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Obstacle Detection and Avoidance Irrigating Robotic System

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ABSTRACT

The project is designed to build an obstacle detection and avoidance irrigating robot to optimize water usage for crops using ultrasonic sensor for its movement. A micro-controller (ATMEGA238) is used to achieve the desired operation, and a Water Pumping System mounted on the robot to irrigate the entire farmland. A robot is a machine like a human being that can perform the task automatically or with guidance. Robotics is a combination of computational intelligence and physical devices (motor). Computational intelligence involves the use of programmed instructions. The autonomous irrigating robotic system is a cost-effective, portable, compact and easily maintainable system that helps farmers to irrigate their farmland.

Keywords: ATMEGA328 Microcontroller, Chassis, L293D motor driver, Obstacle avoiding robot, Obstacle Detecting robot and Ultrasonic sensor.

1. INTRODUCTION

The global agriculture and food sector are changing rapidly because of the intensive increase of global food demand, which is, in turn, the result of population growth and significant shifts in customer preferences. There is a clear need for improvement in the sector`s technological basis to ensure its sustainable development. Robotics and automation are gradually becoming the priority around the world were farmers looking for a new method, cost-effective ways of responding to dynamic customer demands. Over the last several decade's robots have started to play an essential role in increasing the efficiency and reducing the cost of agricultural products. Due to the busy routine of farmers to perform irrigation process and as the size of farmland increases there is a need for farmers to automate its entire methods, such as Reseeding, Seedbed preparation, Seed mapping, weeding, Micro spraying, watering morning and evening. These tasks can be performed by autonomous robots, as they often require numerous repetitions and horticultural activities over an extended period and a large area. Several autonomous prototypes have been described for orchards and horticultural crops, such as oranges (Hannan and Burks, 2004), strawberries (Kondo et al., 2005) and tomatoes (Chi & Ling, 2004). Moreover, automated systems for site-specific irrigation is based on real-time climatic conditions have been described for high-value crops (Miranda et al., 2005). For field crops there are also a number of systems, such as the Demeter system for automated harvesting equipped with a camera and GPS for navigation (Pilarski et al., 2002), the autonomous Christmas tree weeder (Have et al., 2005) and the API platform for patch spraying (Bak & Jacobsen, 2004).

2. EXISTING SYSTEM

The Gantry robotic system is a pivot irrigation control system based on Global Positioning System data of a field. The gantry consists of three linear drives to position the robot at any given coordinate in its working envelope. For a typical plot of agricultural farmland is assumed to be having dimensions of 100x100m. The gantry robot would be an optimum solution for this aspect because it has a good traversal speed. The linear drive has to be suitable for the

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wheels. The direct drive will also have to be precise enough as only simple sensors are to be used to maintain cost effectiveness. The robotic gantry systems used in industries are built robustly and are expensive.

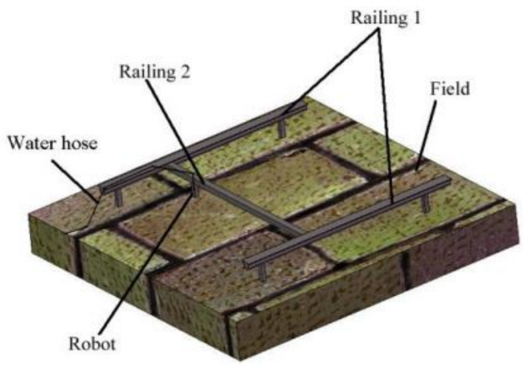

Fig. 1: Gantry Robotic System

A gantry frame would have to be set up through the length cultivated field, which would be the working envelope of the robot. Frequently screwdrivers or timing belt drives are used in industries for precision linear drives. But these trips cannot be used for agricultural purposes as this application demands the direct drive to be cost-effective, extremely fast and applicable for considerable lengths.

3. PROPOSED SYSTEM

The project proposes an autonomous irrigating robotic vehicle. No remote control for controlling the robotic actions. It intelligently detects obstacles present on it path through the sensors, avoid it and decide by internal code that was set for it while irrigating the farmland at the same time. The detail information is given in the following subtopics which will help you to understand the whole system and its design.

4. BASIC DESIGN OF ROBOT

This robot was built with an Arduino development board on which microcontroller is placed. Arduino board is connected with DC Motor through Motor driver board (pin10, pin11, pin12, pin13) which provide power to the actuators. Actuators are used to move the robot in Forwarding, Backward, Left and Right directions. The brief description of inputs pins for movement of the robot written below in the table.

Movement	Pin 10	Pin 11	Pin 12	Pin 13
Left	1	0	1	0
Right	0	1	0	1
Forward	1	0	0	1
Backward	0	1	1	0

The movement of the robot will stop whenever an obstacle is present on its path which can be detected by the ultrasonic sensors. Ultrasonic sensors give time in length to the microcontroller as an input for further actions.

4.1 SENSORS FOR OBSTACLE AVOIDANCE

Varieties of sensors are available which can be used for the detection of obstacles. (Umich, 2017) Some of the very popular sensors are Infrared sensors (IR), Ultrasonic sensors and Cameras that can be used as part of Computer Vision, Sonar. It can measure the distance in its field of view of about thousands to hundreds of points. In the design of the robot, we are using ultrasonic sensors for obstacle detection and avoidance. (Umich, 2017) The ultrasonic transducers continuously emit the frequency signals, when an obstacle is detected these signals are reflected back as input to the detector.

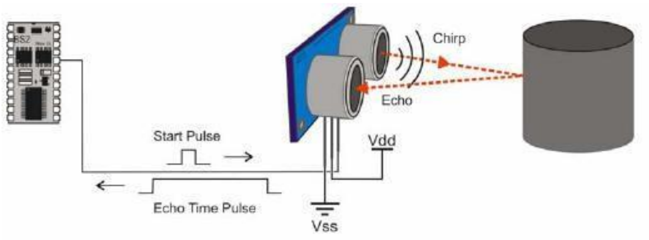

Fig.2: Schematic Diagram

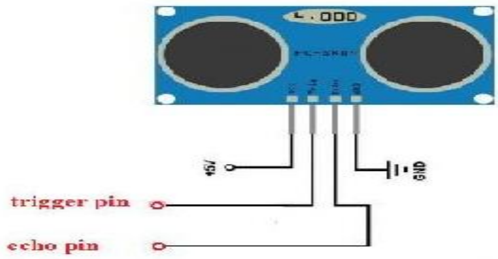

Fig.3: HC-SR04 Sensor Diagram

Features:

Parameter	**HC-SR04 Ultrasonic module**
Operating voltage	DC 5V
Operating current	15 Ma
Operating frequency	40 KHz
Longest range	4 m
Closest range	2 cm
Measurement angel	15°
Input trigger signal	ten µs TTL pulse
Output echo signal	Output high TTL level signal, the length is proportional to the range
Physical Size	45*20*15 mm

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The ultrasonic sensor consists of a multivibrator, which fixed at its base. The multivibrator is a combination of a resonator and vibrator. The ultrasonic waves generated by the vibration are delivered to the resonator. The ultrasonic sensor consists of two parts: the emitter which produces a 40 kHz sound wave and a detector which detects 40 kHz sound wave and sends an electrical signal back to the microcontroller. (Youtube, 2017). In our project, we are using HC-SR04 ultrasonic sensors which consist of 4 pins VCC, Trigger, Echo, and GND. (Random nerd tutorials, 2017).

4.2 ATMEGA328 MICROCONTROLLER

ATMEGA328 microcontroller is a computing device that is capable of executing a program (i.e., a sequence of instructions) and is often referred to as the "brain" or "control center" in a robot since it is usually responsible for all computations, decision making, and communications. To interact with the outside world, ATMEGA328 microcontroller possesses a series of pins (electrical signal connections) that can be turned HIGH (1/ON), or LOW (0/OFF) through programming instructions. These pins can also be used to read electrical signals (coming from sensors or other devices) and tell whether they are HIGH or LOW. It can also measure analog voltage signals (i.e., signals that can have a full range of values instead of just two well-defined states) through the use of an Analogue to Digital Converter (ADC). By using the ADC, ATMEGA328 microcontroller can assign a numerical value to an analog voltage that is neither HIGH nor LOW. ATMEGA328 microcontroller is an electronic prototyping platform that can be used with various sensors and actuators.

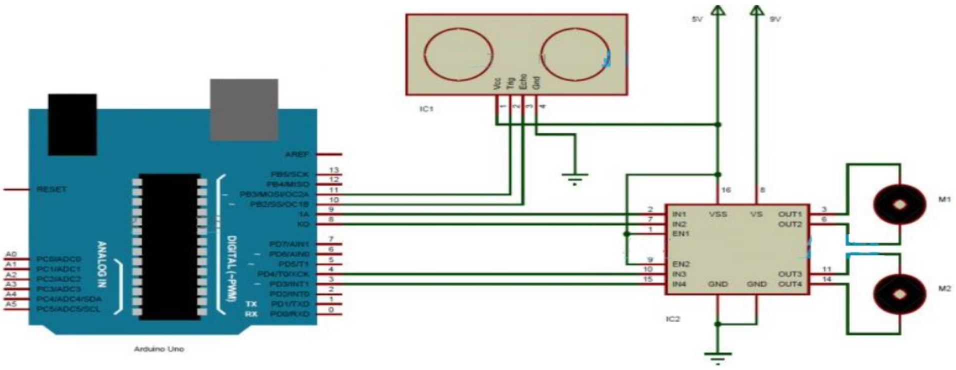

Fig.4: Robotic Vehicle System Circuit

Pin Assignment

ATMEGA328 microcontroller is the central processing unit of the robotic vehicle system. Out of the 14 available digitals I/O pins, 6 pins are used in this project design. The ultrasonic sensor has 4 pins: Vcc, Trig, Echo and Gnd. Vcc and Gnd are connected to the supply Pins of the ATMEGA328. Trig is connected to the 11th Pin and Echo is connected to the 10th Pin of the ATMEGA328. L293D is a 16 Pins Integrated Circuit (IC). Pins 1 and nine are connected to Vcc. Pins 2 and 7 are control inputs from the microcontroller to the first motor (mounted on the left wheel) which is connected to pins 9 and 8 of the Arduino respectively.

Similarly, pins 10 and 15 are control inputs from microcontroller for the second motor (mounted on the right wheel). They are connected to pins 4 and 3 of Arduino. Pins 4, 5, 12 and 13 of L293D are connected to GND (ground). The left wheel is connected to Pins 3 and 6 of L293D and Pin 11 and 14 of the L293D was attached to the right motor. The 16th pin of L293D is Vcc1. This is connected to 5V Vcc. The 8th pins are Vcc2. This is the motor supply voltage. This can be connected anywhere between 4.7V and 36V. In this project, pin eight if L293D is connected to the 12V supply.

4.3 L293D MOTOR CONTROLLER

ATMEGA328 digital output pins (40mA) cannot be connected directly to the motors because it is likely to damage the motor. We used an L293D motor controller which consists of two H-bridges capable of controlling two engines and also have an inbuilt excess protection against short circuits.

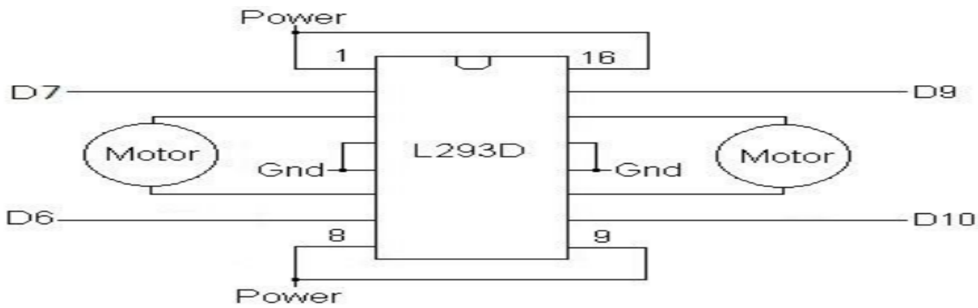

Fig.5: L293D Motor Controller

Wheels

Wheels were used to provide mobility to the robot. Bikes can be any size, from a few centimeters up to 30 cm and more dependent on the working environment of the robot. Tabletop robots tend to have the smallest wheels, usually less than 5 cm in diameter. Robots can have just about any number of bikes, although 3 and four are the most common. In this project, we used four wheels.

Fig.6: Wheel Controller

4.4 Chassis

Chassis is the supporting frame of the robotic vehicle system. It consists of an internal vehicle frame that supports an artificial object in its construction and use, can also protect some interior parts. Metallic rolling chassis assembly of 88cm length X 33cm width.

4.5 Robotic Vehicle Path Design

Obstacles are placed at the four edges of the farmland to make the robot apply the concept of obstacle avoidance and turn with left priority hence completing the irrigation of the entire farmland.

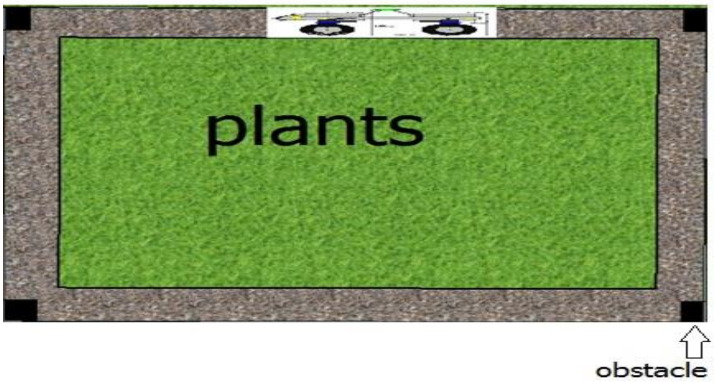

Fig.7: Robot Vehicle Path

4.6 Water Pumping System

A 12v DC motor is used to drive the turbine. The turbine is responsible for pumping water out of the water tank through the water pipe up to the sprinkler.

5. ALGORITHM - WORKING PRINCIPLE

The sonar system is used in an HC-SR04 ultrasonic sensor to determine the distance to an object like bats do. It offers excellent non-contact range detection from about 2 cm to 400 cm or 1'' to 13 feet. Its operation is not affected by sunlight or black material. (Randomnertutorials, 2017).

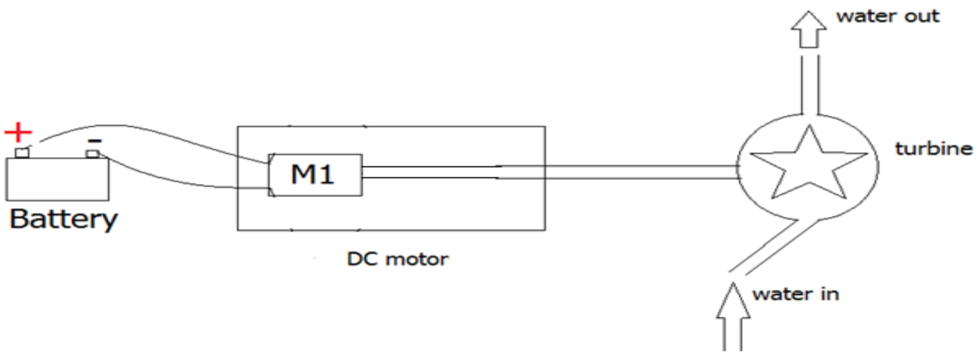

Fig.8: Water Pumping System

The ultrasonic sensor emits the short and high-frequency signal. If they detect any object, then they reflect back echo signal which taken as input to the sensor through Echo pin. (Roboticbible, 2017). Firstly, we initialize Trigger and Echo pin as low and push the robot in the forward direction. when an obstacle is detected Echo pin will give input as high to the microcontroller. Pulse In() function is used for calculating the time of distance from the obstacle. Every time the function waits for the pin to go high and starts timing, then timing will be stopped when the pin goes to low. It returns the pulse length in microseconds, or when the complete pulse was not received within the timeout it returns 0. (Roboticbible, 2017).

The timing has been determined means it gives the length of the pulse and will show errors in shorter pulses. Pulses from 10microseconds to 3 minutes in length are taken into consideration. After determining the time, it converts into a distance. If the distance of the object is moderate, then the speed of robot gets reduced and will take a left turn, if an obstacle is present in left side then it will take a right turn. If the distance of the object is short, then the speed of robot gets reduced and will turn in the backward direction and then can go in a left or right direction.

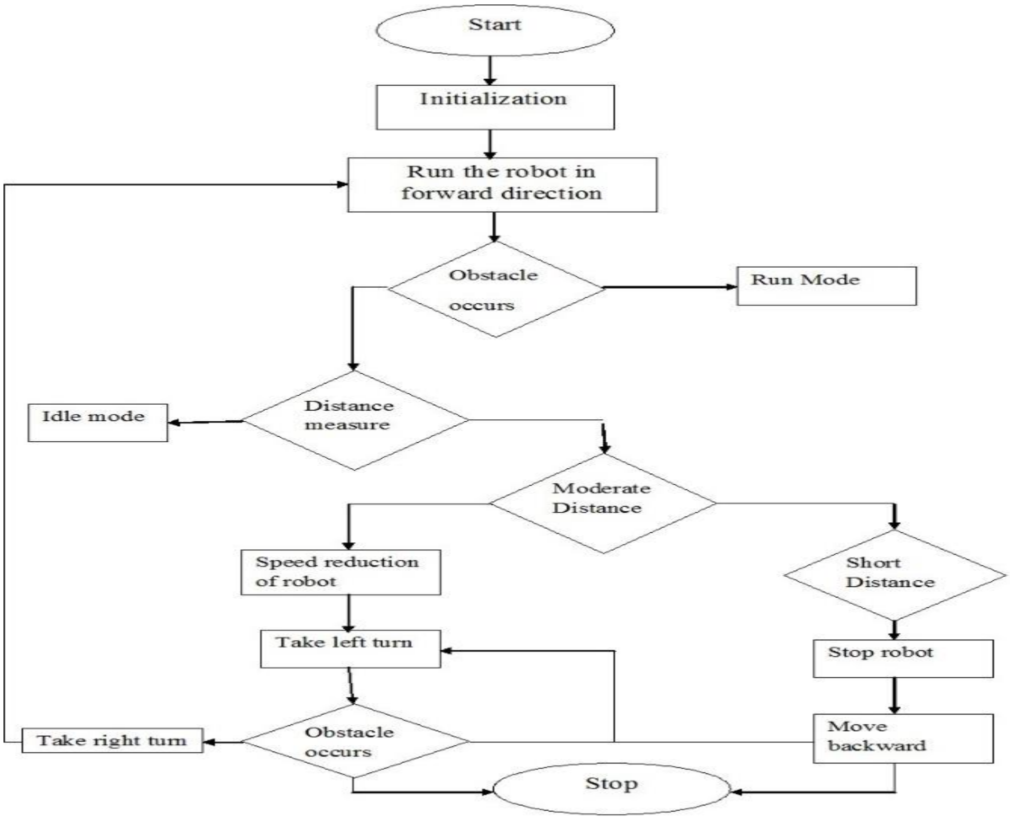

Fig.8: Obstacle Avoidance Flowchart

6. IMPLEMENTATION

The implementation of obstacle avoidance strategy for robot involves the writing and compilation of program using Arduino software. Arduino is a popular programmable board used to create projects. (Roboticbible, 2017). It consists of a simple hardware platform on which microcontroller is placed as well as a free code editor which has a "one click compile or upload" feature. Hence it is designed for the peoples in such a way that they can use it without necessarily being an expert programmer. Arduino offers an open-source electronics prototyping platform that is easy to use and flexible for peoples who are beginners in robotics field with both the software and hardware perspective. The general block diagram for the complete execution is as Follow:

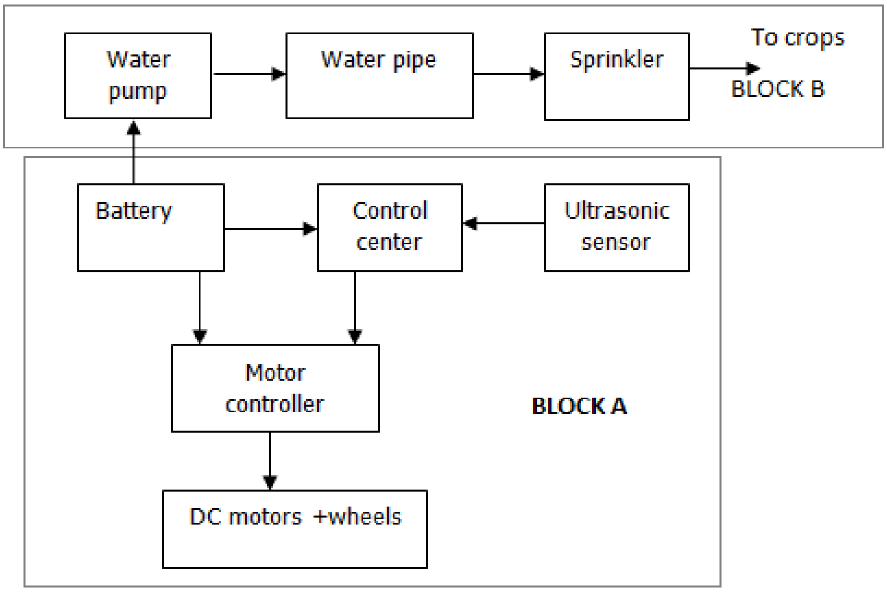

Fig.9: Block Diagram of obstacle avoidance robot

7. THE ROBOTIC SYSTEM DESIGN

The robotic system was designed using metal chassis, 2 DC motors, two wheels, Ultrasonic sensor, L293D motor controller, a 12V battery, and AtMega328 microprocessor.

A metal chassis of length 88cm X width 38cm is used. However, a wooden frame can also be used, but it is durable in the agricultural sector.

The 2 DC motors are mounted on the metal chassis, and the wheels are fixed to them firmly. The powering of the DC motors depends on the wattage of the DC motor. Low-speed motors with high starting torque are used to increase the efficiency of irrigation.

L293D motor controller and ultrasonic sensor are interfaced with the ATMega328 microprocessor to control the motor direction.

The L293D motor controller is powered using a 12V battery supply and the ATMega328 microprocessor using a 5V power supply.

8. PRINCIPLE OF OPERATION

In this project, the farm irrigation process is controlled by a mechatronics system. The robotic vehicle system works based on the concept of obstacle avoidance with left priority. The ultrasonic range sensor performs to identify obstacles prompting the robot to turn with left preference at the edge of the field hence completing the irrigation of the entire farmland.

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The ultrasonic range sensor uses the "Doppler Effect" phenomenon. Doppler Effect is the apparent difference between the frequencies at which sound or light waves leave a source and that at which they reach an observer, caused by relative motion of the observer and the wave source. Using an external trigger signal, the Trig pin on the ultrasonic sensor is made logic high for at least ten μs. A sonic burst from the transmitter module is sent. This consists of 8 pulses of 40 KHz. The signals return after hitting a surface, and the receiver detects this signal. The Echo pin is high from the time of sending the message and receiving it. This time can be converted to distance using appropriate calculations.

12V DC from the accumulator will serve as the overall power supply to the entire robotic irrigation system. When the robot is powered on, both the motors of the robot will run normally and the robot moves forward. During this time, the ultrasonic sensor continuously calculates the distance between the robot and the obstacle.

This information is processed by the ATMEGA328 microcontroller. If the distance between the robot and the obstacle is less than 50 cm, the left wheel motor is reversed in direction, and the right wheel motor is operated normally. This will rotate the robot towards left. This rotation continues until the distance between the robot, and an obstacle is greater than 50 cm. The process continues forever, and the robot keeps on moving without hitting any obstacle as the water pumping system is also irrigating the farmland.

9. TESTING

Testing of project is the process of measuring the workability of the components as well as the complete system; the project was tested in three ways;

i. The practicability of the robotic vehicle system.
ii. The reading accuracy of the ultrasonic range sensor and the reading distance.
iii. The workability of the water pumping system.

10. RESULT

After testing the project, the system was found to be working effectively and efficiently. For the ultrasonic sensor, it was found out that it can detect obstacles at the programmed distance of 50 cm.

11. CONCLUSION

In agriculture, the opportunities for robot-enhanced productivity are immense, and the robots are appearing on farms in various guises and increasing numbers. The other problems associated with autonomous farm equipment can probably be overcome with technology. This equipment may be in our future, but there are important reasons for thinking that it may not be just replacing the human driver with a computer. It may mean a rethinking of how crop production is done. Crop production may be done better and cheaper with a swarm of small machines than with a few large ones. One of the advantages of the smaller machines is that they may be more acceptable to the non-farm community. The jobs in agriculture are a drag, dangerous, require intelligence and quick, though highly repetitive decisions hence robots can be rightly substituted with a human operator.

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The higher quality products can be sensed by machines (colour, firmness, weight, density, ripeness, size, shape) accurately. The present situation in our country all the agricultural machine is working on manual operation otherwise by petrol engine or tractor is expensive; the farmer can't work for a long time manually to avoid this problem, we need to have some power source system to operate the digging machine.

After completing this project, the objectives of this project were accomplished with complete and timely. With this project, hopefully, it can provide many benefits and gains to the agricultural sector since it can be used for irrigation and spraying purposes considering the changing technology overtime and making more significant impacts.

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