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AGROBOT: Sowing and Irrigating Farming Machine

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Abstract—A new and innovative technique for precise farming called 'Agrobot' is proposed here that will shift dependence on large scale agriculture by giving people the ability to cultivate their own plants with little to no actual physical labour on their part. Agrobot would be able to provide specialized care to feed nutrients and water to each plant as needed. This means that, with Agrobot, a person with little to no actual gardening experience could have the home-garden of their dreams with no effort. Agrobot is a scalable automated precision farming machine. Agrobot is a CNC farming project consisting of a Cartesian coordinate robot farming machine, software and documentation. The project aims to develop a CNC farming machine which can cultivate a variety of crops within same area at the same time and is able to operate indoors, outdoors and covered areas. Scope of this project lies in the development of infrastructure, seeding and watering mechanism.

Keywords—CNC machine, precision farming, scalable, Cartesian coordinate, infrastructure, Seeding, Watering.

I. INTRODUCTION

Most agricultural food production in the modern day is performed in large scale, monocrop farms on huge plots of land. While it has been streamlined to produce huge amounts of food at a relatively cheap price, monocrop farming puts a significant strain on the soil and the surrounding environment by using up specific nutrients for different crops, as well as using tremendous amounts of water. The idea with Agrobot is to shift dependence on large scale agriculture by giving people the ability to cultivate their own plants with little to no actual physical labour on their part.

Significant number of researches has focused on farming automation to reduce the human effort required for farming. Precision farming using wireless sensor network [1] helps to focuses on the more current situation of diminishing water tables, going away of streams and tanks, flighty condition that shows the dire need of appropriate usage of water. To adapt up to this, utilization of temperature and dampness sensor at reasonable areas for observing of products is actualized in the proposed work. The innovative advancement in Wireless Sensor Systems in precision farming made it conceivable to use in observing and control of nursery parameter in exactness agribusiness [2].

To overcome the defects of the sensor systems a distributed network [3] was made. A remote detecting and control water system framework utilizes the conveyed remote sensor for variable rate water system, constant in field detecting, controlling of a site and particularly accurate straight move water system framework to augment the efficiency with insignificant utilization of water was created. The entire framework was created utilizing five in-field sensor stations which gathers the information and sends it to the base station utilizing worldwide situating framework (GPS) where essential activity was taken for controlling water system as indicated by the database accessible with the framework. The framework gives a promising minimal effort remote arrangement and additionally remote controlling for exactness water system [4].

An efficient solution for maintaining the water and nutrient supply to the crop fields based on the climate and soil conditions has been proposed in the paper 'Design Architecture of Autonomous Precision Farming System' [5]. It describes the design and development of an Autonomous Precision Farming System (APFS) for agriculture automation. It is a low power, user friendly system which helps the farmers to plan irrigation and fertilization based on environmental and soil conditions. The system can intelligently operate pumps / valves based on the data available from the field and the preloaded programs available in the controller.

Automation system implementation on farming methods can make the cultivation process simple and requires less human effort. Here sensors are used for checking various parameters such as water requirement, water temperature, fertilizer requirements, level of oxygen in water [6] etc. Based on the sensor outputs the system can take the control actions.

In this paper a CNC based farming machine called Agrobot is proposed for the farming automation. It is a CNC machine which with three dimensional motion [7]. Agrobor can move in X, Y, Z directions. Agrobot will be able to perform the seed sowing and the watering mechanisms

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without the use of human physical labour. For this initially an appropriate mechanical design is required for the CNC farming machine [8]. Design of mechanical systems that will be applied to general farming automation take the design of the machine axis cnc with three axes, namely X axis, Y axis and Z axis. There are several key parts of mechanical systems for general farming automation. The first part is to create a vehicle for farming. The second part is to make the path to move each axis. Part three is electronic. Electronic play an important role in distributing the power supply to the motor contained in a mechanical system. The mechanical design has three parts the track, gantry and the cross- slide. The gantry moves along the tracks provided. Cross-slide contains the tools for performing various operations. The mechanical design concept of the cnc farming machine is shown in Fig 1.

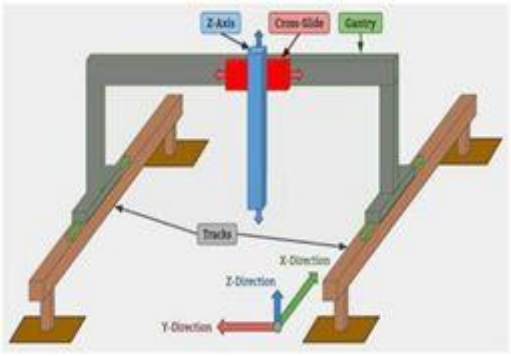

Fig 1 Mechanical design system concept

Agrobot is a scalable automated precision farming machine designed from the ground up with today's technologies. Similar to today's 3D printers and CNC milling machines, AgroBot hardware employs linear guides in the X, Y, and Z directions that allow for tooling such as seed injectors, watering tubes, and sensors, to be precisely positioned and used on the plants and soil. The entire system is numerically controlled and thus fully automated. The hardware is designed to be scalable, simple, and hackable. Agrobot takes a new approach at precision agriculture, tearing down everything from the past and starting from the ground up. By simply placing the tooling equipment on a set of tracks, rather than a free driving tractor, the system has the ability to be extremely precise and reposition tooling in exact locations repeatedly over time. This is done with similar technology that has been around for decades in printers, manufacturing equipment, and more recently 3D printers and CNC milling machines.

In this project the infrastructure for the farming machine is made by using aluminium square tubes and foarm board. The X ,Y and Z axis motion is performed with the aid of NEMA 17 Stepper motors and using the belt and pulley system. In the Z frame for performing the irrigation PVC pipe is attached through which the water tube coming from the water source is inserted. LPC 1769 controller is being used for controlling the motor movement and irrigation system of the farming machine.

Agrobot performs the Seed sowing operation by the Z axis motion of the seedsower attached to Z frame and watering operation based upon the soil moisture sensor value. The irrigation system consist of soil moisture sensor, relay switch, water pump. Whenever the moisture content of the soil is less, the control signal from the controller triggers the relay and turns the water pump on. Agrobot thus have the ability to provide water to each plant.

II. PROPSED SYSTEM DESIGN

A. Hardware Description

Agrobot is a precise CNC farming machine .The basic infrastructure which includes the X, Y, Z axis motion frames are built using Aluminium square tubes and foam board. The Entire system is controlled using ARM Cortex M3 based microcontroller, LPC1769. LPC1769 is used for embedded applications requiring a high level of integration and low power dissipation. It has a running frequency of up to 120 MHz. The X, Y, Z axis motion is performed using 4 NEMA 17 stepper motors. The NEMA 17 is larger and generally heavier than a NEMA 14, but this also means it has more room to put a higher torque. The four motors are driven by TB6600 stepper motor drivers. This is a professional two-phase stepper motor driver. It supports speed and direction control. Soil moisture sensor FC-28 is used for detecting the moisture level of the soil. The water pump is turned on and off with the help of a 5V relay. In the relay circuit the control signal coming from the LPC1769 board, which is high whenever the soil moisture content is less, will trigger the 5V relay, which in turn completes the circuit of the water pump and turns it on. The block diagram of proposed system is shown in fig 2.

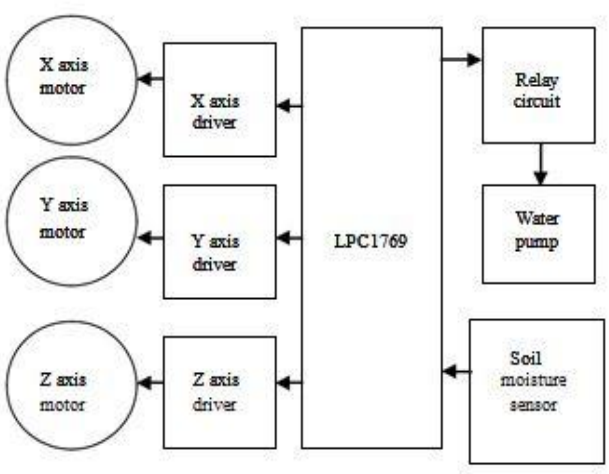

Fig.2 Block diagram of proposed system

B. Infrastructure development

The complete infrastructure was made out of aluminium. For the easier motion, belt and pulley was coupled to the motors. X-axis frame is made up of aluminium. Dimension of the frame is given as 60cm*15cm. Motor is placed at

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one end. Motion is accomplished with the aid of belt and pulley which is attached in the frame. The X axis motion frame developed is shown in Fig. 3.

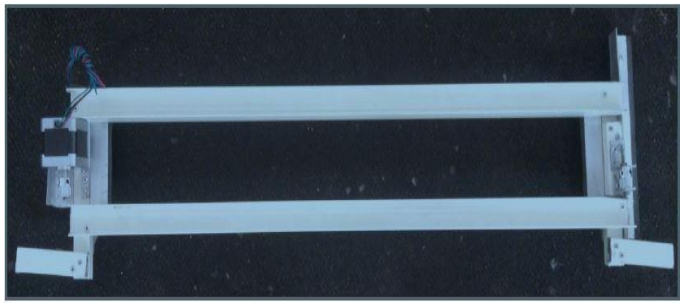

Fig.3 X axis motion frame

Y – axis frame is made up of aluminium. Dimension of the frame is given as 80 cm* 60 cm. Motor is place at both the ends for the balanced motion. Easier movement of the frame is done with the aid of belt and pulley. The Y axis motion frame is shown in Fig. 4.

Placement of Y- axis motors are very much important. They are placed opposite to one another at two ends of Y frame hence while connecting to the driver, connection must be made such that no tilt occurs in the forward movement. Two motors are placed on y axis frame in order to balance the structure. For this two y axis motors only one motor driver can used.

Fig.4 Y axis motion frame

Fig.6 Seed Sower

Z-axisframe is made using the foam sheet. Seeding operation is carried out in Z axis. A soil digger is also attached to the frame so that during the rotation digging of the soil takes place. The centre of the mechanism is attached to the lead of the motor placed behind. NEMA 17 Stepper motor is placed behind the frame. Approx. speed 30rpm. Angle : 1.8º / step

Single seed in a single pit is controlled by the seed sowing mechanism itself. Rotating element has a provision to hold a single seed. Seed storage element is placed closer to the rotating element such that only a single seed can fall in to the provision in the rotating element. Taking full rotation in to account, first half comprises of holding the seed in the storage element and the next half comprises of putting the seed into the seed pit provided in the rotating element of the sower.

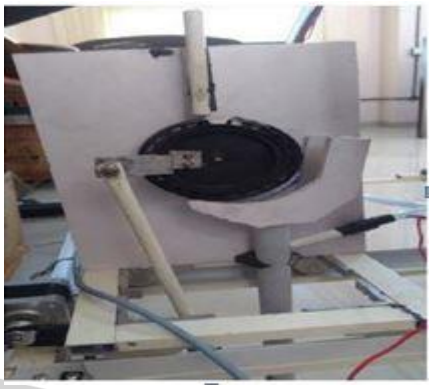

Fig. 5 Z axis frame

III. WORKING PRINCIPLE

1. Material selection

First step in the making of Agrobot is to create the infrastructure. The material must be selected that can reduce the weight of system,will not undergo corrosion easily . the chosen material must be cost effective also. Here Aluminium is chosen as the material for creating the basic infrastructure. Basic infrastructure of Agrobot includes the X,Y,Z axis motion frames which are built using Aluminium square tubes and foam board. Aluminium material was chosen in order to reduce the total weight of the structure. Aluminium is a very desirable metal for mking the infrastructure because it is more malleable and elastic than steel. Aluminium's greatest attribute is that it is corrosion resistant without any further treatment after it is spun. Aluminium does not rust. With Aluminium there is no paint or coating to wear or scratch off..

2. Seed sowing operation

Seed sowing operation is carried out in the Z axis direction. Hence, the whole setup is placed in the Z axis frame. A rotating element is placed in the centre of the frame in to which the soil digger is attached. The lead of the motor is attached to the centre of the rotating element. Therefore when the motor rotates, during the half of the motion soil digging takes place and during the next half rotation seed stored in the structure is sowed. Different parts of the seed sowing mechanism is marked in the fig.6

3. Watering Operation

Watering operation is carried out with the help of a relay circuit, water pump, and soil moisture sensor. Whenever the

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moisture content of soil is less the microcontroller will produce a high signal that will trigger the relay and turn on the water pump. A water tube is connected to the pump which is inserted through a PVC pipe attached to the Z axis. Through this PVC pipe water will reaches the plants .The set up for watering through the PVC pipe is shown in Fig.7.

Fig 7 Watering setup

A 5V Relay is used for turning the water pump on and off. The relay circuit used is shown in fig 8. Emitter follower relay switch circuit is used here. Here switching occurs by applying a positive current to the base of the transistor. This control signal for triggering the relay comes from the lpc1769 microcontroller whenever the moisture content of soil decreases. Normally open 5V relay circuit is used here. One end of the water pump is connected to the normally open pin of the relay circuit. The other end of the pump is connected to the ground. Only when the relay circuit is being trigerred by the control signal the circuit of the water pump gets completed . The water pump used used in this project is a mini Aquarium water Pump. It requires 12V for its operation. When pumping a liquid the pump runs very quietly. The pump is also capable of pumping air.

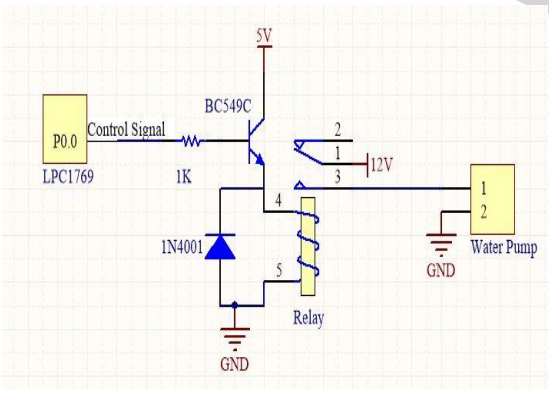

Fig 8 Relay circuit

4. Algorithm

The path to be taken in the two dimensional Cartesian plane is shown in the figure. Algorithm is developed according to this motion path. Algorithm for the total operation of the Agrobot is shown in the fig.9 and explained below.

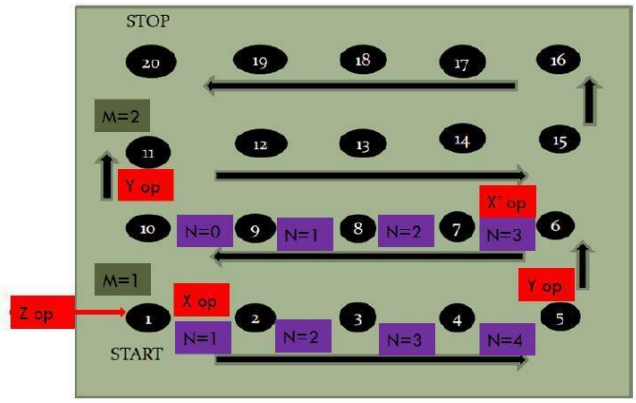

Fig. 9 Motion Algorithm

- At point 1, Z operation takes place after setting the value of M=1.If PUMP ON watering is done else seed sowing operation is carried out
- Inorder to reach the point 2, X operation is carried out. Also value of N is set to be 1.
- Step 2 is carried out by incrementing the value of N until the point 5 is reached.
- After reaching the point 5, Y operation is carried out followed by the Z operation.
- Then X' operation takes place.
- After moving to the point 7, value of N is decremented by1.
- Step 6 is repeated until the point 10 is reached.
- On reaching point 10, Y operation takes place followed by incrementing the value of M.

By using this algorithm we can control the value of M and N, which means that the number of rows and columns can be controlled. For M=1, the operation is carried out in 2 rows.

IV. RESULTS

The objective of the project was to develop a CNC farming machine which can help in cultivating a variety of crops within same area at the same time and is able to operate indoors, outdoors and covered areas. For this the primary concern is to make the infrastructure. The infrastructure is completed using aluminium square tubes and foam board. Four motors are used for controlling the X, Y, Z axis motion. Movement is done with the help of belt and pulley. After the infrastructure development the motion path has been fixed based on the algorithm and the movement of the Agrobot has been verified. Step by step practical testing was done in order to obtain the desired result. Fig. 10 shows the complete structure of Agrobot.

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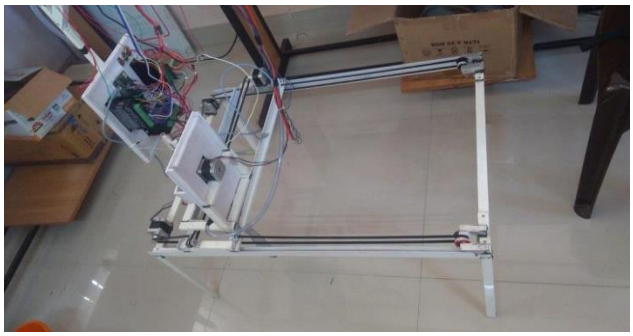

Fig. 10 Agrobot Srtucture

Firstly, X axis movement was tested. The movement was accurate as it stopped at the required points and provided adequate delay for the Z axis operation. After testing the X axis motion, Y axis motion was tested. The motion did not have any tilt due to the presence of two motors attached at the ends. Then, the validation of Z axis operation was done. Seeding operation took place in the Z direction. After infrastructure development and seed sowing operation verified next the watering system was implemented which includes a water pump, soil moisture sensor and a relay switch. The turning on and off of the water pump based on the sensor value has been verified. The water tube for irrigation is inserted through a PVC pipe which is attached to the Z frame of the agrobot

V. FUTURE ENHANCEMENT

In addition to the automated seed sowing, irrigation and nutrients proving it is possible to incorporate additional functions like ploughing of field, harvesting by using appropriate tools in the universal tool mount. Cameras can also be incorporate for weed detection.

VI. CONCLUSION

This paper presents the salient features of a CNC farming machine which can be used for cultivating varieties of crops with a small area. The simplicity, modularity, ease of customization and ease of operation of these Agrobot makes it a proper solution for precision farming that can be used for the efficient water and fertilizer management without manual intervention. The entire structure is made up of Aluminium square tubes as it can reduce the entire weight of the structure and prevents resulting. Belt and pulley system is used for the smooth movement of the Agrobot . The seed sowing and irrigation operations are controlled by LPC1769 microcontroller. Since stepper motors are used rather than DC motors, motor drivers are necessary. Using the switch control here we can choose the required operation. .

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