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IoT Grass Cutting Robot

Nagini Yarramsetty[1,*], Venkata Sushma Chinta[1], D. Sudhiksha[2], K. Vishrutha Reddy[2], N. Meenakshi Reddy[2], Saneela Z.[2], Saryu A. Reddy[2]

Abstract

The demand for efficient and sustainable lawn care solutions has escalated with the increasing urbanization and the need for environmentally friendly practices. In response to this, our group embarked on the development of an innovative IoT-enabled grass cutting robot. This project aims to address the limitations of traditional lawn mowing methods by integrating modern technology to automate and optimize the maintenance process. The proposed grass cutting robot leverages Internet of Things (IoT) principles to enhance functionality and user experience. Equipped with sensors, actuators, and connectivity modules, the robot can autonomously navigate through the lawn, detect obstacles, and adjust its cutting pattern accordingly. Real-time data acquisition enables remote monitoring and control, empowering users to manage their lawn care tasks conveniently through a mobile application or web interface.

Keywords: Internet of Things, L298N driver, brushed DC motor, brushless DC motor, RS555 motor

INTRODUCTION

The completely in control solar lawn cutter is an automated vehicle that uses solar energy to cut grass wholly without any human intervention, while also avoiding challenges.

Both the grass cutter motor as well as the vehicle movement motors are powered by 12 V batteries. Additionally, we use a photovoltaics to remove the need for external powering of the batteries.

An ESP32 family microcontroller has communication with the vehicle and lawn cutter motors to regulate their operation. Additionally, it has a camera interface, particularly for recognition of objects (Figure 1). The microprocessor propels the vehicle's motors onwards if there are no impediments observed. When the ultrasonic sensor identifies barriers, the processing unit cuts the lawn cutter motor to protect the item, person, or animal. The robot rotates using the microcontroller until it passes the hurdle, at which point it moves the grass cutter forward once more.

***Author for Correspondence**
Nagini Yarramsetty
E-mail: ynagini_mech@cbit.ac.in

[1]Assistant Professor, Mechanical Engineering Department, Chaitanya Bharathi Institute of Technology, Hyderabad, Telangana, India
[2]Student, Department of Computer Science and Engineering, Chaitanya Bharathi Institute of Technology, Hyderabad, Telangana, India

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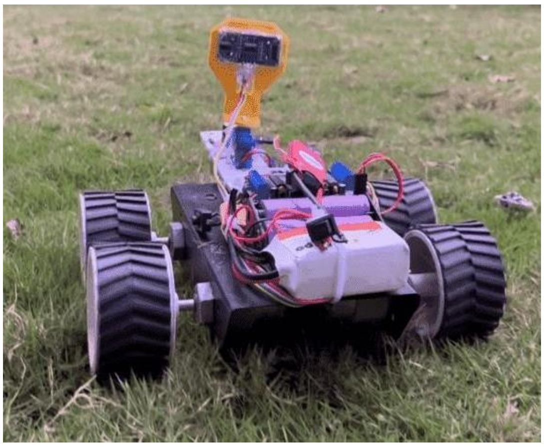

Figure 1. Grass cutting Robot.

USES OF THE PROJECT

A grass-cutting robot powered by IoT (Internet of Things) technology offers several benefits and applications:

1. Convenience and Time-Saving:
    - *Autonomous Operation:* The robot handles mowing duties without requiring constant human supervision, freeing up your time.
    - *Scheduling and Remote Control:* You can schedule mowing sessions through a smartphone app or web interface, eliminating the need to manually mow whenever needed.
2. Efficiency and Potential Environmental Benefits:
    - *Optimized Path Planning:* The robot can potentially navigate the lawn in an optimized path, reducing wasted movement and energy consumption.
    - *Solar Power Integration (optional):* If your design incorporates solar panels, the robot can operate using renewable energy, lowering its environmental impact.
3. Improved Safety (compared to traditional lawnmowers):
    - *Obstacle Detection:* Sensors can help the robot identify and avoid obstacles like toys, furniture, or pets left on the lawn.
    - *Remote Monitoring:* The ability to monitor the robot's progress remotely allows for quick intervention if needed.

Overall, the IoT-based grass cutting robot offers a solution for maintaining a well-kept lawn with greater ease, efficiency, and potentially less environmental impact compared to traditional methods.

LITERATURE REVIEW

The development of an IoT-enabled grass cutting robot integrates various technological advancements from fields such as robotics, automation, Internet of Things (IoT), and smart home systems. This literature review explores existing research and developments related to these areas to provide a comprehensive background for the project.

Robotics and Automation in Lawn Maintenance

Robotic lawn mowers have been in development for several years, with early models focusing on basic autonomous navigation and mowing capabilities. Studies have shown significant advancements in the algorithms and hardware used for navigation, obstacle detection, and power management.

Autonomous Navigation: Research by Ferri *et al.* highlights the use of GPS and boundary wire systems to guide robotic lawn mowers [1]. Modern approaches incorporate machine vision and AI for improved accuracy and flexibility in navigation [2].

Obstacle Detection: Advances in sensor technology, including ultrasonic and infrared sensors, enable robots to detect and avoid obstacles effectively. A study by Moulton and Yao (2019) discusses the integration of multi-sensor systems to enhance obstacle detection and collision avoidance [3].

Internet of Things (IoT) Integration

IoT technology enhances the functionality of robotic lawn mowers by enabling remote monitoring, control, and data collection.

Remote Monitoring and Control: IoT platforms allow users to interact with robotic lawn mowers via mobile applications, providing real-time updates and control options. Research by Park *et al*. illustrates the implementation of IoT-based control systems for home automation [4].

Data Analytics: IoT-enabled robots can collect operational data, which can be analyzed to optimize performance and predict maintenance needs. According to Singh and Singh, predictive maintenance using IoT data analytics significantly reduces downtime and maintenance costs [5].

Power Management and Sustainability

Efficient power management is crucial for the performance and sustainability of robotic lawn mowers [5].

Battery Management: Studies by Zhang *et al*. show how advanced battery management systems (BMS) improve the efficiency and lifespan of batteries used in robotic lawn mowers [6].

Renewable Energy Integration: There is ongoing research into integrating solar panels with robotic mowers to extend their operational time and reduce reliance on external power sources [7].

Safety and Efficiency

A vital field of research is making sure automated lawn mowers are reliable and secure.

Safety Mechanisms: Literature by García and González explores the implementation of safety features such as automatic shutoff when obstacles are detected or when the robot is lifted [8].

Efficiency Algorithms: Optimization algorithms for mowing patterns are critical for minimizing energy consumption and reducing mowing time. A study by Leite *et al*. presents various path-planning algorithms that enhance the efficiency of robotic mowers [9].

Future Trends and Innovations

Artificial intelligence (AI) and algorithmic learning (ML) are employed in the field of lawn care robots to further improve their skills.

AI and Machine Learning: AI and ML are being used to improve navigation, obstacle detection, and adaptive mowing strategies. Research by Patel *et al*. demonstrates the application of AI in creating more intelligent and adaptive robotic systems [10].

This literature review provides a comprehensive understanding of the current state of technology and research relevant to the development of an IoT-enabled grass cutting robot, offering insights into the various components and innovations that drive this field forward.

USES AND FUNCTIONALITY OF COMPONENTS

ESP32: The ESP32 is a Wi-Fi module that can be programmed via a basic yet powerful Arduino Uno (Figure 2). It has USB-TTL built in, and it is plug-and-play; Wi-Fi networking, event-driven API for network-based applications, and has a PCB antenna [11].

Figure 2. ESP32.

L298N Driver: This gives you complete oversight over the direction and speed of one bipolar stepper motor (Figure 3), or two parallel DC motors [12–14]. Motors experiencing a voltage between 5 and 35 V DC can be utilized with the L298N H-bridge unit.

DC Motor: Any rotational electrical equipment that translates electrical energy from direct current into biomechanical energy is called a DC motor. The most prevalent kinds are dependent on the forces that arise from magnetic fields. The fundamental principle utilized by nearly any form of DC motor, whether it be electronic or electromechanical, allows the unit to periodically alter the direction of current flow in a specific region (Figure 4). DC motors were the first to be widely used because they could be powered by the direct-current lighting power distribution systems that were already in place. By altering the supply voltage or the current strength in the field windings, a DC motor's speed may be controlled across a wide range. Small DC motors are used in tools, toys, and conveniences [13].

Despite the universal motor is lightweight and suitable for portable power tools and appliances, it may run on direct current. Larger DC motors are utilized in steel rolling mill drives, elevators, hoists, and electric vehicle propulsion. The advancement about electronics has made it practical to use AC motors in numerous applications over DC motors.

Brushed DC Motor

The brushed DC electric motor provides torque directly from the DC current supplied to the motor utilizing internal commutation, stationary magnets (either permanent or electromagnets), and whirling electrical magnets [14].

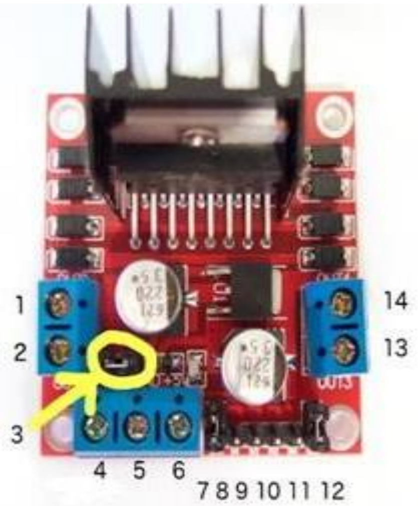

Figure 3. L298N Driver.

Figure 4. DC Motor.

A brushed DC motor's inexpensive starting cost, great dependability, and easy motor speed control are among the many advantages it offers. The limited lifespan and significant maintenance requirements for high-intensity applications are its drawbacks. The commutator should be maintained or replaced on an annual basis, and the carbon brushes and wells that carry the electric current should also be serviced.

These parts are required to deliver electrical power from the motor's outside to the rotor's internally spinning wire windings. Conductors are what make up brushes [15].

Brushless DC Motor

Brushless DC motors generally employ one or more permanent iron magnets in the rotor and the electromagnets on the motor housing for the armature [16].

DC is converted to AC via a motor controller. Since there is no need to transfer power from outside the motor to the whirling rotor, this design is mechanically simpler than brushed motors. The motor controller will precisely regulate the timing, phase, and other aspects of the current passing through the rotor coils to enhance torque, conserve power, regulate speed, and even apply brakes for pausing by using Hall effect sensors or other similar devices that recognize the rotor's location [17].

Brushless motors provide advantages of great efficiency, long lifespan, and little to no maintenance. High starting prices and more intricate motor speed controllers are drawbacks. A few of these brushless motors are occasionally called "synchronous motors" even though, unlike standard AC synchronous motors, they do not have an external power source to keep pace with [18].

Permanent Magnet Stator

Instead of using a field winding on the stator construction, a PM motor uses PMs to generate the magnetic field that the rotor field interacts with to generate torque. To improve commutation under load, monetary windings along in series with the armature may be effective for large motors.

This field cannot be changed for speed control since it is fixed. In small motors, PM fields (stators) are useful for reducing the field winding's power consumption. The "dynamo" kind of DC motors are larger and have a stator winding.

In the past, field windings were an easier way to get the required level of flux because PMs could not be made to keep high flux if they were disassembled. However, wound fields are usually chosen for big machines since huge PMs are expensive, hazardous, and challenging to put into place.

In order to minimize overall size and weight, and miniature PM motors can use high energy poles that contain neodymium or other key elements, most often neodymium-iron-boron compositions.

Electric equipment with high-energy PMs may compete with any properly designed singly driven synchronous and induction electric machines due to their greater flux density. The miniature motors resemble the image, with the exception that they feature at least three rotor poles (ensuring they can start regardless of the rotor's position) and an outer casing made of a steel tube that magnetically connects to the exterior of the curved field magnet [19].

Battery

The cells have a very big power to weight ratio because of their capacity to deliver strong surge currents; nevertheless, they have a very low energy-to-weight ratio and a low energy-to-volume ratio. They are useful for use in cars to provide the high current sought by vehicle starting units because of those attributes as well as the cost they come with (Figure 5).

Figure 5. Battery RS555 Motor.

Figure 6. RS555 Motor.

RS555 Motor

A DC motor is any moving electrical motor that can convert direct current (DC) electrical energy into kinetic energy. The most prevalent kinds are dependent on the forces that result from magnetic fields. Almost every kind of DC motor has an inherent mechanism, either electronic or electromechanical, that allows it to intermittently alter the direction of the current flowing through a component of the motor's shaft [20].

DC motors were the first type of motor to be widely used, as they could be powered directly by the existing direct-current power distribution networks. The speed of a DC engine may be adjusted in a large range by varying the field windings' current energy or the supply voltage. Appliances, toys, and tools all employ small DC motors. The universal motor, or a lightweight brushed motor employing in lightweight power instruments and appliances, may run on direct current (Figure 6). These days, larger DC motors are utilized in steel twirling mill drives, elevators, hoists, and electric vehicle propulsion. In many applications, AC motors may now be deployed in place of DC motors thanks to the universe of power electronic devices [21, 22].

SPECIFICATIONS OF COMPONENTS

ESP32-10 GPIOs D0-D10, PWM functionality, IIC and SPI communication, 1-Wire and ADC A0 etc., all in one board (Figure 7).

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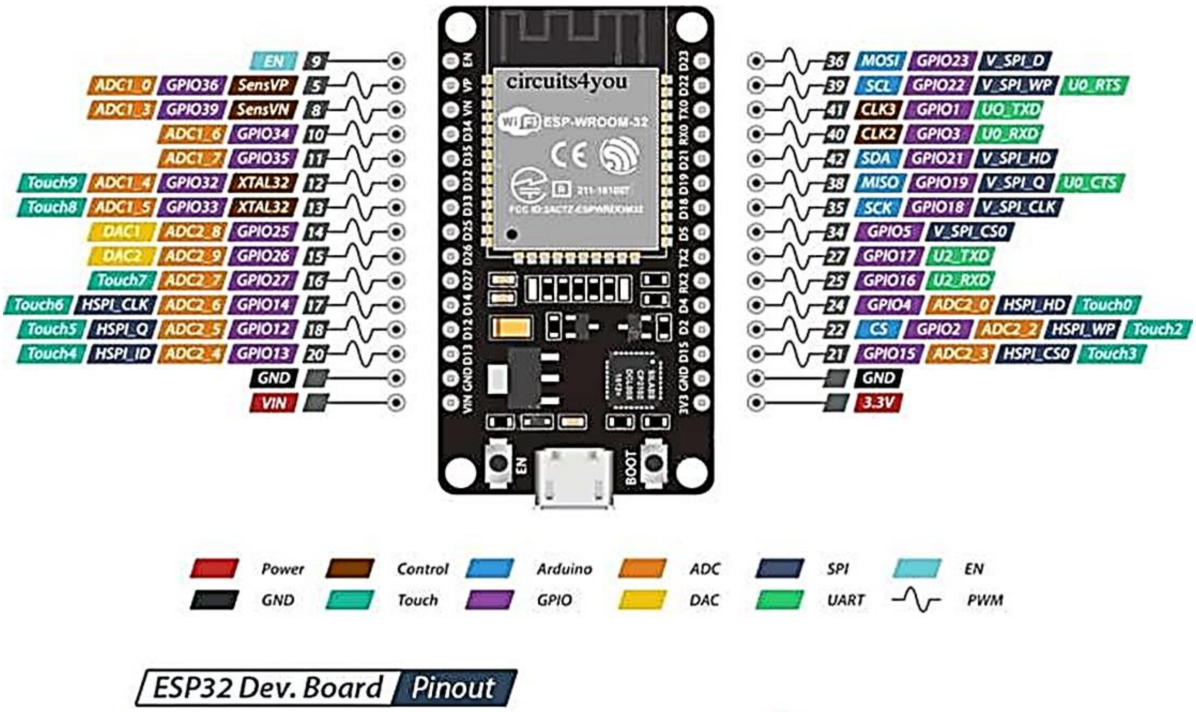

Figure 7. ESP32 Components.

ESP32-CAM

- The smallest 802.11b/g/n Wi-Fi BT SoC module.
- Up to 160 MHz clock speed, summary computing power up to 600 DMIPS.
- Low power 32-bit CPU, can also serve the application processor.
- Built-in 520 kb SRAM, external 4 MP SRAM.
- Supports UART/SPI/I2C/PWM/ADC/DAC.
- Supports OV2640 and OV7670 cameras, built-in flash lamp.
- Supports image Wi-Fi upload.
- Supports TF card.
- Supports multiple sleep modes.
- Embedded Lwip and FreeRTOS.
- Supports STA/AP/STA+AP operation mode.
- Supports Smart Config/AirKiss technology.
- Supports serial port local and remote firmware upgrades (FOTA).

MATERIALS REQUIRED

1. Software Requirements: Arduino IDE.
2. Hardware Requirements:
   - ESP32-CAM,
   - L298N Driver,
   - DC Motor (Brushed and Brushless), and
   - Permanent Magnet Stator Battery.
   - RS555 Motor
   - Jumper Wires

CIRCUIT DIAGRAM

The IoT grass-cutting robot integrates advanced sensing and control technologies to autonomously maintain lawns (Figure 8).

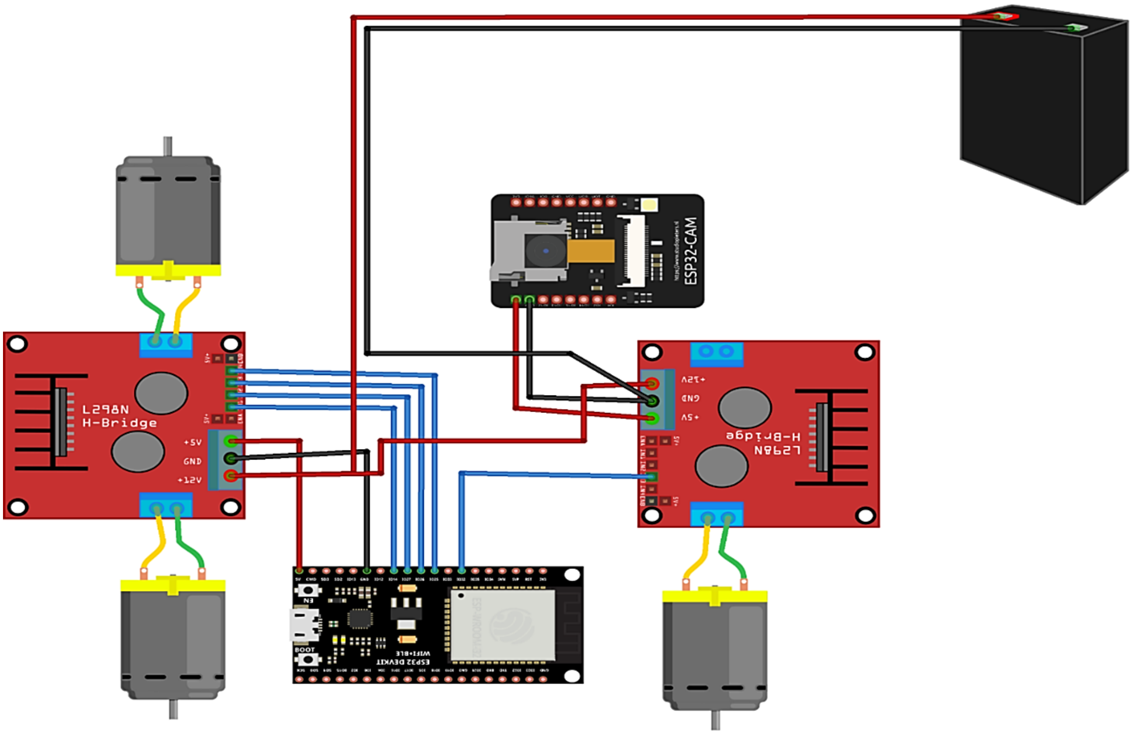

Figure 8. Circuit Diagram.

ESP32 Code:

```
#define BLYNK_PRINT Serial
#include <WiFi.h> #include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>

// You should get Auth Token in the Blynk App.
// Go to the Project Settings (nut icon).
char auth[]="cxY68-v4sW4HTOYPPRUb9zg_yTwFsq9x";

// Your WiFi credentials.
// Set password to "" for open networks. char ssid[]="robot";
char pass[]="12345678";

void Stop()
{

digitalWrite(14, LOW); digitalWrite(27, LOW); digitalWrite(26, LOW); digitalWrite(25, LOW);
}

void Forward()
{

digitalWrite(14, LOW); digitalWrite(27, HIGH); digitalWrite(26, LOW); digitalWrite(25, HIGH);
}

void Backward()
{
```



```
digitalWrite(14, HIGH); digitalWrite(27, LOW); digitalWrite(26, HIGH); digitalWrite(25, LOW);
}

void Right()
{

digitalWrite(14, LOW); digitalWrite(27, HIGH); digitalWrite(26, HIGH); digitalWrite(25, LOW);
}

void Left()
{

digitalWrite(14, HIGH); digitalWrite(27, LOW); digitalWrite(26, LOW); digitalWrite(25, HIGH);
}

void setup()
{

Serial.begin(9600), pinMode(14, OUTPUT), pinMode(27, OUTPUT), pinMode(26, OUTPUT),
pinMode(25, OUTPUT), pinMode(33, OUTPUT), digitalWrite(33, LOW), Stop();

Blynk.begin(auth, ssid, pass); }

BLYNK_WRITE(V1)
{

Forward();
}

BLYNK_WRITE(V2)
{

Backward();
}

BLYNK_WRITE(V3)
{

Left();
}

BLYNK_WRITE(V4)
{

Right();
} BLYNK_WRITE(V5)
{

Stop();
}
void loop()
{
```



```
Blynk.run();
}
```

ESP32 Cam Code:

```
//Viral Science www.youtube.com/c/viralscience www.viralsciencecreativity.com
//ESP Camera Artificial Intelligence Face Detection Automatic Door Lock

#include "esp_camera.h" #include <WiFi.h>

//
// WARNING!!! Make sure that you have either selected ESP32 Wrover Module,
//              or another board which has PSRAM enabled
// // Select camera model
//#define CAMERA_MODEL_WROVER_KIT
//#define CAMERA_MODEL_ESP_EYE
//#define CAMERA_MODEL_M5STACK_PSRAM
//#define CAMERA_MODEL_M5STACK_WIDE
//#define CAMERA_MODEL_M5STACK_NO_PSRAM #define CAMERA_MODEL_AI_THINKER
#define Relay 2
#define Red 13
#define Green 15 #include "camera_pins.h"

const char* ssid="robot"; //Wifi Name SSID
const char*password="12345678"; //WIFI Password
void startCameraServer();
boolean matchFace=false; boolean activateRelay=false; long prevMillis=0;

int interval=5000; void setup() {pinMode(Relay, OUTPUT); pinMode(Red, OUTPUT); pinMode(Green, OUTPUT); digitalWrite(Relay, HIGH); digitalWrite(Red, HIGH); digitalWrite(Green, LOW);

Serial.begin(115200); Serial.setDebugOutput(true); Serial.println();

camera_config_t config;
config.ledc_channel=LEDC_CHANNEL_0; config.ledc_timer=LEDC_TIMER_0; config.pin_d0=Y2_GPIO_NUM; config.pin_d1=Y3_GPIO_NUM; config.pin_d2=Y4_GPIO_NUM; config.pin_d3=Y5_GPIO_NUM; config.pin_d4=Y6_GPIO_NUM; config.pin_d5=Y7_GPIO_NUM; config.pin_d6=Y8_GPIO_NUM; config.pin_d7=Y9_GPIO_NUM; config.pin_xclk=XCLK_GPIO_NUM; config.pin_pclk=PCLK_GPIO_NUM; config.pin_vsync=VSYNC_GPIO_NUM; config.pin_href=HREF_GPIO_NUM; config.pin_sscb_sda=SIOD_GPIO_NUM; config.pin_sscb_scl=SIOC_GPIO_NUM; config.pin_pwdn=PWDN_GPIO_NUM; config.pin_reset=RESET_GPIO_NUM; config.xclk_freq_hz=20000000; config.pixel_format=PIXFORMAT_JPEG;

//init with high specs to pre-allocate larger buffers if(psramFound()){

config.frame_size=FRAMESIZE_UXGA; config.jpeg_quality=10;
config.fb_count=2;
} else {
config.frame_size=FRAMESIZE_SVGA; config.jpeg_quality=12;
config.fb_count=1;
```

```
} #if defined(CAMERA_MODEL_ESP_EYE) pinMode(13, INPUT_PULLUP); pinMode(14, INPUT_PULLUP);
#endif

// camera init
esp_err_t err = esp_camera_init(&config); if (err!= ESP_OK) {
Serial.printf("Camera init failed with error 0x%x", err); return;
}

sensor_t*s=esp_camera_sensor_get();
//initial sensors are flipped vertically and colors are a bit saturated if (s->id.PID==OV3660_PID) {
s->set_vflip(s, 1);//flip it back
s->set_brightness(s, 1);//up the blightness just a bit s->set_saturation(s, -2);//lower the saturation
}
//drop down frame size for higher initial frame rate s->set_framesize(s, FRAMESIZE_QVGA); #if defined(CAMERA_MODEL_M5STACK_WIDE) s->set_vflip(s, 1);
s->set_hmirror(s, 1); #endif

WiFi.begin(ssid, password);

while (WiFi.status()!=WL_CONNECTED) {delay(500);
Serial.print(".");
}
Serial.println(""); Serial.println("WiFi connected");
startCameraServer();

Serial.print("Camera Ready! Use 'http://"); Serial.print(WiFi.localIP()); Serial.println("'to connect");
}

void loop() {if(matchFace==true && activateRelay==false)
{

activateRelay=true; digitalWrite(Relay, LOW); digitalWrite(Green, HIGH); digitalWrite (Red, LOW); prevMillis=millis();
}
if (activateRelay==true && millis()-prevMillis>interval)
{
activateRelay=false; matchFace=false; digitalWrite(Relay, HIGH); digitalWrite(Green, LOW); digitalWrite(Red,HIGH);
}
}
```

CONCLUSION

This study describes the most recent advances and technologies incorporated in a newly created bespoke grass cutter that is entirely reliant on robotics and the Internet in Things.

This grass cutter's unique feature is that, because to its broadband connection, it can be operated from anywhere in the globe. Even our mobile phone, a ubiquitous device carried in everyone's pocket, may be used to manage it. All programming for this gadget, to the smallest wheel movement, is done using the Arduino IDE software. A new gadget called the rs555 Motor has been invented for the up-and-down action of the grass cutter. It uses an ESP32 camera to identify obstructions and tell the arm when to react. Lastly, we are here to discuss the energy consumption of this gadget, for which a 12 V battery had to be used.

REFERENCES

1. Ferri G, *et al*. Autonomous Navigation Systems for Robotic Lawn Mowers. J Field Robot. 2017; 34(7): 1332–1351.
2. Khan A, *et al*. Machine Vision in Robotic Lawn Mowers. Robotics and Autonomous Systems. 2020.
3. Nare Karapetyan, Adam Braude, Jason Moulton, Burstein Joshua A, Scott White, O'Kane Jason M. Riverine Coverage with an Autonomous Surface Vehicle over Known Environments. 2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). 2019; 3098–3104.
4. Park J, *et al*. IoT-Based Control Systems for Home Automation. Int J Smart Home. 2018; 12(3): 1–14.
5. Singh R, Singh K. Predictive Maintenance Using IoT Data Analytics. Journal of Industrial Information Integration. 2021.
6. Zhang Y, *et al*. Battery Management Systems for Autonomous Robots. Energy Storage and Management. 2019.
7. Ahmed S, *et al*. Integration of Solar Panels in Robotic Lawn Mowers. Renewable Energy Journal. 2020.
8. García P, González R. Safety Features in Robotic Lawn Mowers. Safety Science. 2016.
9. Leite F, *et al*. (2022). Path-Planning Algorithms for Robotic Mowers. Computational Intelligence.
10. Aljamal M, Patel S, Mahmood A. Comprehensive Review of Robotics Operating System-Based Reinforcement Learning in Robotics. Applied Sciences. 2025 Feb 11;15(4):1840.
11. National Center for Education Statistics (NECS). STEM Attrition: College Students' Paths Into and Out of STEM Fields. [Online] Available: http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001rev.
12. Blázquez M, Castro M, Tovar E, Llamas M, Plaza I, Meier R. Are engineering students decreasing? A Spanish case study. Global Engineering Education Conference (EDUCON) 2011 IEEE. 2011 Apr; 242–251.
13. Jamieson P, Herdtner J. More missing the Boat — Arduino Raspberry Pi and small prototyping boards and engineering education needs them. 2015 IEEE Frontiers in Education Conference (FIE). 2015 Oct; 1–5.
14. Plaza P, Sancristobal E, Carro G, Castro M, Blazquez M. Scratch day to introduce robotics. 2018 IEEE Global Engineering Education Conference (EDUCON). 2018 Jun; 208–216.
15. Ertmer PA, Ross EM, Gopalakrishnan S. Technology-using teachers: How powerful visions and student-centered beliefs fuel exemplary practice. In: Society for Information Technology & Teacher Education International Conference: Proceedings of SITE 2000. 2000; 1518–1525. [Online]. Available: http://www.edcipurdue.edu/ertmer/docs/SITE2_2000.pdf.
16. Gülbahar Y, Tinmaz H. Implementing Project-Based Learning And E-Portfolio Assessment In an Undergraduate Course. J Res Technol Educ. 2006; 38(3): 309–327.
17. Blumenfeld P, Soloway E, Marx R, Krajcik J, Guzdial M, Palincsar A. Motivating Project-Based Learning: Sustaining the Doing Supporting the Learning. Educ Psychol. 1991; 26(3): 369–398.
18. Hadim H, Esche S. Enhancing the engineering curriculum through project-based learning. IEEE 32nd Annual Frontiers in Education. 2002 Nov; F3F–F3F.
19. Livingstone D, Lynch K. Group Project Work and Student- centred Active Learning: Two different experiences. Stud High Educ. 2000; 25(3): 325–345.
20. Edwards C. Not-so-humble Raspberry Pi gets big ideas. Engineering & Technology. 2013 Apr; 8(3): 30–33.
21. Jann Ingmire. (2015 Apr 29). Learning by doing helps students perform better in science. [Online]. Available: https://news.uchicago.edu/story/learning-doing-helps-students-perform-better-science.
22. Callaghan V. Buzz-Boarding; In Practical Support for Teaching Computing Based on the Internet-of-Things. Proceedings of the 1st Annual Conference on the Aiming for Excellence in STEM Learning and Teaching. 2012 Apr 12–13.

