Design And Implementation Of A Smart Agricultural Robot Bulldog(Sardog)

[1]Korukonda Hanuja, [2]Katravath Kalyani, [3]Karikal Chandana , [4]Medari Thriveni, [5]Madupu Harika
Department of Electronics & Communication Engineering,
Guru Nanak Institutions of Technical Campus , Hyderabad, India.

ABSTRACT
Over the past few decades, agricultural systems have encountered significant global challenges, including short-age of food supply, declining water availability, rising input costs, and diminishing agricultural labor. The advancement of Agricultural Technology (AgTech) in recent years has increased farm productivity and replaced manual monotonous tasks that are unsafe or inefficient for farm labor workers to do by hand. In this paper, we propose to develop and implement a smart agricultural robot named SARDOG that is based on the Farm-ng Amiga robot framework.LiDAR, Internet-of-Things (IoT) sensors, and a robotic arm all of which work hand in hand to perform multiple intelligent farming tasks autonomously and effectively. SARDOG is capable of autonomous GPS-less navigation using LiDAR, picking fruits using the robotic arm, testing the soil properties using a robotic actuator sensor framework, it can follow the farmers in the field and carry the produce for them among many other applications. The purpose of SARDOG is to make multiple major farming processes more efficient, cost-effective, and humane, as well as to perform some new farming processes that are not widely explored.

Keywords: Agricultural Robots,LiDAR,Internet-of-Things (IoT) sensors,Navigation,Crops,Farm Automation.

1. INTRODUCTION

For a very long time, agriculture will continue to be the foundation of the Indian economy. A man who goes three days without eating will argue, fight, and eventually perish. Over the past forty years, India's record of agricultural improvement has been fairly spectacular. The agricultural industry has done an excellent job of keeping up with the growing demand for food. The contribution of expanding he amount of land used for agriculture has decreased over time, and the advances in production over the previous two decades have mostly been attributable to rising productivity. The world's population, or more than 42%, has made agriculture their significant employment.

Agriculture faces pressing challenges due to increasing population, shrinking labor pools, and environmental degradation. By 2050, the global population is expected to reach 9.7 billion,necessitating a 70% increase in food production (United Nations, 2019). Autonomous agricultural equipment offers a potential solution by enhancing precision, productivity, and sustainability.

Autonomous agricultural equipment consists of machines capable of operating with minimal human intervention. Examples include self-driving tractors, robotic harvesters, drones for crop monitoring, and automated irrigation systems. These technologies optimize resource use and improve operational efficiency.

Agriculture has long been the backbone of human civilization, but modern challenges such as food shortages, climate change, increasing input costs, and labor shortages have made traditional farming methods less sustainable. The need for innovative solutions has led to the rise of smart agriculture, where advanced technologies such as robotics and the Internet of Things (IoT) play a crucial role in improving efficiency.

The Smart Agricultural Robot Bulldog (SARDOG) is designed to address these challenges by integrating cutting-edge robotics with IoT-based automation. This intelligent robot can autonomously perform essential agricultural activities such as real-time soil analysis, precision planting, automated irrigation, and pest detection. By reducing human intervention in repetitive and labor-intensive tasks, SARDOG enhances productivity, ensures better resource utilization, and promotes data-driven farming practices, ultimately leading to improved crop yields and sustainability.

2. LITERATURE SURVEY

The goal of Nitin P.V. et al. [1] is to design, develop, and manufacture a robot that can dig the ground, plant seeds, level the ground to muck, and spray water. The robot's whole system runs on solar and battery power. Most people in the world— more than 40%— choose agriculture as their primary line of work. As autonomous car technology has advanced, interest in agriculture has grown. Through the input of an IR sensor, a relay switch controls the vehicle. A user can communicate with the robot using language, which is accessible to the majority of people. These robots have the benefit of quick and hands-free data entry. An idea has been created in autonomous agricultural vehicles to see if several tiny autonomous machines may be more effective than conventional big tractors and human labor.

The agriculture bot is presented by Abdul Rahman et al. in [2]. Agriculture is a significant industry in Kerala, Assam, Punjab, and Maharashtra. It all began due to the "Green Revolution" and how it helped farmers learn about the various farming methods and their benefits. Due to the advancement of knowledge throughout the years, certain contemporary agricultural practices were created. These cutting-edge methods included the creation of insecticides, the use of tractors to cultivate the land, the development of tube wells, and more. Water pressure can be used to find and resolve the seed block. Remote operation of the machine is possible, and a solar panel is utilized to charge a DC battery. The microcontrollers are programmed in assembly language. With the aid of a DC motor, the Raspberry-pi is utilized to control and observe the system motion of a vehicle. Also given is the outcome of the unit's implementation.

Future Precision Autonomous Farming is made possible by a simplified method provided by Nobutaka Ito et al. [3] The primary subject of this work is the recommended definition of agricultural systems, which includes farming system layout, sensing systems, and actuation units such as tractor-implement combinations. To construct trustworthy, economical, and practical farming systems, the authors describe how to use the Precision Agricultural Data Set (PFDS), produced off-line before crop production. The construction of autonomous agricultural vehicles is presently underway, and the outcomes of a thorough mathematical study of illustrative actuation units are being used.

The improved weed control system, built on a robotic platform and optimizes agricultural activities like weed management, is discussed by S. A. Amrita et al. in [4]. They have created a robotic car with four wheels and a dc motor for steering. The machine manages the weed in the business by taking specific rows per column at a defined distance based on crop into account. The issue of obstacles detected by sensors has also been considered. The whole algorithm, computation, processing, and monitoring were created using motors and sensors.

According to T. Blender et al. [5], the current state of the globe is that most nations lack sufficient trained labor, particularly in the agricultural sector, which impacts the development of emerging nations. To solve this issue, they have tried to automate the agriculture industry. The innovative idea behind their product was to automate the process of sowing pulses like black gram and green gram as well as crops like sunflower, baby corn, peanuts, and vegetables like beans, lady's finger, and pumpkin. To eliminate labor-intensive manual labor and boost output. Using a DC motor, automated seed planting is carried out. The distance between the two seeds may be adjusted and changed using a microcontroller. Additionally, a variety of seeds may be grown at various distances. Remote switches can adjust the robot's direction once it has reached the field's end. Microcontrollers are used to control the entire operation.

1.EXISTING SYSTEM

The current agricultural practices heavily rely on manual labor and traditional machinery, which can be inefficient, time consuming, and costly. Farmers often face challenges such as labor shortages, inconsistent crop monitoring, and difficulty in managing large areas of farmland. Additionally, existing automated solutions are often not versatile enough to handle the diverse tasks required in modern farming, such as soil analysis, planting, watering, and pest control.

2.PROPOSED SYSTEM

The proposed Smart Agricultural Robot Bulldog (SARDOG) aims to revolutionize farming by integrating advanced robotics, and IoT technologies. SARDOG is designed to autonomously perform a variety of agricultural tasks with precision and efficiency. It will feature capabilities such as real-time soil analysis, precision planting, automated irrigation, and pest detection and control. This smart robot will not only reduce the reliance on manual labor but also enhance productivity and crop yield through data-driven decision-making and precise farming techniques.

3.METHOD AND METHODOLOGY

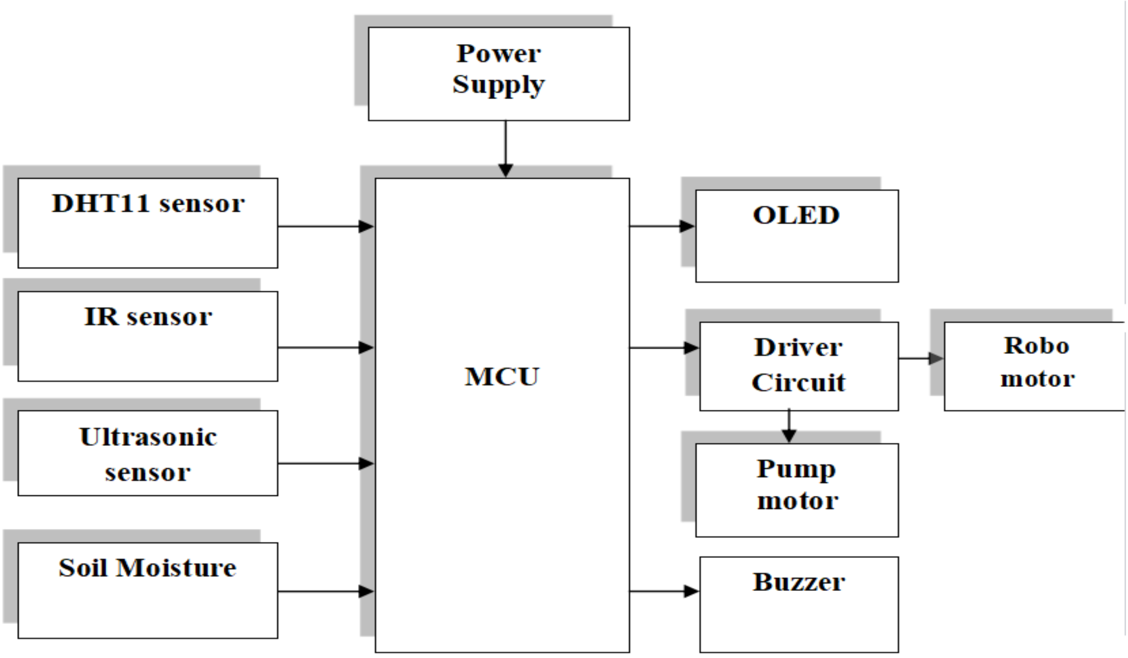

Fig 1:Proposed System Block Diagram

3.1 Microcontroller:

The central processing unit of the system that controls all operations,acts as the brain of the SARDOG system.Possible choices include Arduino, ESP32, or Raspberry Pi, depending on computational requirements.The Raspberry Pi Pico W is a compact and cost-effective microcontroller board with Wi-Fi connectivity, making it suitable for IoT and wireless sensor network applications. It is an upgraded version of the Raspberry Pi Pico, adding wireless capabilities while maintaining the same form factor and core features.Uses the RP2040 microcontroller chip, designed by Raspberry Pi.Dual-core ARM Cortex-M0+ processor, running at up to 133 MHz.264 KB of SRAM and 2 MB of onboard flash storage.

3.2 Power Supply:

The power supply is a crucial component that provides the necessary voltage and current to all the sensors, microcontroller unit (MCU), and actuators. The system typically operates on a 12V rechargeable battery or a solar panel, ensuring continuous operation in agricultural fields. Since different components require different voltage levels, voltage regulators (such as a buck converter) are used to step down 12V to 5V for powering the sensors and MCU, while motors operate directly at 12V.

3.3 Sensors:

Sensors play a crucial role in providing real-time data for autonomous decision-making. The system includes multiple sensors for environmental monitoring, obstacle avoidance, and soil analysis.

DHT11 Sensor (Temperature & Humidity Sensor): This sensor measures the temperature and humidity of the environment, helping farmers monitor climatic conditions and adjust irrigation accordingly.The DHT11 is a digital sensor that measures ambient temperature and humidity, which is essential for understanding weather conditions and optimizing irrigation schedules. Temperature and humidity data can also be used to predict plant water requirements and prevent overwatering. If humidity levels are low, the system can recommend additional irrigation, whereas high humidity may reduce the need for watering.

IR Sensor (Infrared Sensor for Obstacle Detection): The IR sensor is primarily used for detecting nearby obstacles to prevent collisions while the robot is moving. It works by emitting infrared light and detecting the reflected signal from objects. If an object is detected within a certain range, the MCU adjusts the robot's path to avoid the obstacle, ensuring safe navigation across the field. This is useful in environments where the robot must navigate between plants, avoid rocks, or move around other equipment.

Ultrasonic Sensor (Distance Measurement & Navigation): While the IR sensor detects nearby objects, the ultrasonic sensor is used for measuring distances more accurately using ultrasonic waves. It sends a high-frequency sound pulse and calculates the time taken for the echo to return, determining the distance to an obstacle. This helps in path planning and precise movement adjustments, allowing the robot to navigate autonomously even in unstructured environments.

Soil Moisture Sensor (Irrigation Control): The soil moisture sensor is a key component for smart irrigation management. It measures the water content in the soil, and the data is used to determine whether irrigation is needed. If the soil moisture level falls below a certain threshold, the MCU activates the pump motor to supply water to the crops. This ensures optimal water usage, preventing both overwatering (which can lead to root rot) and underwatering (which can stress plants).

3.4 OLED Display (Real-Time Monitoring & Data Display): The OLED (Organic Light Emitting Diode) display is used to provide real-time feedback to farmers by displaying important sensor readings such as temperature, humidity, soil moisture levels, and robot status. Unlike LCD screens, OLED displays have a high contrast ratio, low power consumption, and better visibility under sunlight, making them ideal for field applications. The display allows farmers to monitor environmental conditions without needing an external mobile app or cloud connection, making it useful in remote agricultural areas with limited network connectivity.

3.5 Driver Circuit (Motor Control & Navigation System): The driver circuit is an interface between the MCU and high-power actuators such as motors and pumps. Since microcontrollers cannot directly supply the required current for DC motors, a motor driver (such as L298N or L293D) is used to amplify the control signals. The motor driver allows bidirectional movement (forward and reverse) and speed control by regulating the voltage supplied to the motors. The MCU sends PWM (Pulse Width Modulation) signals to the driver circuit, enabling precise speed and direction control of the robot. This is essential for smooth navigation in the field, allowing the robot to move between crop rows, avoid obstacles, and reach irrigation points accurately.

3.6 Robo Motor (Movement & Autonomous Navigation): The robo motor consists of two or more DC motors (or servo motors) that drive the wheels of the robot. These motors are responsible for moving the robot forward, backward, and turning left or right based on the inputs from the IR and ultrasonic sensors. The use of high-torque motors with rugged wheels ensures that the robot can traverse different types of terrain, including muddy or uneven agricultural fields. Some advanced designs may use differential drive systems or even four-wheel drive (4WD) for enhanced stability and mobility.

3.7 Pump Motor (Automated Irrigation System): The pump motor is activated when the soil moisture sensor detects dry soil, triggering automatic irrigation. The pump draws water from a reservoir or nearby water source and delivers it to the crops through pipes or a drip irrigation system. The system ensures optimal water usage, reducing human intervention and preventing water wastage. The pump motor is typically 12V or 24V, depending on the water flow requirements. In some cases, a relay module is used to switch the pump on/off efficiently.

3.8 Buzzer (Audio Alerts & Notifications): The buzzer provides an audio alert system to notify users about important events. For example, it can sound an alarm when:Low soil moisture is detected, indicating the need for irrigation.An obstacle is detected, signaling that the robot needs to change direction.Battery levels are low, requiring a recharge.The irrigation process is completed, notifying farmers that watering has been successfully executed.

3. CONCLUSION AND FUTURE SCOPE:

The Smart Agricultural Robot Bulldog (SARDOG) exemplifies the transformative impact of integrating advanced technologies such as artificial intelligence (AI), LiDAR, Internet of Things (IoT) sensors, and robotic actuators in modern agriculture. By autonomously performing tasks like GPS-less navigation, fruit picking, and soil analysis, SARDOG enhances farm productivity and reduces the reliance on manual labor.

Future developments could focus on incorporating renewable energy sources, such as solar power, to improve sustainability, and expanding functionalities to include tasks like ploughing and seeding. Additionally, integrating SARDOG with cloud-based farm management systems could facilitate remote monitoring and control, further advancing precision agriculture practices. These advancements have the potential to revolutionize farming methodologies, promoting resource optimization and environmental sustainability.

4. REFERENCES:

1. N. S. Naik, V. V. Shete and S. R. Danve, "Precision agriculture robot for seeding function", 2016 International Conference on Inventive Computation Technologies (ICICT), vol. 2, pp. 1-3, 2016.
2. G. Zhang, Z. Zhisheng, X. Zhijie, D. Min, P. Meng and J. Cen, "Implementation and research on indoor mobile robot mapping and navigation based on rtab-map", International Conference on Mechatronics and Machine Vision in Practice (M2VIP), pp. 1-6, 2022.
3. S. Ramachandran and F. Sahin, "Smart Walker V: Implementation of RTAB-Map Algorithm", 2019 14th Annual Conference System of Systems Engineering (SoSE), pp. 340-345, 2019.
4. K. Wang, N. Jiasheng and L. Yanqiang, "A Robust LiDAR State Estimation and Map Building Approach for Urban Road", 2021 IEEE 2nd International Conference on Big Data Artificial Intelligence and Internet of Things Engineering (ICBAIE), pp. 502-506, 2021.
5. H. T. Warku, N. Y. Ko, H. G. Yeom and W. Choi, "Three-Dimensional Mapping of Indoor and Outdoor Environment Using LIO-SAM", 2021 21st International Conference on Control Automation and Systems (ICCAS), pp. 1455-1458, 2021.

6. S. Mihai, P. Shah, G. Mapp, H. Nguyen and R. Trestian, "Towards autonomous driving: A machine learning-based pedestrian detection system using 16-layer lidar", 2020 13th International Conference on Communications (COMM), pp. 271-276, 2020.
7. M. Velas, M. Spanel, M. Hradis and A. Herout, "CNN for IMU assisted odometry estimation using velodyne LiDAR", IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), pp. 71-77, 2018.
8. A. Katiyar, S. Behal and J. Singh, "Automated defect detection in physical components using machine learning", 2021 8th International Conference on Computing for Sustainable Global Development (INDIACom), pp. 527-532, 2021.
9. F. Zhang, Q. Li, Y. Ren, H. Xu, Y. Song and S. Liu, "An Expression Recognition Method on Robots Based on Mobilenet V2-SSD", Inter. Conference on Systems and Informatics (ICSAI), pp. 118-122, 2019.
10. X. Song, "Research and design of robot obstacle avoidance strategy based on multi-sensor and fuzzy control", 2022 IEEE 2nd In-ternational Conference on Data Science and Computer Application (ICDSCA), pp. 930-933, 2022.