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Design and Implementation of Multifunctional Agriculture Robot

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Abstract: The foundation of the Indian economy has always been and will continue to be agriculture. To acquire a decent harvest, however, timely farming procedures, including seed sowing, harrowing, pesticide spraying, and moisture measurement, have become crucial. As a result, modern advancements in robotic technology can be a very beneficial tool. Multitasker Agribot, which can execute all the vital agricultural tasks remotely, is created with the benefits of robotics, such as hands-free and quick data entry procedures. It is an electromechanical machine driven by hub motors to guide its wheels. Depending on the crop, an automated system would cultivate specific rows and columns of the farm. To acquire a decent harvest, however, timely farming procedures, including seed sowing, harrowing, pesticide spraying, and moisture measurement, have become crucial. As a result, modern advancements in robotic technology can be a very beneficial tool. Multitasker Agribot, which can execute all the vital agricultural tasks remotely, is created with the benefits of robotics, such as hands-free and quick data entry procedures. It is an electromechanical machine driven by hub motors to guide its wheels. An automated system cultivates the farm according to the produce, considering specific rows and columns. A smartphone is used to operate the bot remotely. A webcam-based method for monitoring plant health can find plant diseases. The system's sensors may collect data from their surroundings, analyze it, make decisions based on those decisions, and then direct other system components to take action. In this, the Raspberry Pi and NodeMCU drive the robot. 48-volt lithium-ion battery powers the robot, while a 12-volt lithium-ion battery powers its many electrical components and functions. 7-inch display screen transmits commands to some actuators and displays data. The bot is designed with catiya software, while the GUI is made with node-red. Agribot's multitasker has a runtime of 6 hours with better efficiency and productivity.

***Index Terms* – Agriculture, Agribot, Embedded, NodeMCU, Robot.**

I. 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 the 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. Autonomous cars in agriculture have drawn more attention in recent years. Due to this advancement, numerous researchers have begun to create more logical and adaptive vehicles.

A concept is being investigated in autonomous agricultural vehicles to determine whether a fleet of tiny autonomous machines would be more effective than conventional big tractors and human labor. These machines should have the intelligence to function intelligently in a semi-natural environment for extended periods, unattended while doing a valuable purpose. They should be able to operate continuously throughout the year, in most weather situations. Autonomous cars can do various field tasks with more advantages than traditional machinery.

Robotic technology in agriculture is a relatively new concept. The potential for robot-enhanced productivity in agriculture is enormous, and more and more robots of all shapes and sizes are showing up on farms. We can anticipate autonomous agricultural robots undertaking tasks like seed sowing, grass cutting, water spraying, and pesticide application. The Node MCU and Wi-Fi model operate the robot. 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 robots to see if several tiny autonomous machines may be more effective than conventional big tractors and human forces.

Agriculture is the foundation of the Indian economy. Farmers are the backbone of the food-producing industry. Traditionally, humans have done farming using bullock carts, tractors, tillers, and other tools. The primary issues facing agriculture in the current period include labor shortages, a lack of understanding of soil testing, rising labor costs, seed and water waste, and increased labor costs. The development of the agricultural robot aims to address all these drawbacks. The application of robotic technology in the agricultural area is the primary goal of agricultural robots. Plowing, sowing, and mud leveling are all expertly handled by the farm robot on an autonomous basis. A robot is a mechanical device that can carry out a variety of duties without the assistance of a person. The controller issues a command to the robot, which follows them. Along the robotic journey, numerous sensors are employed to sense various characteristics. The robotic system's microprocessor, which sits at its core, controls every single movement it makes. Managing the DC motors also regulates the motion of a wheel. The DC motor is driven by a motor driving circuit, which regulates the wheel's velocity.

II. 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 remove 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 contemporary methods included using tractors to cultivate the land, insecticides, tube wells, etc.

The agriculture bot is presented by Abdul Rahman et al. in [3]. 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. [4] 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 [5]. 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. [6], 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.

T. Mueller-Sim et al. [7] discuss an advanced system that uses a robotic platform to enhance agricultural activities like growing on the ploughed ground. They created a robotic car with four wheels and a DC motor for steering. The sophisticated autonomous system design provides the ability to create a whole new line of agricultural equipment based on tiny intelligent devices. Depending on the crop, the machine will cultivate the farm by taking specified rows and columns into account at a given distance. The issue of obstacles detected by infrared sensors will also be considered. Motors and sensors that are interfaced with a microcontroller are used to create the whole algorithm, computation, processing, and monitoring. Also shown is the outcome of the example activation unit.

III. Proposed System

The block diagram of the proposed multifunctional agriculture robot is presented in Fig.3.1. The bot's work is divided into two parts, as shown in Fig.1. It consists of a battery, Node MCU ESP8266 controller, hub motors, relay module, dc-dc converter. The bot is controlled remotely by establishing a Wi-Fi connection between node MCU and smartphone using the Blynk app. The bot is powered by a 12V Li battery having a capacity of 1.2 Ah. Four 12V DC motors have the power which allows for the moment of the bot. It provides maximum power to the wheel. The relay module connects the Node MCU ESP8266 and the DC motors. Using that module, we either provide or cut the power to the motors. The operating voltage of the Node MCU is 5V, and hence a dc-to-dc converter is used to convert 12V to 5V.

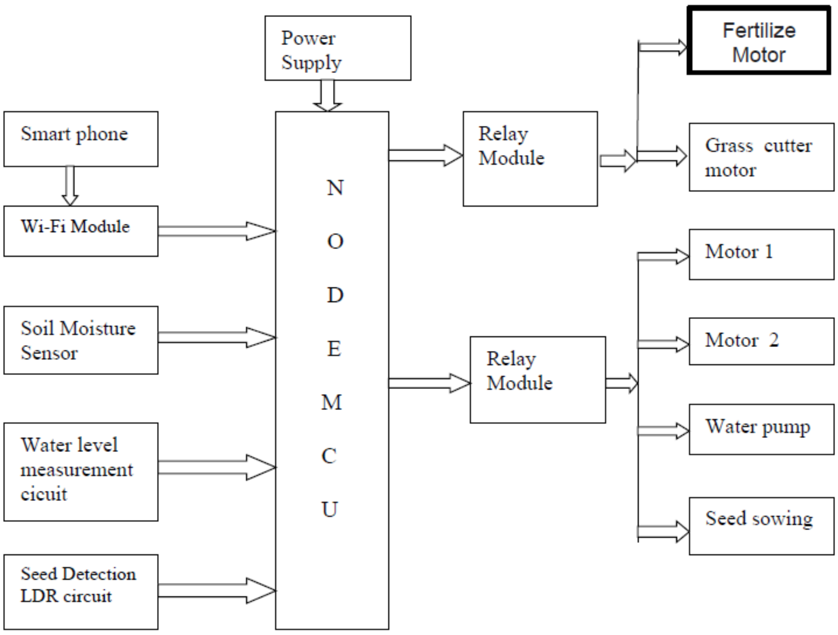

Fig.1 Block diagram of the proposed multifunctional agriculture robot

The Raspberry Pi is the heart of the system that controls the bot's functioning. It consists of sensors, motors, relay module, 12V Li battery, lights, speaker, and display. Motors are also used in various bot systems, such as automatic seed sowing, pesticide, fertilizer spraying, etc. The NODMCU controls these systems with the help of the relay module. Soil moisture sensor, ultrasonic sensor, and LDR circuit will give information to Raspberry Pi, shown on display. The camera is interfaced with Raspberry Pi using an HDMI cable. Headlights light the way during the dark hours of the day or night. These electronic components are powered by a 12V LiFepo4 battery, having a capacity of 60 Ah. Therefore, it can run for at least 5 hours. For wiring together hardware devices, APIs, and online services Node-Red programming tool is used. The graphical user interface on LCD is created using node-red. There is a different attachment for different functions like seed sowing and plowing. At a time, we can do 3 or 4 tasks. Switches 1 and 2 are used for the on-off function of lights. The data on soil moisture and plant health monitoring is displayed on display.

IV. Implementation

4.1 Software Specification

4.1.1 Arduino IDE

Java was used to create the cross-platform Arduino integrated development environment (IDE), available on Microsoft Windows, macOS, and Linux. It originated from the integrated development environment (IDE) for Wiring and Processing. It offers a code editor with text replacement, automatic indenting, brace matching, syntax highlighting, and text copy and pastes. Additionally, it provides simple one-click tools for developing and uploading Arduino applications. There is also a toolbar with buttons for everyday activities, a message area, a text terminal, a hierarchy of operational menus, and more.

The C and C++ programming languages are supported by the Arduino IDE using particular code organization principles. A software library from the Wiring project is included in the Arduino IDE and offers several standard input and output functions. User-written code only requires two essential functions, which are paired with a program stub main() to produce an executable cyclic executive program using the GNU toolchain, which is also included with the IDE, for the sketch to begin and the main program loop. The Arduino IDE uses avrdude to convert the executable code into a hexadecimal-encoded text file that is subsequently converted into the Arduino UNO board by a category in the firmware.

4.1.2 Proteus

The Proteus Design Suite is a unique toolset for electrical design automation. Technicians and electronic design professionals mostly use the application to create electronic prints and schematics for printed circuit board manufacturing. The Proteus Develop Suite is a Windows application that designs PCB layouts and simulates schematics. Depending on the scale of the designs being generated and the need for microcontroller simulation, it may be acquired in various configurations. Auto-routing with primary mixed mode All PCB Design solutions come with SPICE simulation capabilities. Schematic capture is used in the Proteus Design Suite throughout the PCB layout project's design phase and for design simulation. As a result, it is crucial and comes with every product configuration.

4.1.3 IOT Blynk Software

The most widely used IoT platform for managing thousands of deployed items, connecting devices to the cloud, and creating apps to manage and monitor them remotely is called Blynk. A PaaS makes it possible for individuals and businesses to go quickly from the prototype stage of a connected product to the market launch. Customers may connect any device to the Internet and utilize software solutions to start business ventures since more than 400 hardware models are supported. Everything you need to build and manage connected devices, such as device provisioning, sensors data display, remotely through mobile and web apps, Under firmware, secure cloud, data analytics, user and access controls, alarms, automation systems, and much more. Low-batch producers of sophisticated HVAC systems, agricultural machinery, innovative home items, and everything in between are powered by the Blynk platform.

4.1.4 Python IDE

Python is an interpretative programming language that focuses on objects. Classes, dynamic typing, highly high-level dynamic data types, exceptions, and modules are all present. In addition to supporting object-oriented programming, it also supports procedural and functional programming.

4.1.5 Software Design

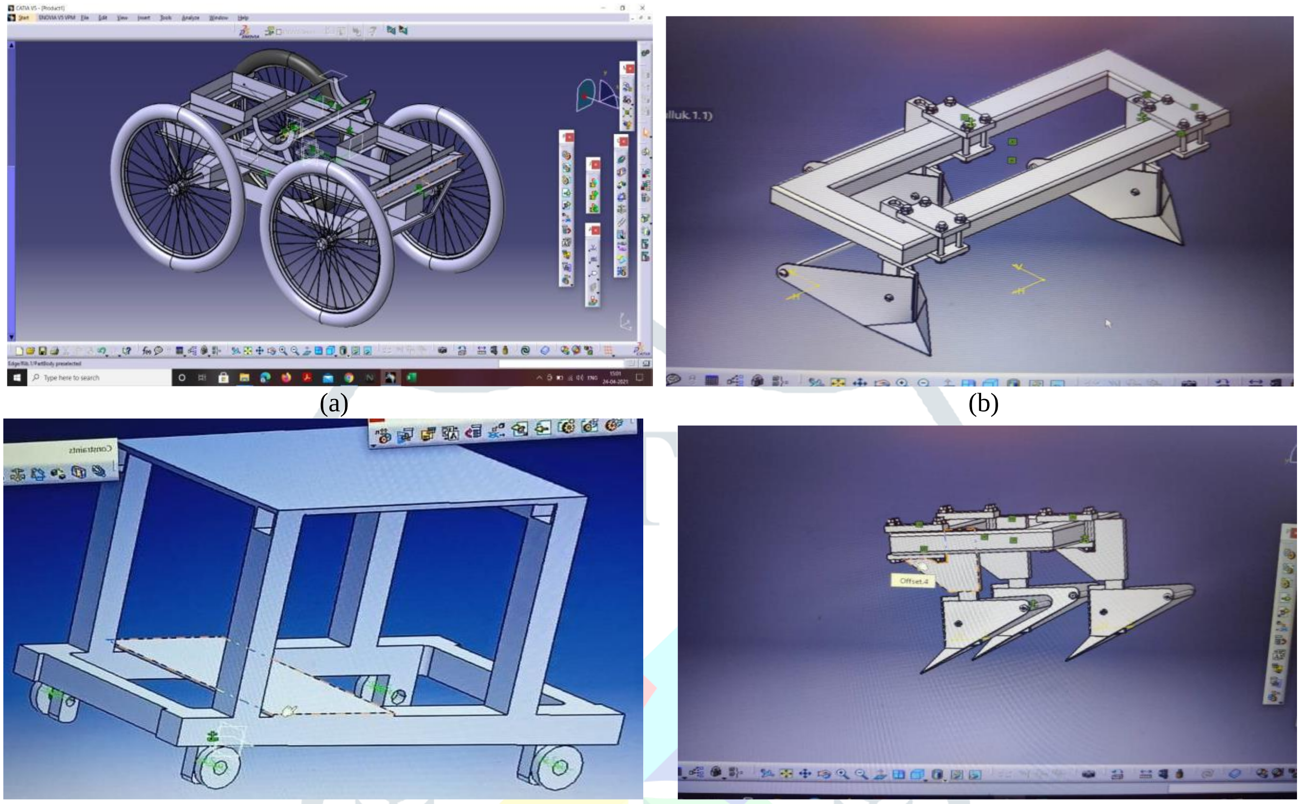

Fig.2 (a) Design of mechanical frame (b) (c) design of cultivator (d) side view of designed cultivator

4.2 Hardware Specification

4.2.1 Raspberry Pi 3

Fig.2 Raspberry Pi 3 B+

The Raspberry Pi 3 is a developer board in the PI series. It might be compared to a single-board computer with the LINUX operating system. Due to its abundant features and fast processing, the board is suitable for sophisticated applications. The PI board is created primarily for engineers and hobbyists interested in LINUX systems and IoT (Internet of Things). The Raspberry Pi hardware has undergone multiple iterations, each with differences in the kind of CPU, memory capacity, networking capabilities, and support for peripheral devices. This block diagram shows the descriptions for Models B, B+, A, and A+. The equivalent Pi Zero variations lack the Ethernet and USB hub components. The Ethernet adapter is connected to a different USB port on the inside. The USB ports of the Model A, A+, and Pi Zero are directly attached to the system on a chip (SoC). The USB/Ethernet chip of the Pi 1 Model B+ and subsequent models contain a five-port USB hub, of which four ports are accessible, in contrast to the Pi 1 Model B's two ports. On the Pi Zero, the USB port is also directly connected to the SoC, but it uses a micro-USB (OTG) connection. In contrast to all prior Pi versions, the Pi Zero lacks the 40-pin GPIO connection, and the pin locations only have solderable through-holes.

4.2.2 NodeMCU

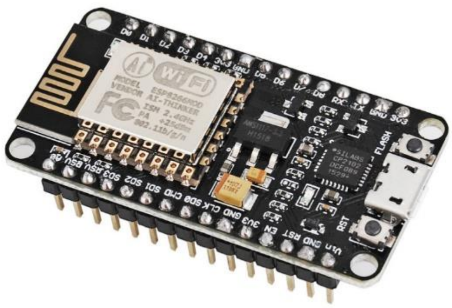

Fig.3 NodeMCU Board

There are open-source prototype board designs for the NodeMCU open-source firmware. Node and MCU are combined to form the moniker "NodeMCU" (micro-controller unit). In a technical sense, "NodeMCU" only refers to the firmware, not the related development kits. The designs for the prototype boards and firmware are also open source. The firmware employs the Lua programming language. The firmware was created using the Espressif Non-OS SDK for ESP8266 and was based on the eLua project. There is extensive use of open-source initiatives like SPIFFS and Lua-cjson. Users must choose the components needed for their project and create firmware specific to their needs due to resource limitations. 32-bit ESP32 capability has also been included. The dual in-line package (DIP), which combines a USB controller with a smaller surface-mounted board holding the MCU and antenna, is the sort of prototype hardware that is typically employed. The DIP format's selection makes breadboard prototyping simple. The ESP-12 module of the ESP8266, a Wi-Fi SoC combined with a Tensilica Xtensa LX106 core and extensively utilized in IoT applications, served as the design's basic foundation.

4.2.3 DC MOTOR

Fig.4 NodeMCU Board

DC motors are electric motors that use DC electricity as their energy source. Through these mechanisms, electrical energy is converted to mechanical energy. The fundamental idea behind DC motors is the same as that of electric motors: spin is produced by the magnetic interaction between the rotor and stator. Since controlling DC motors is more straightforward than other motors, they are frequently used in speed and direction control. A DC drive is used to regulate the motion of a DC motor. The motor's speed and direction of motion are altered using a DC drive. Some DC drives are rectifiers with series resistors that deliver conventional AC power to the motor through a switch and a series resistor, converting it into DC.

4.2.4 Soil Moisture sensor

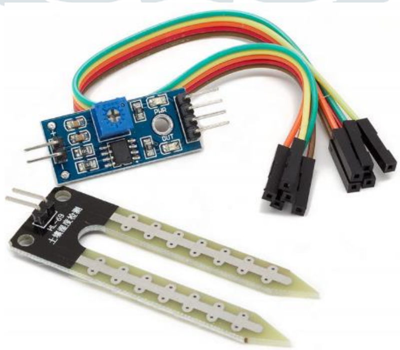

Fig.5 Soil moisture sensor

The sensor's output is now at a high level when the soil is experiencing a water deficit and at a low level otherwise. To assess the soil's moisture, use this sensor. Using this sensor, one may automatically water the flowing plant or any other plants that need it. The amount of water in the soil is measured by soil moisture sensors. Multiple soil moisture sensors make into a soil moisture probe. A capacitance sensor or other frequency domain sensor is a typical form of commercially used soil moisture sensor. The neutron moisture gauge is a different sensor that uses the neutron moderator qualities of water.

4.2.5 Relay Module

Fig.6 4 channel 12V relay module

This 4-channel, 5V relay interface board needs a 15-20mA driving current for each channel. Numerous high-current gadgets and appliances may be run on it. It contains high-current relays that run at 250 AC or 30 DC volts and 10 amps. It has a standard interface that a microcontroller may use to control it directly.

4.2.6 Water motor

Fig.7 water pump

A DC motor used in a water pump is a machine that transfers liquids. A DC motor converts electrical power supplied by the direct current into mechanical power. A current-carrying conductor suffers a torque and tends to move when exposed to a magnetic field. This is the fundamental principle of a direct current (DC) motor. This is known as motoring action. Pumps employ a mechanism, typically a reciprocating or rotating, to move fluid, which takes energy to complete. Pumps come in various sizes, from tiny ones used in medical applications to enormous ones used in industry. They may be run on several energies, such as human labor, electricity, motors, or wind power.

4.2.7 LDR

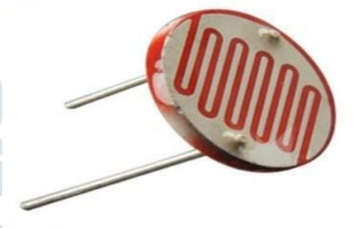

Fig.8 LDR

Manual operation and maintenance are frequently used to regulate lighting and residential appliances. However, human negligence or unexpected conditions may result in power loss during regulating appliances. To solve this issue, we may adjust the loads based on the brightness of the light by using a light-dependent resistor circuit. A device built of high resistance semiconductor material is known as an LDR or photoresistor.

V. Results

The fundamental building block is the NodeMCU microcontroller. By choosing one of the input switches on the Blynk app, input is supplied manually. A seed tank and a water tank are linked for the storage of seeds and water. A revolving wheel mechanism with a pulley is attached to a DC motor to drop the seeds. The water is sprayed using a submersible, completely waterproof DC water pump and sprinkler. We have only used transistors and four LEDs to indicate the water level at four separate phases in our water level indicator, which is used to detect the water level. Before beginning the sowing procedure, an LDR circuit is attached to the seed tank to verify if it is empty. The suggested system is an open loop control system, meaning that no output-side feedback is provided. Mechanical components are used in the project to carry out this execution. Aluminum metal makes up the mechanical frame. The dimensions are 1.5 feet long and 1 foot wide. Two DC motors must move the front two wheels. DC motors are utilized to power the grass-cutting and seed-sowing processes. To allow DC motors to rotate, 4 channel relay modules are attached to them.

The primary goal of automating farming tasks like sowing, watering, and mowing the grass is to improve traditional techniques' efficiency and accuracy. The following are the principal separations between two rows and two cotton crops. This may be understood as the separation between rows and columns. The Blynk app uses Wi-Fi connectivity to control the farm robot's several functions manually. On the screen of our smartphone, there is a joystick that we may use to move the robot left or right. We attempted to create the fundamental design for reference, with all measurements being 2 x 4 ft.

Fig.8 Implemented Structure

VI. Conclusion

The potential for robot-enhanced productivity in agriculture is enormous, and farms see an increase in the use of robots in various forms. Technology can probably solve the other issues connected to autonomous agricultural equipment. These devices might be a part of our future, but there are compelling arguments against the idea that they would simply substitute computers for human drivers. It can include reevaluating the methods used in agricultural production. A swarm of little machines may produce crops more effectively and less expensive than a few giant ones.

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