Development of a hardware unit to control an autonomous robot for a farming system application problem

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Abstract

In this paper, we present a robotic architecture automatic plant watering system that we can build. It is an Raspberry and Arduino based automatic plant watering system that uses a IR Sensor. By implementing this method we can also reduce the man power required to look after the plants. Using this technique we can detect whether the plant is in good condition or not based on that we will decide what action should be taken. Robotics is playing a significant role in agricultural production and management. There is a need for autonomous and time saving technology in agriculture to have efficient farm management. The work done in this paper is the effect of the project work undertaken by the under-graduate students of the college under the guidance of the faculties, which is a part & parcel of the UG curriculum in the final year.

1. Introduction

Population increases, climate change, degradation and loss of arable land, and the increasing appearance of new pests and diseases threaten the world's food supply. Understanding how plants respond to environmental and genetic perturbations is essential to accelerating the improvement of crops and agriculture .High-throughput phenotyping provides an unprecedented opportunity to study the physiological, developmental, and molecular mechanisms that govern the dynamic behavior of plants. An agricultural robot is a robot deployed for agricultural purposes. The main area of application of robots in agriculture today is at the harvesting stage. Emerging applications of robots or drones in agriculture include weed control, [1][2][3] cloud seeding, [4] planting seeds, harvesting, environmental monitoring and soil analysis [5][6].

However, existing systems that allow highly automated collection of basic phenotypic data for small numbers of plants in the greenhouse fall far short of the need to examine and characterize thousands of plants under real world conditions. Building systems that can collect multi-modal, multi-character data in real time in the field requires integrating plant biology and crop science with robotic vision and computer engineering. These systems must be accurate and reliable, and should provide richer information than the current methods available for automated greenhouse or manual field phenotyping. By doing so, they will help us to link plant genotypes as well as the molecular and eco-physiological responses with the expression of specific phenotypes in response to the growing conditions.

2. Block diagram of the proposed implemented system

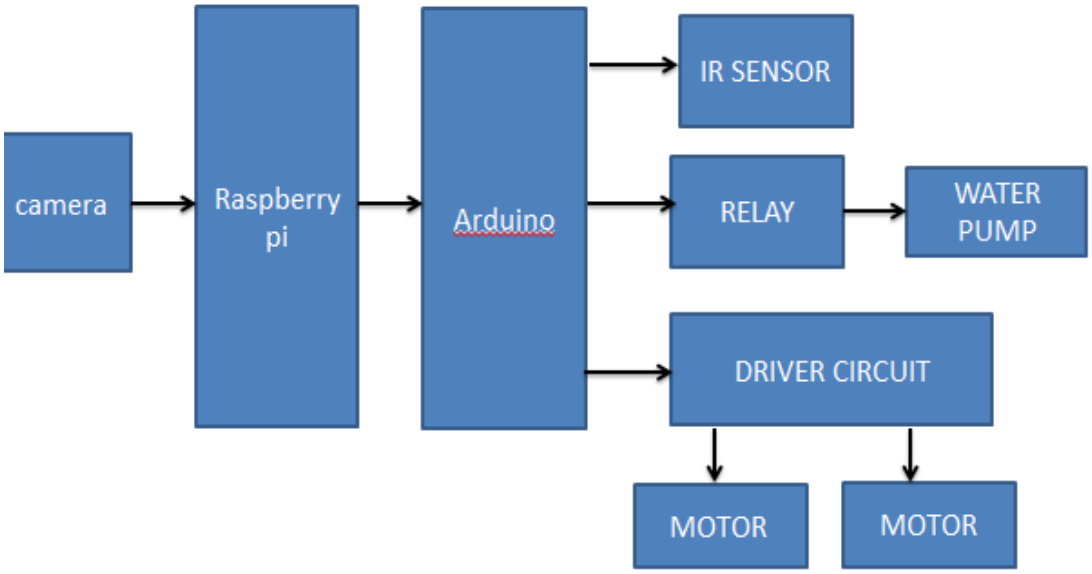

Fig. 2.1 : Design block-diagram of the robot control

3. Working

In the above block diagram, IR sensor which is connected to Arduino Uno microcontroller is used to sense the plant, whenever it senses then motors will automatically comes into rest position. Then the pi camera which is connected to Raspberry pi gets activated and capture the pictures, this pictures are send to raspberry pi where image processing takes place to detect the colour of the leaf. Based on those image processed pictures necessary actions are taken, if the plant is green then water pump gets activated which is connected through relay if plant is light green or yellow then water pump that is placed in pesticide mixed water gets turned on otherwise the cutting tool gets turned on when the leaf is brown in colour after performing any one of the action the robot moves to the next plant and continues the same process.

4. Tools required

In this section, the tools required, i.e., the hardware & software parts is being presented.

Hardware

- Raspberry Pi
- Arduino
- IR Sensor
- Wireless Camera
- DC Motors
- Driver Circuit
- Relay
- Water pump

Software

- Arduino IDE
- Phython IDE

5. Electrical circuit design

In this section, the design of the electrical circuits for the hardware interface between the mechanical part & the electrical part is being presented in a nutshell.

The DC Motor - The DC Motor or Direct Current Motor to give it its full title, is the most commonly used actuator for producing continuous movement and whose speed of rotation can easily be controlled, making them ideal for use In applications were speed control, servo type control, and/or positioning is required. A DC motor consists of two parts, a "Stator" which is the stationary part and a "Rotor" which is the rotating part. The result is that there are basically three types of DC Motor available

Brushless Motor - This type of motor produce a magnetic field in the rotor by using permanent magnets attached to it and commutation is achieved electronically. They are generally smaller but more expensive than conventional brushed type DC motors because they use "Hall effect" switches in the stator to produce the required stator field rotational sequence but they have better torque/speed characteristics, are more efficient and have a longer operating life than equivalent brushed types.

Servo Motor - This type of motor is basically a brushed DC motor with some form of positional feedback control connected to the rotor shaft. They are connected to and controlled by a PWM type controller and are mainly used in positional control systems and radio controlled models.

Advantages of DC Motor - Here, the advantage of why the DC motor has been used as the actuators is being presented in a nut-shell as follows.

Speed control over a wide range both above and below the rated speed: The attractive feature of the dc motor is that it offers the wide range of speed control both above and below the rated speeds. This can be achieved in dc shunt motors by methods such as armature control method and field control method. This is one of the main applications in which dc motors are widely used in fine speed applications such as in rolling mills and in paper mills.

High starting torque: dc series motors are termed as best suited drives for traction applications used for driving heavy loads in starting conditions. DC series motors will have a staring torque as high as 500% compared to normal operating torque. Therefore dc series motors are used in the applications such as in electric trains and cranes.

Accurate steep less speed with constant torque: Constant torque drives is one such the drives will have motor shaft torque constant over a given speed range.

- In such drives shaft power varies with speed.
- Quick starting, stopping, reversing and acceleration
- Free from harmonics, reactive power consumption and many factors which make dc motors more advantageous compared to an ac induction motors.

Disadvantages of DC motor -

- High initial cost
- Increased operation and maintenance cost due to presence of commutator and brush gear
- Cannot operate in explosive and hazard conditions due to sparking occur at brush (risk in commutation failure)

DRIVER CIRCUIT (L293D) – An IC which is used for driving the motors / actuators & used for obtaining the rotary motion.

H bridge motor driver circuit – This is a circuit which is used as the interface to drive a particular motor or an actuator which is used for movement in the robots.

Description: The circuit given here is of a simple H bridge motor driver circuit using easily available components. H Bridge is a very effective method for driving motors and it finds a lot of applications in many electronic projects especially in robotics. The circuit shown here is a typical four transistor H Bridge. The diodes D1 to D4 provide a safer

path for the back emf from the motor to dissipate and thus it protects the corresponding bipolar transistors from damage. Resistors R1 to R4 limit the base current of the corresponding transistors. Working of this circuit is very easy to understand. When terminal D is grounded and A is pulled to +Vcc, transistors Q1 and Q4 will be on and current passes through the motor from left to right. When terminal B is grounded and C is pulled to +Vcc, transistors Q3 and Q2 will be on and current passes through the motor from right to right making the motor to rotate in the opposite direction.

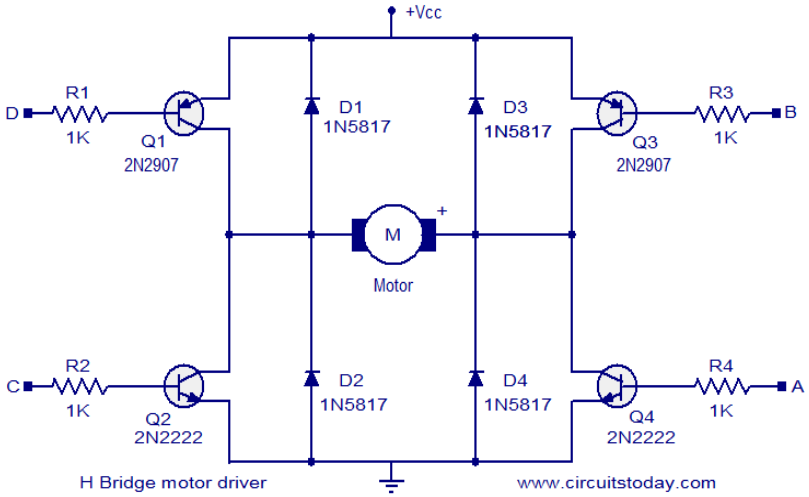

Fig. 5.1 circuit diagram of driver circuit [source : 7]

Action	A	B	C	D
Coast / Roll / Off	Ground or Disconnected	$+V_{cc}$ or disconnected	GND or Disconnected	$+V_{cc}$ or disconnected
Forward direction	GND or Disconnected	Ground	$+V_{cc}$	$+V_{cc}$ or disconnected
Reverse direction	$+V_{cc}$	$+V_{cc}$ or disconnected	Ground or Disconnected	Ground
Braking or Slowing down	$+V_{cc}$	$+V_{cc}$ or disconnected	$+V_{cc}$	$+V_{cc}$ or disconnected

Table 5.1 : Logic levels of Driver circuit [Source : 8]

A bidirectional H bridge DC motor control circuit is shown here. The circuit is based on the IC L298 from ST Microelectronics. L298 is a dual full bridge driver that has a wide operating voltage range and can handle load currents up to 3A. The IC also features low saturation voltage and over temperature protection. In the circuit diode D1 to D4 are protection diodes. Capacitor C2 is the logic power supply filter and capacitor C2 is the supply voltage filter. The state of the motor will depend on the logic level of the pins 10, 11, 12 and it is described in the table shown below the circuit diagram.

Circuit diagram of H bridge motor controller:

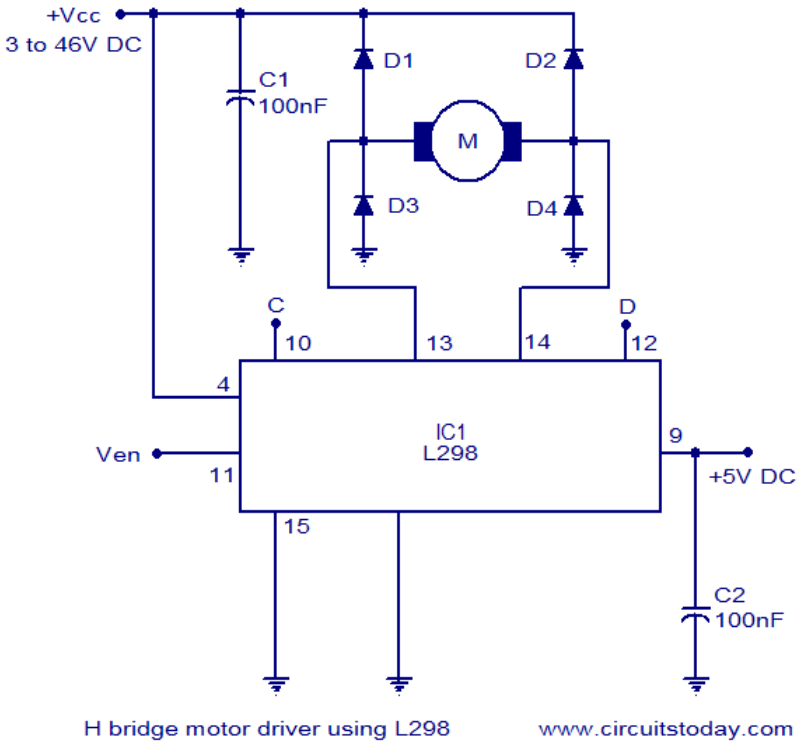

Fig. 5.2 **:** Circuit diagram of H bridge motor controller [Source : 6]

H Bridge Motor Control Circuit Schematic

Inputs		Function
V_{en} = H	C = High ; D = Low	Forward motion of the motor
	C = Low ; D = High	Reverse motion of the motor
	C = D	Fast motor stopping
V_{en} = Low L	C = X ; D = X	Free running of the motor stopping
L = Low	H = High	X = Don't care

Table 5.2 : H Bridge control logic design [Source : 9]

IR SENSORS:

An IR sensor consists of two parts, emitter circuit and the receiver circuit. This is collectively known as photo coupler or an opto-coupler. The emitter is an IR LED and the receiver is an IR photodiode. The IR photo diode is sensitive to an IR light emitted by IR LED. The photo-diode's resistance and output voltage change in proportion to the IR light received. This is the underlying working principle of IR sensor. It consists of 3 pins V_{CC}, GND and OUTPUT pin.

Fig. 5.3 : IR Sensor used

The type of incidence may be direct incidence and indirect incidence. In direct incidence, the IR LED is placed in front of the photodiode with no obstacle in between. In indirect incidence, both the diodes are placed side by side with an opaque object in front of the sensor. The light from the IR LED hits the opaque object and reflects towards the photodiode.

RELAY:

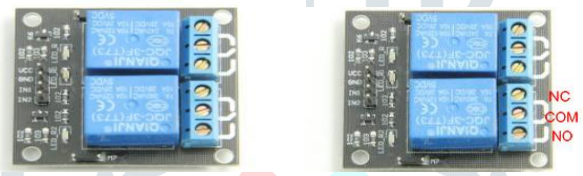

Fig. 5.4 : Relay used

- A relay is similar to a switch, it is either open or closed.
- When the switch is open no current passes through the relay, the circuit is open, and the load that is connected to the relay receives no power.
- When a relay is closed, the circuit is completed and current passes through the relay and delivers power to the load.
- To open and close a relay an electromagnet is used.
- When the coil controlling the electromagnet is given a voltage, the electromagnet causes the contacts in the relay to connect and transfer current through the relay.
- COM- Common pin
- NC- Normally Closed, in which case NC is connected with COM when INT1 is set low and disconnected when INT1 is high;
- NO- Normally Open, in which case NO is disconnected with COM1 when INT1 is set low and connected when INT1 is high.
- Terminal 2 is similar to terminal 1,except that the control port is INT2
- INT 1- Relay 1 control port
- INT 2- Relay 2 control port

6. Photographic view of the developed prototype

In the Fig. 6.1 shown, a photographic view of the hardware developed is being presented which is used for various types of agricultural applications. The designed electrical part is shown on the platform along with the battery backups.

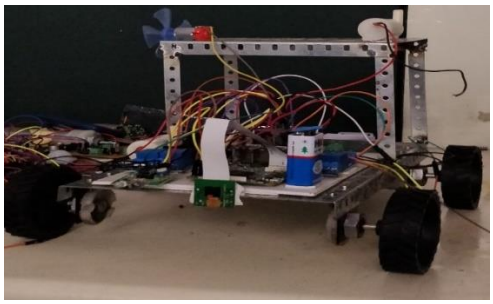

Fig. 6.1 : Photograph of the developed robot

7. Applications

- During summer season people often neglect to water the potted plants so we can use this system to provide water
- Regions where there is shortage of water we can use this robot for efficient use of water for agricultural purpose.
- This project reduces the man power required for agricultural purpose

8. Conclusions

In this paper, the main design of the electrical parts is presented which is used for controlling the driving interface of the robot that could be used for a host of agricultural applications. Here, only a jist of the work done by the UG students under the guidance of the faculty members is being presented in a nut-shell.

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