FARMBOT

AIM

To make an autonomous agricultural robot to automate agricultural tasks with minimal human intervention.

MOTIVATION

The driving factor behind the project was the need of autonomous farming robot in a developing nation like India which is on the path of agricultural and technological development. In a nation like India, agriculture is perceived as a backward or sub-normal occupation. Thus, people don't prefer to take it up as an occupation. The problem is two-fold-

1. Due to several factors leading to hardships in this occupation, the number of farmers is on a decline.
2. Due to a skewed penetration of technology in agriculture, development in agriculture is not vast as it is in other fields like service and manufacturing.

So, the Farmbot is our humble contribution to minimise this skew in the agricultural field.

INTRODUCTION

The Farmbot project is inspired by the Genesis v1.0 robot which achieves a similar automation in farming. But, the cost of this robot is not what an average Indian person could afford. The latest version is priced at $3900 or roughly Rs. 2,61,000. Moreover, the Genesis bot is aimed at gardening and small-scale agriculture automation, which is, in our opinion, inadequate for the food crop oriented agriculture practices of India.

Our Farmbot is designed keeping the above point in mind. The differentiating factor is the cost, at around Rs. 10,000, it is a mere 5% of what the Genesis costs.

WORKING MECHANISM

Movement in x-direction:

The Farmbot will have a gantry system as shown in Fig 1, which will move on the horizontal tracks, in x direction with the help of two Johnson motors. The gantry is fixed with respect to the body or chassis of the bot. The gantry consists of a printer bed which has a carriage moving in y direction only.

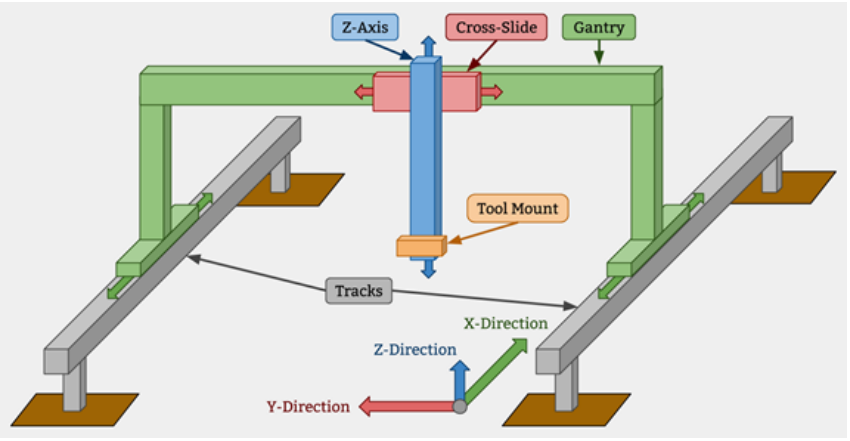


Figure 1 : Structural Diagram of Farmbot

Movement in y-direction:

The carriage is moved with the help of a DC brushed motor and the reference of position is kept using an optical encoder in the form of marked plastic tape. An IR (infrared) LED pair is used where when light from transmitter reflects across the tape and the receiver produces pulse according to the speed of movement.

Movement in z-direction:

Rack and pinion mechanism is used for movement along z-direction. In this cross-slide is used. It is a type of linear actuator that converts rotational motion into linear motion. Here, circular gear is called pinion which engages teeth on linear bar called rack. Rotational motion applied to pinion causes rack to move relative to pinion thereby translating rotational motion of pinion into linear motion, directed in the z-direction.

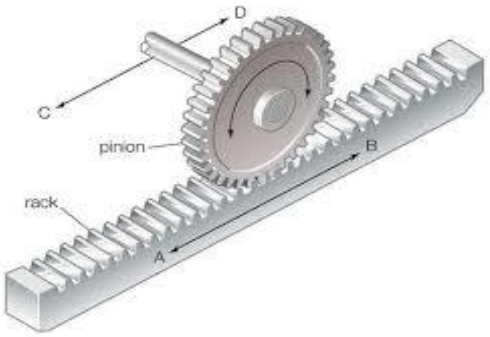


Figure 2 : Rack and Pinion Mechanism

Mechanism for sowing seeds:

A container with seeds is attached to the boundary of the device. Different containers may be used, that can contain different types of seeds. A vacuum pump controlled by the raspberry pi is used to create suction through a nozzle. This nozzle is mounted on the rack that is mentioned in the previous para. This nozzle acts as both a picker and dropper for the seeds. The vacuum pump creates suction that will hold a few seeds to the nozzle and drop them at the required spot.

Mechanism for irrigation:

An elevated water tank carries the water to be used for irrigation. The flow of water is controlled using a solenoid valve, which is controlled using the raspberry pi. The solenoid valve is a magnetic device having an inductive coil used as a solenoid to push and pull a plunger which acts as a valve. This device is commonly used to control the flow of fluids in hydraulic and pneumatic systems.

POWER MANAGEMENT

All components (except the vacuum pump) of the bot are powered by a single 500W PSU. It is capable of converting 240V, 50Hz mains supply into dc, which can be further utilized by various electronic components. The particular PSU we are using is capable of producing maximum output power of 500W and dc in range 3.3V-12V.

CONTROL MECHANISM

The Farmbot is powered by a Raspberry Pi 3 and an Arduino Uno. The Raspberry Pi 3 is a single board computer run by a 1.2GHz 64-bit quad-core ARMv8 CPU. The operating system used is Raspbian, a free OS based on Debian optimized for the Raspberry Pi hardware. Raspbian comes preloaded with Python, the official programming language of the Raspberry Pi and IDLE 3, a Python Integrated Development Environment. Python is used to interface the raspberry pi with external devices. The Arduino Uno on the other hand is a single board microcontroller that uses an ATmega328 microcontroller. The device is programmed using C.

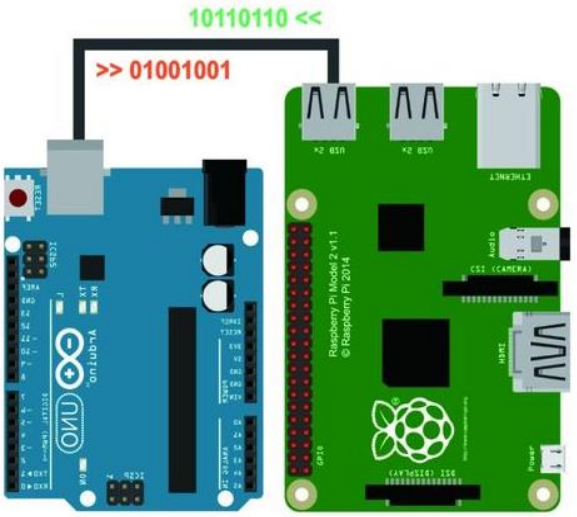


Figure 3 : Serial Communication between Raspberry Pi and Arduino

The Raspberry Pi performs the following functions:

1. The various operations performed by the Farmbot are all controlled by the Raspberry Pi. The control signals are then sent to the Arduino Uno serially which are then mapped with functions in C programming to control the hardware devices used in the Farmbot.
2. A camera is mounted on the gantry for observing the plant growth and to detect the presence of weeds. This is done with the help of computer vision and image processing. The camera is connected to the Raspberry Pi, which allows us to use OpenCV in python to perform the various computer vision algorithms.
3. With an internet connection, the system can automatically syndicate weather forecast information using several online APIs, and accordingly decide the amount of water to use for irrigation. For example, if rains are expected in near future, the system can use lesser amount of water.
4. The Raspberry Pi is also able to host a web server service. This can be exploited to use the Farmbot from remote location. A control interface using Internet Protocol can be devised that will make it possible to control it manually.

Control Architecture:

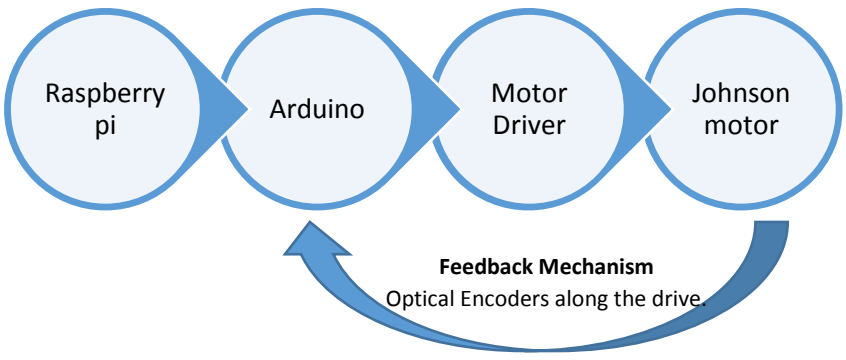


Figure 4 : Block Diagram of the Control System for motion

The figure 3 above, shows the flow of control through various components in the system.

The Arduino here, is acting as a priority queue for performing the operations, as the system can do only one work at a time. The Raspberry pi acts as a feed for control commands, which the Arduino interprets and stores in a queue arranged in the order of their priority. The commands are purged once they are executed.

The Arduino is also responsible for controlling the motors and actuators. This is done using the principles of Numeric Control, widely used in applications like printers and CNC machines. A feedback mechanism composed of optical encoders is used to keep track of the movement of the gantry and the cross slide/carriage. The optical encoders employ an IR LED pair which are made to pass over a marked tape, with alternate black and white (clear) markings. The movement generates a pulse output across the photodetector, from which the relative displacement can be calculated by counting the number of negative edges starting from a certain time instant.

TECHNICAL SPECIFICATIONS

Hardware Components:

1. Raspberry pi Model 3 B+
2. Arduino Uno
3. L298 Motor Driving IC
4. Johnson High torque motor
5. Camera

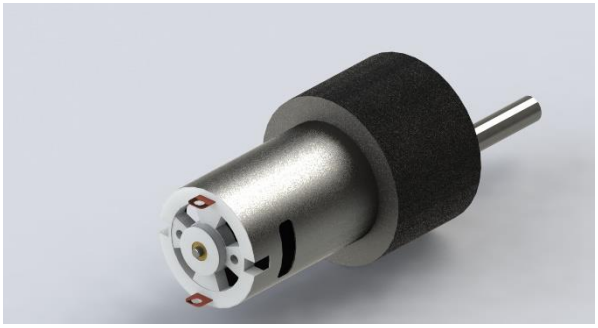
Other Components:

1. Vacuum pump
2. Rack and pinion mechanism
3. Cross slide and gantry mechanism

SCHEMTAICS AND IMAGES

Raspberry Pi Single Board Computer

Arduino Uno



Johnson Motor used for locomotion

Electric Air Pump

Switched Mode Power Supply Unit

Printer Bed Mechanism

REFERNCES

1. Most of the design is based on the Genesis Farmbot v1.0 White Paper at https://drive.google.com/file/d/0B-wExYzQcnp3ZWxheXgwRU1yVkU/view
2. Weed Recognition Using Image-Processing Technique Based on Leaf Parameters at http://www.davidpublishing.com/davidpublishing/Upfile/9/23/2012/2012092383363257.pdf