluetooth master- mobile phone- PDA- PSP and so on.

This is a basic 16 character by 2 line Alphanumeric display. Black text on Green background. Utilizes the extremely common HD44780 parallel interface chipset . Interface code is freely available. You will need Minimum 6

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general I/O pins to interface to this LCD screen. Includes LED backlight. Works in 4bit and 8 bit Mode.

DHT11 is a Humidity and Temperature Sensor, which generates calibrated digital output. DHT11 can be interface with any microcontroller like Arduino, Raspberry Pi, etc. and get instantaneous results. DHT11 is a low cost humidity and temperature sensor which provides high reliability and long term stability.

It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and outputs a digital signal on the data pin (no analog input pins needed). Its very simple to use, and libraries and sample codes are available for Arduino.

This 1-channel 5V control Single-Pole Double-Throw (SPDT) High-level trigger AC power relay board can be controlled directly via a microcontroller and switch up to 10A at 250 VAC. The inputs of 1 Channel 5V Relay Module are isolated to protect any delicate control circuitry. The default state of the relay when the power is off for COM (Power) to be connected to NC (Normally Closed). This is the equivalent of setting the relay board IN pin to HIGH (has+5V sent to it).

IV. MODELING AND ANALYSIS

The rapid advancement of automation and artificial intelligence has opened new avenues for developing intelligent systems in agriculture. Among these innovations, the integration of solar-powered robotics with plant disease detection has proven to be a sustainable and efficient solution for modern-day farming and lawn maintenance. This paper presents the modeling and analysis of a multifunctional system that combines a solar-based autonomous grass cutting robot with an AI-powered grape leaf disease detection module. The fusion of these technologies addresses key issues such as environmental sustainability, labor shortages, and the timely diagnosis of plant diseases, which significantly affect crop yield

The core of the system consists of two primary modules—an autonomous grass cutting robot powered entirely by solar energy, and a deep learning-based leaf disease detection system using a Convolutional Neural Network (CNN). These components work either independently or collaboratively to maintain agricultural fields or gardens, while simultaneously detecting any potential signs of disease on grape leaves.

The solar-based grass cutting robot is designed using an Arduino UNO R4 microcontroller, which acts as the brain of the system. The robot receives power through a 12V solar panel connected to a rechargeable battery. This setup ensures continuous operation in sunny environments without the need for external power sources, making it especially useful in remote or off-grid locations. The stored energy is distributed to various modules such as DC motors, sensors, the LCD display, and control circuits. A pair of 12V DC motors—each capable of 100 RPM—is connected through an L298N motor driver, enabling the robot to move and cut grass using a rotary blade mechanism. The robot navigates autonomously with the help of ultrasonic sensors that detect obstacles and adjust its path accordingly. The inclusion of a Bluetooth module (HC05) allows for manual control via a mobile application, offering flexibility and user intervention if necessary.

V. RESULT AND DISCUSSION AND CONCLUSION

The developed solar-based grass cutting robot with integrated leaf disease detection system effectively demonstrates the use of renewable energy and AI for smart agriculture. Testing showed successful autonomous grass cutting and accurate identification of grape leaf diseases using a VGG16-based CNN model. This dual-function robot not only reduces labor and environmental impact but also enhances crop monitoring and health management. Challenges like variable sunlight and uneven terrain were noted but are manageable with optimized design. Overall, the project showcases a sustainable, efficient solution for lawn care and early disease diagnosis, promoting eco-friendly practices and precision agriculture in rural settings.

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