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Solar-Powered Multipurpose Rover with Wireless Control for Efficient Agriculture

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ABSTRACT_ Modernising Indian agriculture need for both quick and long-term answers. The current work presents a Bluetooth-controlled solar-powered multipurpose electric rover meant to carry out several agricultural tasks concurrently, hence lowering time and dependence on toxic fuels. Powered by solar energy, this eco-friendly rover guarantees sustainability and affordable performance. Raspberry pi, motor drivers, servo motors, and a Bluetooth module for wireless control and communication power the system. Among its many duties, the rover effectively ploughs, sows seeds, sprays water, applies pesticides, and plants rice. It also has a blading mechanism to properly remove weeds. The rover improves operational convenience by including wireless control, hence enabling farmers to remotely operate its activities with accuracy and simplicity. The electric rover maximises agricultural efficiency, lowers physical effort, and minimises environmental effect via its reliance on renewable energy and capacity to execute several jobs simultaneously. This initiative reflects a sustainable and technologically sophisticated way to farm, hence supporting more production and environmental responsibility.

1.INTRODUCTION

One of the basic operating field in human existence is agriculture. Sustainable farming in this field now mostly depends on human power. The yield of land and the quantity of labours have a direct correlation. High amounts of labour, on the other hand, add additional expense during the manufacturing process. Apart from that, optimal product growth calls for another crucial factor to be considered: maintaining product (i.e., plant) health throughout farming till they are harvested from soil. Chemical pesticides are mostly used to prevent plants from insects, illnesses, negative consequences of climate change, etc. in order to accomplish this. Present methods of pesticide spraying entail direct contact between plant and pesticide itself, which has major negative consequences for the plant, the environment, and more crucially for the human labour. Human mistake is another element that results in unanticipated problems while spraying. For example, human labour might walk down to the field and harm them by walking in, or spray additional dosage on the plants causing major harm. Robotics connected to and automation technologies help greatly both farmers and agricultural sector. Common uses for these equipment include sowing, spraying, fruit picking, plant classification, etc.

Automated agricultural chores offer several advantages to the field which minimises unanticipated or hazardous consequences of chemical exposure which also helps to enhance general efficiency and production. Automation offers several benefits to landowners or farmers that helps the job be more accurate, consistent, and affordable [1]. Furthermore, farmers gain significantly from high technology automation since it reduces work, calls for less labour, and removes maintenance and labour expenses while still enjoying high profit. Recent literature reveals many investigations on mobile robots for agricultural uses. Singh et al. showed a robot system to start spraying operations; complicated algorithms depending on fuzzy logic keep navigation. There also additional studies looked into robot in the 3 greenhouse capable of spraying, classifying, cleaning and harvesting. This work suggests to automate whole process by using robot platform where it allows to avoid exposure of hazardous materials while enhancing the efficiency. A semi-autonomous mobile robot will spray plants and repel insects from the field improving sustainable agricultural conditions by safeguarding health of the plants and soil in order to do this. The agricultural population of three-fourths lives on Indian farmland. Farmers will cultivate several crops in their field depending on the environment and other resources available to them. High productivity and great quality, however, call for some technical help. The requirement of work in the agricultural areas is growing day by day as the people now a days are less interested in agriculture therefore all we need is a robot which can replace humans. Protecting the field depends much on pesticide spraying. Many individuals do not want to spray pesticides since they are developing lung issues and negative skin diseases. Carbon dioxide released as a pollutant during the operation of such pumps also harms the environment. Human mistake causing unanticipated problems during spraying is another key element.

For example, Ignorance causes human labour to spray additional dosages onto the crops, which seriously harms the land. While we can locate some of the robots on the market for pesticide spraying, what sets robot shown in this project apart from them is first we are creating a totally human-controlled robot via mobile app using IOT, second live monitoring is the additional feature included to this project which provides more accuracy and uniformity in spraying this may boost the yield as well. More than 60% of the work is agricultural. It is the foundation of the Indian economy. Simultaneously offering safe farming of the farmers helps to significantly increase the efficiency and productive capacity of agriculture. Operations such as fertiliser sprinkling and pesticide spraying are quite laborious. Although spraying of insecticides has become required, it also turns out to be a damaging process for the farmers. Farmers, particularly when they spray pesticides, take too many precautions like wearing suitable clothing, masks, gloves, etc so that, it does not affect them. The desired result has to be fulfilled, hence avoiding pesticides is not entirely feasible. Therefore, in such situations, the deployment of robots provides the optimal results for these issues as well as the needed 4 production capacity and efficiency. This agricultural robotic vehicle incorporates cost-effective technology using components such as ESP8266 / ESP32 Microcontroller for the control of agriculture robot, geared motors that facilitate the robot wheels to move and mobile application to guide the robotic movement to make all of the above feasible.

Robotics has advanced in many areas, from home automation to the military. Robotics used in machinery design and task completion with agricultural vehicles has led to further study and investment. The automatic performance of such agricultural vehicles allows for continuous administration of the agricultural land. The capabilities of the agricultural vehicles can be categorised as steering, detection, action, and mapping. Vehicle's map-reading method is called guidance; environmental feature extraction is called detection; execution of the designated task is called action; and field mapping with its features is mapping. Every four groupings are separate. This approach is founded on creating a robotic vehicle for agricultural application to spray toxic pesticides. This project uses PIC ESP8266 / ESP32 microcontroller to control the movement of the robot with the help of a mobile application. This affordable robotic vehicle can increase agricultural application safety, output capacity, and labour demand fulfilment.

2.LITERATURE SURVEY

Recent developments in micro-electro-mechanical systems (MEMS) and wireless communication have resulted in the deployment of low-cost, low power, multifunctional sensor nodes. Small in size, these sensor nodes communicate themselves to relay the data. Power use should be reduced since the nodes in sensor networks have low battery power (<0.5 Ah, 1.2 V) and it is not practical or viable to recharge or replace the batteries, therefore extending the lifetime of the whole network. Mainly power lost while idle listening, data processing, data transfer, and data reception. Of every node, the power used during transmission is the largest part of energy usage. This survey examined several methods and algorithms meant to extend the network lifetime.

WSNs are thought to be one of the possible emerging computing technologies given recent developments in Micro Electro-Mechanical Systems (MEMS) technology, low power digital circuits and RF designs. Among the many beneficial and diverse uses of WSNs are those calling for information collecting in hostile, harsh settings, weather and climate monitoring, identification of chemical or biological agent risks, and healthcare monitoring. These applications call for the use of several devices including cameras, acoustic tools and sensors for measuring distinct physical properties.

Made up of many usually tiny sensors known as sensor nodes, Wireless Sensor

Networks (WSNs) each contain four components: sensor, processor, transceiver, and battery (the energy source). A low-cost, low-power, multifunctional small embedded system is the sensor node. The primary goal of Wireless Sensor Networks is how to cope with their restricted energy resources. The performance of Wireless Sensor Networks is greatly dependent on their lifetime. Dynamic thus follows.

Power Management strategies aiming at lowering energy use in sensor nodes. Sensor nodes run on limited battery power, and node batteries are challenging to replace or recharge. Once the nodes are installed, node transmits the sensed data as long as battery power is adequate. Minimising the energy use for maximising the life time becomes a main difficulty in the design of the WSNs since the batteries of sensor nodes are small with limited power capacity. Designing WSNs with lifetime requires energy conservation to be a major and important concern. Greater Communication uses more energy than processing; in radio modes such as receiving, transmit, and idle or listening mode, this is used energy; in sleep mode, it can be decreased at least an order of magnitude [2, 10, 37]. Therefore, depending on the particular use, it is extremely crucial to switch off the radio as early as feasible. Many research projects worldwide have been conducted to lower the energy use in radio communications. The research has suggested several energy conservation plans as ideal taxonomy separating all energy efficient strategies into three primary categories: duty-cycling, data reduction, and mobility based approaches [11]. Duty cycle control split into two categories one topology control, in this different topology algorithm are created such Low Energy Adaptive Clustering Hierarchy (LEACH), Directed Diffusion [10], Energy Efficient Sensor Routing (EESR), Adaptive Self-Configuring Sensor Network Topologies (ASCENT) [17] etc, each having benefits and drawbacks, The second kind is power management, which falls into three categories: on-demand wakeup, scheduled wakeup, and asynchronous wakeup [18]. Topology control method using some kind of clustering and other techniques such power adjustment or power mode to extend the network lifetime is the hybrid approach [17]. Network architecture, the data aggregation process and the underlying routing protocol [1] are among the elements that define the energy efficiency of a sensor network. So far, many methods have been suggested and put into practice for energy efficient WSNs. We want to create and build a novel algorithm to extend the life of Wireless Sensor Networks. Composed of multiple sensor nodes with certain energy and size constraints, Wireless Sensor Networks (WSNs) The energy constraint for these nodes forces us to make very good use of their energy so the network lifetime rises. To tackle particular issues that cannot be solved by utilising human being, hundreds to thousands of micro nodes can be deployed in many domains like health, environment and combat monitoring, therefore WSN is the excellent option for such case. Certain treatments harm the WSN monitored area and therefore compromise the precision of the findings. Once a wireless sensor network is operational, its lifetime should as long as feasible depending on the initially supplied battery energy. The only way to extend the life of wireless sensor networks is to lower their energy use. Some techniques to extend the life of WSN include data aggregation, routing protocol, and network topology. Automated farming's progress has spurred the creation of several autonomous systems meant to boost agricultural productivity. Many research papers and studies have looked at how agricultural robotics, autonomous control, and precision farming help to modernise conventional farming practices. This literature assessment builds a basis for the suggested project by means of a review of current studies on data aggregation methods, Bluetooth-based control systems, and multifunctional agricultural robots.

3.PROPOSED SYSTEM

This project offers a low-cost, multifunctional agricultural robot wirelessly controlled via Bluetooth (HC-05) operating without GPS or ultrasonic sensors to overcome the constraints of conventional and current automated systems. Designed to carry out several farming activities in one tiny system, this robot is a reasonably priced and efficient option for medium and small-scale farmers.

Fig 1: Block Diagram

3.1 Hardware components

1.Raspberry Pi Pico

2.Bluetooth Module

3.Relay 5v -2Channel

4.Water Motor 12v dc

5.Grass Cutting Motor 1000rpm

6.SG 90 Servo Motor for Planting

7.MG995 Servo for Seeding and Plowing

8.12v 7ah Battery Lead Acid

9.Lm2596

10.l293d Driver

11.DC 45rpm Motor

3.1.1Raspberry Pi Pico

The Raspberry Pi Pico is a low-cost, high-performance microcontroller board based on the RP2040 chip, which was designed by Raspberry Pi. Unlike full Raspberry Pi computers (like the Pi 4 or Pi Zero), the Pico is a microcontroller, meaning it doesn't run a full operating system but instead executes programs directly from flash memory.

Pin Configuration:

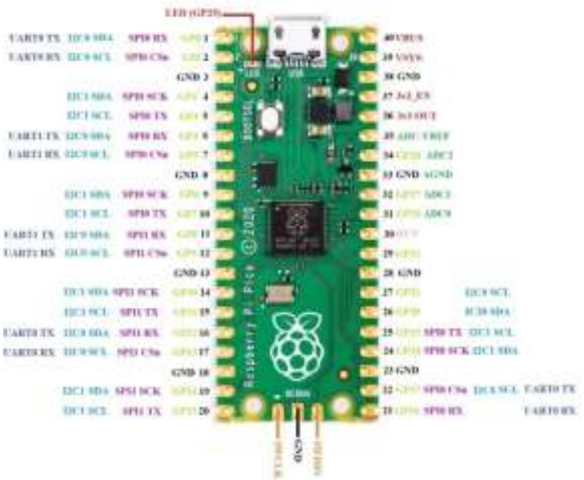

Fig 2.Raspberry Pi Pico Pin Diagram

3.1.2 Bluetooth Module (HC-05)

The **HC-05/HC-06 Bluetooth module** allows for **wireless communication** between the robot and a **remote device** such as a smartphone, tablet, or laptop. This enables farmers to **control and monitor** the robot without direct physical intervention.

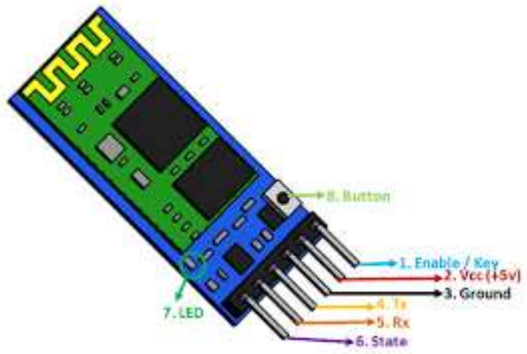

Fig 4.3.1 HC-05 Diagram

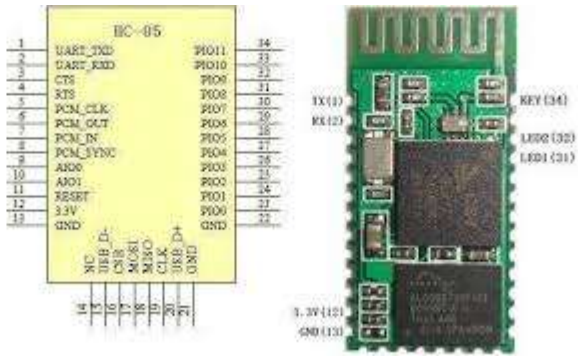

Fig 3 HC-05 Pin Diagram

3.1.3 12V DC Water Motor

A 12V DC water motor (pump) is used to spray water or fertilizer for crops.

Fig 4. DC Water Motor

3.1.3 1000 RPM Grass Cutting Motor

This high-speed motor is responsible for cutting grass and removing crop residues.

Fig 5:Grass Cutting Motor

3.1.4 SG90 Servo Motor (For Planting)

The SG90 servo motor is a small, lightweight motor used for precise movement.

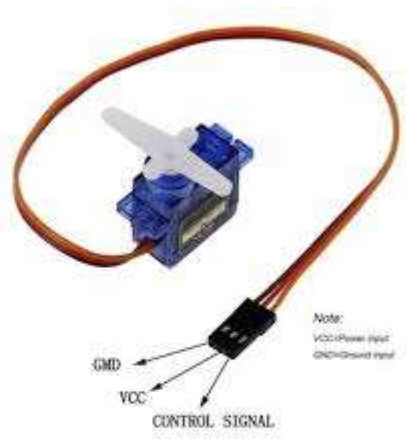

Fig 6 Servo Motor

3.1.5 MG995 Servo Motor (For Seeding and Plowing)

The MG995 is a high-torque servo motor, ideal for heavy-duty agricultural tasks.

Fig 7 MG995 Servo Motor Layout

4.RESULTS AND DISCUSSION

Modernising Indian agriculture need for both quick and long-term answers. The current work presents a Bluetooth-controlled solar-powered multipurpose electric rover meant to carry out several agricultural tasks concurrently, hence lowering time and dependence on toxic fuels. Powered by solar energy, this eco-friendly rover guarantees sustainability and cost-effective performance.
The system has motor drivers, servo motors, Raspberry pi Pico, and a Bluetooth module for wireless control and communication. Among its many duties, the rover effectively ploughs, sows seeds, sprays water, applies pesticides, and plants rice. It also has a blading mechanism for efficient weed eradication.
The electric rover maximises agricultural efficiency, lowers physical effort, and minimises environmental effect by using renewable energy and capacity to execute several chores simultaneously. This project reflects a technologically advanced and

sustainable approach to agriculture. .

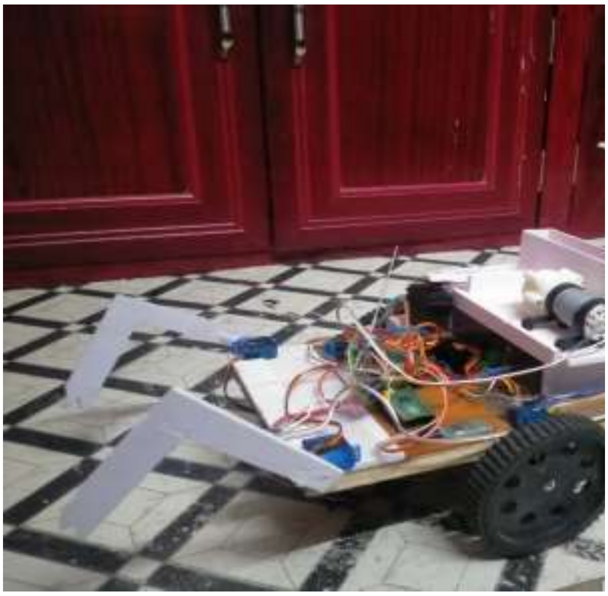

Fig 8 Wireless - Controlled Solar-Powered Multipurpose Electric

Rover: Advancing Sustainable and Efficient Farming

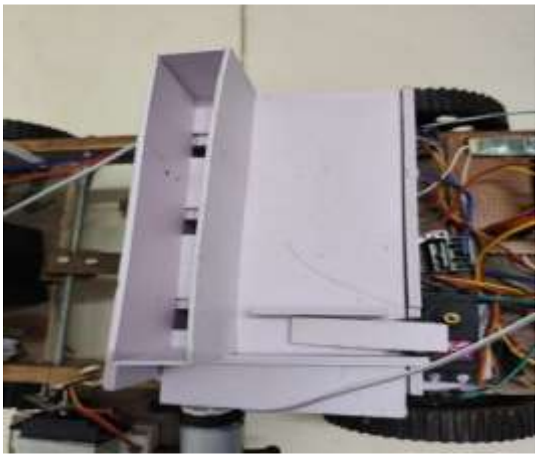

Fig 9 Seeding

Fig 10 Plowing

Fig 11 Blading or weed removing

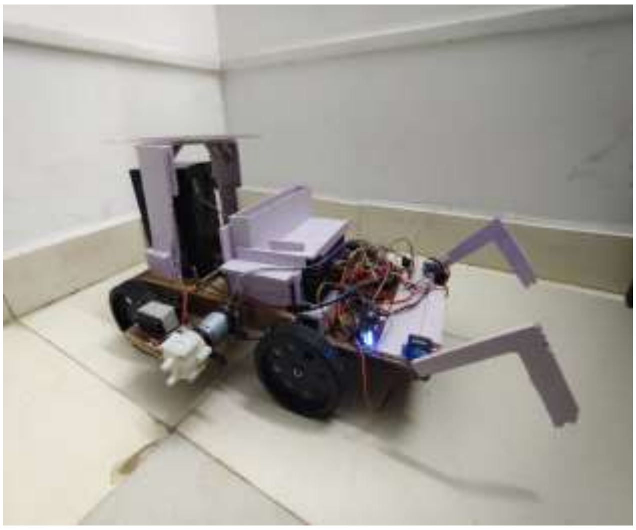

Fig 12 Watering or Pesticide Spraying

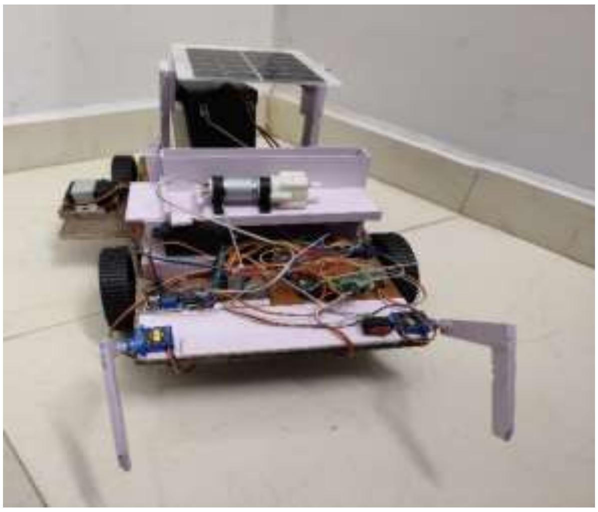

Fig 13 Planting

5.CONCLUSION

Using Raspberry Pi Pico in agricultural robotics is a turning point towards modernising farming methods. These systems improve agricultural sustainability and production by providing affordable, scalable options. The possibility for more complex and efficient agricultural robots becomes more realistic as technology develops, so providing a future where farming is both ecologically conscious and technologically advanced. Fundamentally changing modern agriculture, the inclusion of Raspberry Pi Pico into agricultural robots signals a major advance towards improved production and sustainability. Diverse access to innovative agricultural technology is democratised by these scalable, affordable solutions, therefore equipping farmers with instruments to maximise resource use and reduce environmental impact. From automated irrigation systems that accurately control water distribution to precision spraying robots that reduce chemical use, the Raspberry Pi Pico's adaptability enables the development of bespoke robotic solutions fit for particular agricultural demands. Moreover, the capacity to gather and analyse real-time environmental and crop data helps data-driven decision-making, hence empowering farmers to proactively handle problems and maximise production. With technology advancing, the possibility for more complex applications, such as AI-driven crop monitoring and autonomous harvesting, becomes more realistic, so promising a future where farming is not only technically advanced but also firmly anchored in environmentally conscious practices.

Advancements in sensor technology and machine learning open the path for more precise and predictive agricultural management, while the creation of collaborative robots, or cobots, able to work alongside human farmers further improves efficiency and solves labour shortages. Still important issues, though, include guaranteeing durability in hostile conditions, creating simple interfaces, and handling data security.

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BATTA BHAVANI SIVA is a B.Tech student specializing in Electronics and Communication Engineering at NRI Institute of Technology. She is passionate about exploring emerging technologies and continuously enhancing her skills through hands-on challenges. She has completed internships in VLSI DFT and South Central Railways. Additionally, she has earned NPTEL certifications in Sensors and Actuators .

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