KANTIPUR ENGINEERING COLLEGE

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A FINAL YEAR PROJECT REPORT ON

CNC BASED AUTOMATED FARMING SYSTEM

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A FINAL YEAR PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF BACHELOR IN ELECTRONICS AND COMMUNICATION ENGINEERING

Submitted to:

Department of Computer and Electronics Engineering

April, 2022

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ABSTRACT

The agriculture industry plays an important role in the needs of humankind. The rising of the world population, as well as the decrease in the number of workers in the agricultural sector, calls for an increased demand for food suppliers. When we are presented with the current food production system and when it comes to mass harvesting of crops and vegetables, we have surrendered our control on how our food is been produced and as a result affecting our health and environment. In this fast pace life where no one has time to carry out gardening and grow desired fruits, vegetables and other plants, this system is a backyard robot that is developed for a fully automated gardening for food production on personal and small-scale level. In this study, a precision farming system was created using Computer Numerical Control (CNC) technology. CNC is a machine tool automation system that is operated by command, randomly programmed. By using CNC technology, it allows the machine to follow the coordinate points that are entered into the system accurately. The command to drive a CNC machine is usually called the G-Code. This robot can also be used as accessibility technology, i.e. it can help individuals with disability in growing their own business in horticulture and to empower individuals who might not otherwise be able to grow their own food.

***Keywords*–G-code, CNC**

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LIST OF ABBREVIATIONS

CNC - Computer Numerically Controlled

IC - Integrated Circuit

3D - Third Dimension

DTMF - Dual Tone Multi-Frequency Signaling

OS - Operating System

LXDE - Lightweight X11 Desktop Enviroment

APT - Automatic Package Transfer

GUI - Graphical User Interface

IDE - Integrated Development Environment

USB - Universal Serial Bus

HDMI - High Definition Multimedia Interface

CSI - Camera Serial Interface

AC-DC - Alternate Current - Direct Current

ICSP - In Circuit Serial Programming

MOSFET - Metal Oxide Semiconductor Field Effect Transistor

PWM - Pulse Width Modulation

ESD - Electrostatic Discharge

LED - Light Emitting Diode

UART - Universal Asynchronous Transmitter and Receiver

SMPS - Switched Mode Power Supply

CHAPTER 1
INTRODUCTION

1.1 Background

Nepal is an agriculture country, where most of the population lives in rural areas with a livelihood as farmers. Nepalese people generally consume agricultural products for their daily needs and help in their economy. Agriculture in Nepal needs to increase production as much as possible to be able to meet national needs. The extent of agriculture in Nepal which is increasingly narrowing, this is the biggest challenge that must be faced today, however, there are ways that can be done to anticipate that is by carrying out development in the agricultural sector. Agricultural development is an effort to manage natural resources that are carried out to ensure long-term agricultural production capacity and improve farmers' welfare through environmentally friendly choices. All agricultural businesses are basically activities that require the same basic knowledge of land use, seed selection, cultivation, processing, packaging, to marketing, but for limited land cultivation or gardening can use several land-use methods such as the use of a roof garden needs to be considered well because it requires a large investment and careful planning. The important thing is there are factors that support the growth and development of plants such as the presence of sunlight, planting media, fertilizer, and water.

CNC based automated farming system is an open source project allowing hardware, software and documentation modifications and additions from users. The entire system is automatically operated. The hardware is designed to be scalable, simple, and hackable. Using the open source webbased software package, the farmer can graphically design their farm to their desired specifications and upload numerical control code to the hardware. Other software features include storing and manipulating data maps, a decision support system to facilitate data driven design, access to open data repositories, and enterprise class analytics. CNC based automated farming system has several distinct advantages over today's methods and technologies.

It is also a precision agriculture CNC farming project consisting of a Cartesian coordinate robot farming machine, software and documentation including a farming data repository. In this study, a precision farming system was created using Computer Numerical Control technology. CNC is a machine tool automation system that is operated by randomly programmed commands and stored on storage media. By using CNC technology, it allows the machine to follow the coordinate points that are entered into the system accurately. The command to drive a CNC machine is usually called the G-Code. By utilizing CNC technology, plant spacing can be adjusted via a Graphical User Interface connected to the machine. This makes it easy for users to plant various types of plant seeds by considering the area of growth. By utilizing the timing IC, watering can be done periodically and / or when the water content in the soil is detected low. The development of CNC based automated farming system can be a breakthrough for urbanites who want to farm on limited land and monitoring time. CNC based automated farming system allows the surveillance of crops by camera.

1.2 Problem Statement

Agriculture is the main source of food, income and employment in Nepal. However, taking this into consideration, we still rely heavily on food sourced from outside of the country. This is a result of the inability of the agricultural sector to keep up with the growing population of the country. Agriculture in Nepal requires modernization, diversification, commercialization and promotion for creating crops to sustain the country and to increase export. There is a massive shortage of distribution, extension channel, knowledge, production and competition. Additionally, there is also a lack of proper agricultural infrastructures like storage facilities, market centre, roads, telecommunication and irrigation networks. The state of production of agriculture is affected by scarce or small productions, obsolete technology, lack of farm managerial skills, fragmented and small-sized land, policy level constraints, and most importantly lack of information services.

So, CNC based automated farming system robot is an engaging, multi-generational tool that overcomes the problem of current traditional agriculture. Seeking to influence the next generation of food production, this system is the open-source, small-scale farming machine which gives individuals the power to create and manage a farm using current technologies. Using open-source technology, farmers can assemble the software and hardware that oversee the automated planting, watering, and monitoring of crops.

1.3 Objectives

- To automate the traditional agricultural practices using a modified and scalable farming system.
- To remotely perform operations and surveillance in agricultural systems.
- To extract practical data for better understanding of challenges faced in agriculture.

1.4 Features

- Efficient CNC based model for farming.
- Automatic irrigation.
- Camera for surveillance and security
- Accessible via any electronic devices using internet
- Dynamic, portable and scalable

1.5 Applications

1. **Commercial Use:** This technology can be used in greenhouses to automate and increase the production of horticulture.
2. **Domestic Use:** This technology can be used for kitchen gardening or local gardens in backyard with minimum effort and time.
3. **Research Purpose:** Due to the efficiency of this technology , it can be used in studying characteristics of plants in a closed environment.

1.6 Feasibility Analysis

1.6.1 Technical Feasibility

In technical term, our project seems to be technically feasible on its structural development and its hardware requirement. By using the limited numbers of sophisticated electronic components we can receive desired output. The basic designing is taken to higher level by designing a more sophisticated system based on our case study. This project is based on modern technology based on hardware components and devices which will be applicable for future.

1.6.2 Economic Feasibility

The electronic components required for this project are not so expensive. The components required for this project are feasible from perspective of economic view. Thus, the project is economically feasible.

1.6.3 Operational Feasibility

Once the project is properly assembled and interfaced, it mostly runs on its own. The proposed system can be easily built in a small area and also it is easy to use and operate. So ,it is operationally feasible.

CHAPTER 2
LITERATURE REVIEW

FarmBot is an open-source CNC farming machine and software package designed for small-scale precision food production. Simply, it is a robotic open hardware system that assists anyone with a small plot of land and a desire to grow food with planting, watering, soil testing, and weeding. Similar to 3D printers and CNC milling machines, FarmBot hardware employs linear guides in the X, Y, and Z directions. This allows for tooling such as seed injectors, watering nozzles and sensors tools to be precisely positioned and used on the plants and soil. The FarmBot project was started in 2011 by American Rory Aronson whilst studying mechanical engineering at California Polytechnic State University. Aronson attended an elective course in organic agriculture where he learned about a tractor that used machine vision to detect and cover weeds which removed the need for herbicides or manual labour, the tractor cost over 1 million USD. In September 2013 Aronson published a white paper outlining the goals of the project to ”Grow a community that produces free and open-source hardware plans, software, data, and documentation enabling everyone to build and operate a farming machine”. The project is a response to the 60 percent increase food production needed due to the growth in world population to between 7 - 9 billion by 2050 and the potential of precision agriculture to reduce the environmental impacts of farming by reducing water use, energy, transportation, petrochemicals and time required to grow crops. In March 2014 Aronson began working on the project full-time funded by a grant from the Shuttleworth Foundation. Firmware developer Tim Evers and software developer Rick Carlino later joined the project as core developers and the open source community Farmbot.cc was created to support the development of the project. He also created the company Farmbot.io to provide hardware kits and software services and to serve as a funding source to maintain the open source community. In 2014 and 2015 FarmBot was entered into the Hackaday Prize where it became a finalist in 2015. Farmbot.io began preorders of the first commercially available version of FarmBot, the FarmBot Genesis, the ninth iteration of the design in July 2016.[1]

Balaji Banu designed a wireless sensor networks too serve the conditions of the farming and increasing the crop yield and quality. Sensors are used to monitor different conditions of environment like water level, humidity,temperature etc. The processors ATMEGA 8535 and ICS8817 BS, analog to digital conversion and wireless sensor nodes with wireless transceiver module based on Zig bee protocol are used in the designing the system. Database and web application is used to retrieve and store data. In this experiment the sensor node failure and energy efficiency are managed. [2]

A remote sensing and control irrigation system using distributed wireless sensor network aiming for variable rate irrigation, real time in field sensing, controlling of a site specific precision linear move irrigation system to maximize the productivity with minimal use of water was developed by Y. Kim. [3]

In 2020 Self-Automated Agriculture System include a GPS based robot to perform tasks like weeding, spraying, moisture sensing, bird scaring, keeping vigilance, etc. This project required smart irrigation with smart control and best decision making based on accurate real time data. This includes crop management, waste management, warehouse management, theft control etc. [4]

In 2017,Automated Farming with Interfaced Robot was developed to control supply of pump by cell phone from any place of the world. For this IC8870 is used to convert Dual Tone Multi Frequency(DTMF) signal into binary signal.By this project we can make efficient use of time by using microcontroller IC89C52 which is used to interfaced IC8870 and ULN2003. A flexible multipurpose farming and weeding robot platform named BoniRob was developed as a joint project between the University of Osnabrueck, the DeepField Robotics start-up, Robert Bosch company, and the machine manufacturer Amazonen-Werker.[5]

A novel agricultural robot based on CNC machine namely FaRo (FArming RObot), for farming crops autonomously without any human intervention was developed. What differentiates the FaRo from other farming platforms is the ability to carrying out the farming process from seeding to the harvesting of crops. [6]

Hokkaido University developed a crop row detector which is equipped with a one-dimensional image sensor, this machine detects boundary lines of the crop rows. With the implementation of machine learning, the detection of crop row lines became more precise and accurate.[7]

Shreyash Kulkarni AgriBot was designed for agricultural purposes. This Bot can perform basic elementary functions like ploughing, sowing, watering, fertilizing, pesticides and closing the dig. It also provides manual as well as auto control. The main component here is the Arduino that supervises the entire process. Seeding is one of the first steps in farming. During this process seeding is carried out in all the rows of the farming plot. In irrigation process, slowly applies small amount of water to the planted seeds in all the rows of the farming plot. The fertilization process is same as irrigation process, but some crops need fertilizers when the seed germinates, and the plant begins to grow.[8]

M. Priyadarshini has founded the robot which performs operation like soil, moisture testing, seeding, spraying pesticides, removes compost from the field, which also performs obstacles avoidance operation and metal detection in the path. The robot is controlled using cell phone using DTMF technique. Because of using DTMF technique it overcomes the range or distance problem of using Bluetooth or RF module which having limited working range. Agribot integrated system which uses Wi-Fi to communicate between two robots which perform activities like seeding, weeding, spraying of fertilizers and insecticides. It is controlled using Arduino Atmega2560 controller and powerful Raspberry pi minicomputer to control and monitor working of robot. It has hexapod body which can move in any direction as per required. It has ultrasonic proximity sensor to avoid the obstacles in the path, and underbody sensor system to detect that seed is planted or not. It can dig a hole in soil plant seed in it and cover the hole again with soil and necessary preemergence fertilizers applies on it and move on along with communicating with another robot near to it using Wi-Fi. Command based self-guided digging and seed sowing rover, a sensor guided rover for digging, precise seed positioning and sowing has been proposed to reduce the human effort and also to increase the yield.[9]

CHAPTER 3
SYSTEM REQUIREMENTS

3.1 Software Requirements

3.1.1 Python

Python is a remarkable powerful dynamic programming language that is used in a wide variety of application domains. It is also the primary language the Raspberry Pi is designed to operate on. Its features are:

- Excellent for beginners, yet superb for experts
- Highly scalable, suitable for large projects as well as small ones
- Embeddable
- Simple yet elegant

3.1.2 Raspbian OS

Raspberry Pi OS (formerly Raspbian) is a Debian-based operating system for Raspberry Pi. Raspberry Pi OS was first developed by Mike Thompson and Peter Green as Raspbian, an independent and unofficial port of Debian to the Raspberry Pi. Raspberry Pi OS is highly optimized for the Raspberry Pi line of compact single-board computers with ARM CPUs. It runs on every Raspberry Pi except the Pico microcontroller.

Its features are:

- **User Interface:** Raspberry Pi OS's desktop environment, PIXEL, looks similar to many common desktops, such as macOS and Microsoft Windows, and is based on LXDE.[10] The menu bar is positioned at the top and contains an application menu and shortcuts to Terminal, Chromium, and File Manager. On the right is a Bluetooth menu, a Wi-Fi menu, volume control, and a digital clock.

- **Package Management:** Packages can be installed via APT, the Recommended Software app, and by using the Add/Remove Software tool, a GUI wrapper for APT.

3.1.3 Arduino IDE

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards. The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution.

3.2 Hardware Requirements

3.2.1 Raspberry Pi 4

The Raspberry Pi is a series of small single-board computers to promote teaching of basic computer science in schools and in developing countries. It consumes 4 watt power and works in 3.3 volt. It is widely used in many areas, such as for weather monitoring,because of its low cost, modularity, and open design. It supports 2 × USB 3. 0 ports, 2 x USB 2. 0 Ports, 2 × micro HDMI ports supporting up to 4Kp60 video resolution, 2-lane MIPI DSI/CSI ports for camera and display 4-pole stereo audio and composite video port, Micro SD card slot for loading operating system and data storage.

Figure 3.1: Raspberry Pi 4

3.2.2 Arduino Mega 2560

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

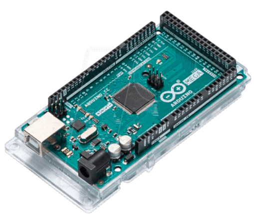

Figure 3.2: Arduino Mega 2560

3.2.3 L293D Motor Shield

L293D is basically a high current dual motor driver/controller Integrated Circuit. It is able to drive load having current up to 1A at the voltage ranging from 4.5V to 36V. Motor driver usually act as current amplifier because they receive a low current signal as an input and provides high current signal at the output. Motors usually operates on this higher current. L293D has to builtin H-Bridge driver circuits and is able to control two DC motors at a time in both clockwise and counter clockwise direction. It has two enable pins and they should be kept high in order to control the motor. By changing the polarity of applied signal motor can be rotated in either clockwise or counter clockwise direction. If L293D enable pin is high, its corresponding driver will provide the desired out. If the enable pin is low, there will be no output. L293D has different features including internal ESD protection, large voltage supply range, large output current per channel, high noise immunity input etc.

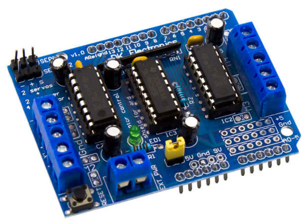

Figure 3.3: L293D Motor Shield

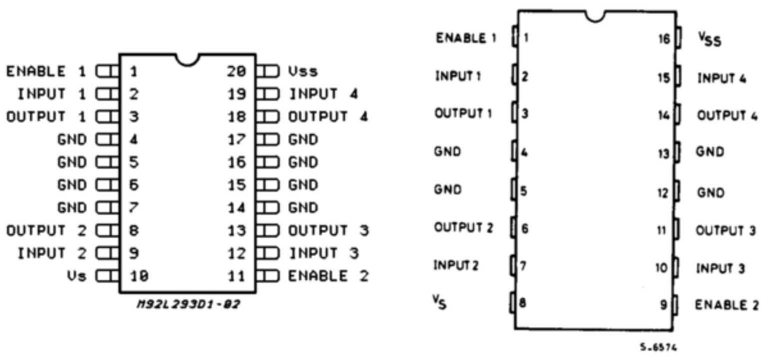

Figure 3.4: Schematic figure L293D Motor Driver

3.2.4 Stepper Motor Nema 17

A stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movements.It is brush less DC motor that divides full rotation into a number of equal steps. Stepper motor is known by its property to convert a train of input pulses to precisely defined increment in shaft position. Each pulse moves shaft through a fixed angle.Stepper motors consist of multiple toothed electromagnets arranged around the central gear. The electromagnets are energized by an external driver circuit or micro controller. When one electromagnet is energized which magnetically attracts the gear's teeth and the teeth are aligned to first electromagnet , and when another consecutive electromagnet is energized turning off first one,gears rotates to align second electromagnet and process is repeated for complete rotations. Each of rotation aligning to electromagnets is called step, with an integral number of steps makes a full rotation and can be turned by precise angle.

NEMA 17 stepper motors are those that have a 1.8 degree step angle (200 steps/revolution) with a 1.7 x 1.7 inch faceplate. NEMA 17 steppers typically have more torque than smaller variants, such as NEMA 14 and have a recommended driving voltage of 12-24V. These steppers are also RoHS compliant.

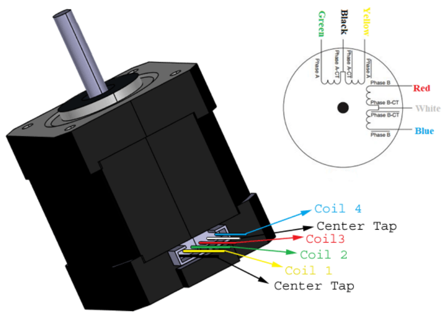

Figure 3.5: Stepper Motor Nema 17

3.2.5 Pi Camera Rev 1.3

The Pi camera module is a portable light weight camera that supports Raspberry Pi. It communicates with Pi using the Mobile Industry Processor Interface camera serial interface protocol. Raspberry Pi Board has Camera Serial Interface(CSI) to which we can attach PiCamera module directly. This Pi Camera module can attach to the Raspberry Pi's Camera Serial Interface port using 15-pin ribbon cable. Pi camera Rev 1.3 size is 25mm x 25mm x 10mm and weighs about 2.8g. Its pixel count is 2592 x 1944(5-megapixel), focal lengtgh is 3.57 mm, f/2.8, view angle is 65 degrees and supports 1080p@30fps with codec H.264 (AVC), 720p@60fps and 640x480p@60/90 fps video record.

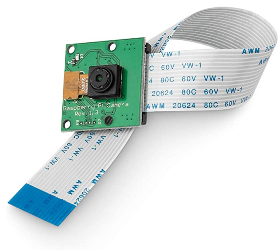

Figure 3.6: Pi Camera 1.3

3.2.6 Water Pump

Pump is a machine or mechanical equipment which is required to lift liquid from low level to high level or to flow liquid from low pressure area to high pressure area or as a booster in a piping network system. Pump also can be used in process operations that requires a high hydraulic pressure. Water pump when used when running will pull about 5 Amps at 12 volts or about 60 watts.

Figure 3.7: Water Pump

3.2.7 Relay RAS-0610

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof. Relays control one electrical circuit by opening and closing contacts in another circuit. Relay RAS-0610 uses 6V input DC and can provide 24 volt DC output. It is about 0.53 cubic inches and weighs about 0.031 kilograms.

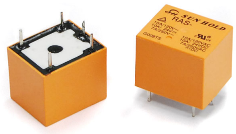

Figure 3.8: Relay RAS-0610

3.2.8 Moisture Sensor

Soil Moisture Sensor is a simple breakout for measuring the moisture in soil and similar materials. The soil moisture sensor is pretty straight forward to use. The two large exposed pads function as probes for the sensor, together acting as a variable resistor. The more water that is in the soil means the better the conductivity between the pads will be and will result in a lower resistance, and a higher SIG out. Its operating voltage is 3.3v - 5v. It has on-board lm393 comparator and on-board power indicator LED. Its sensing probe dimensions is 60x30mm.

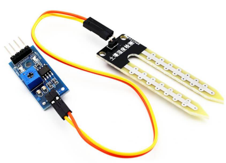

Figure 3.9: Moisture Sensor

3.2.9 Shaft Coupler

It is hardware mechanism to translate the rotation on the shaft of the motor to an extended external shaft. The torque as provided from the rotors of the motor is translated onto this external shaft to be used for other useful applications.

Figure 3.10: Shaft Coupler

3.2.10 Linear Bearings

Linear bearings are a type of bearing that ”bear” or support the load of the carriage during its single-axis linear movement and provide a low friction sliding surface for the guide rails. In a linear guide, the carriage is the component that travels in a straight line, back and forth, along the length of the guide rail. The guide rail is fitted and inserted into the linear bearing. A linear bearing is a critical component of the linear guide assembly. Its applications are in cutting machinery, X-Y positioning tables, machine slides, industrial robots, and instrumentation systems. Either a motor-driven ball screw, lead screw, or manual force can be used to drive the motion. The single-axis motion is limited in the X-Y plane. The types of linear bearings are divided into two main classifications: the rolling linear bearings and the plain linear bearings.

Figure 3.11: Linear Bearings

CHAPTER 4
METHODOLOGY

4.1 Block Diagram

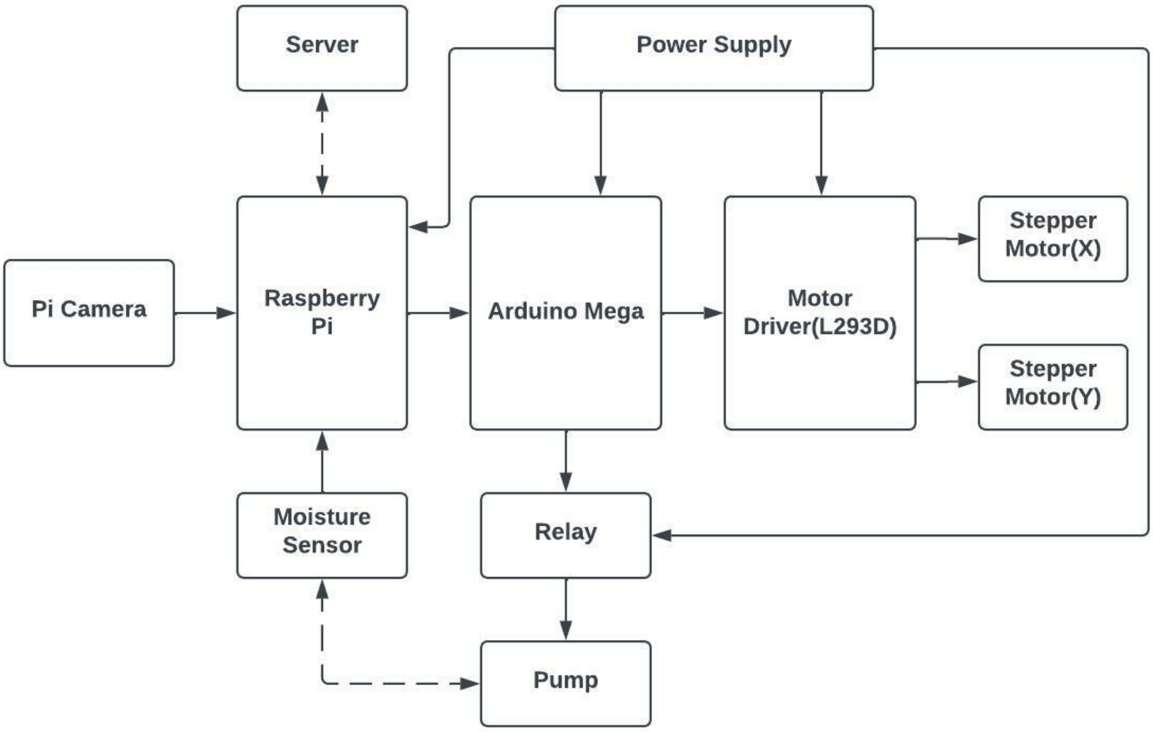

Figure 4.1: Block Diagram for CNC based Automated Farming System

4.2 System Overview

In the block diagram, Raspberry Pi and Arduino mega is connected serially using USB cable. Raspberry Pi acts as master and Arduino mega as slave. Arduino mega controls stepper motor X and Y direction using motor shield. Motor shield is used to regulate power to motors and work according to Arduino commands. Relay is also used to control water pump for irrigation which is connected with Arduino. Pi camera is used for taking pictures of crops and identification and surveillance which is interfaced by Raspberry Pi. Wireless connection of system is interfaced with server or user. Raspberry Pi sends commands to the system according to the user data input and output. For automation, moisture sensor is used which is connected to Raspberry Pi. When sensor detects low moisture level ,Raspberry Pi sends commands to Arduino to activate the pump. User interfaced is created via MIT app inventor, and the system is connected wirelessly.

4.3 Mechanical Design Specification

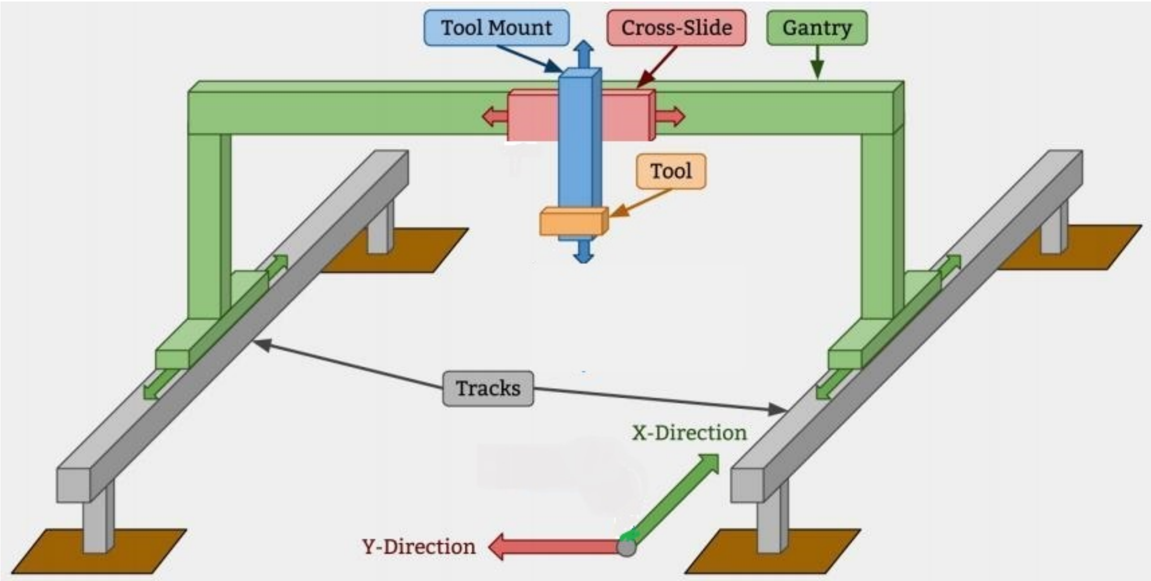

Figure 4.2: Mechanical Design of CNC based Automated Farming System

Farm Dimension - 750mm x 450mm

System Height - 400mm

X-Axis - 700mm

Y-Axis - 400mm

Materials used -

- Bearings(x6)
- Shaft Couplers(x2)
- Plywood
- Screws
- Linear Guides(x4)

Pump nozzle length - 180mm

4.4 Algorithm

Step 1: Start

Step 2: Is CNC at reference point, If no then set at reference point.

Step 3: Divide the farm into grids and select using $x=(n-1)a+a/2$ and $y=(m-1)b+b/2$ where a=grid length ,b=grid breadth

Step 4: Move the CNC to required grid.

Step 5: Read the data from moisture sensor.

Step 6: If moisture level is low then activate the pump.

Step 7: User input select the activity in the app. If pump is select then activate the pump. If camera is select then activate the camera and takes the snapshot.

Step 8: Are all the grids complete?

If no then goto step 4

If yes then reset the CNC

Step 9: Stop

4.5 Flowchart

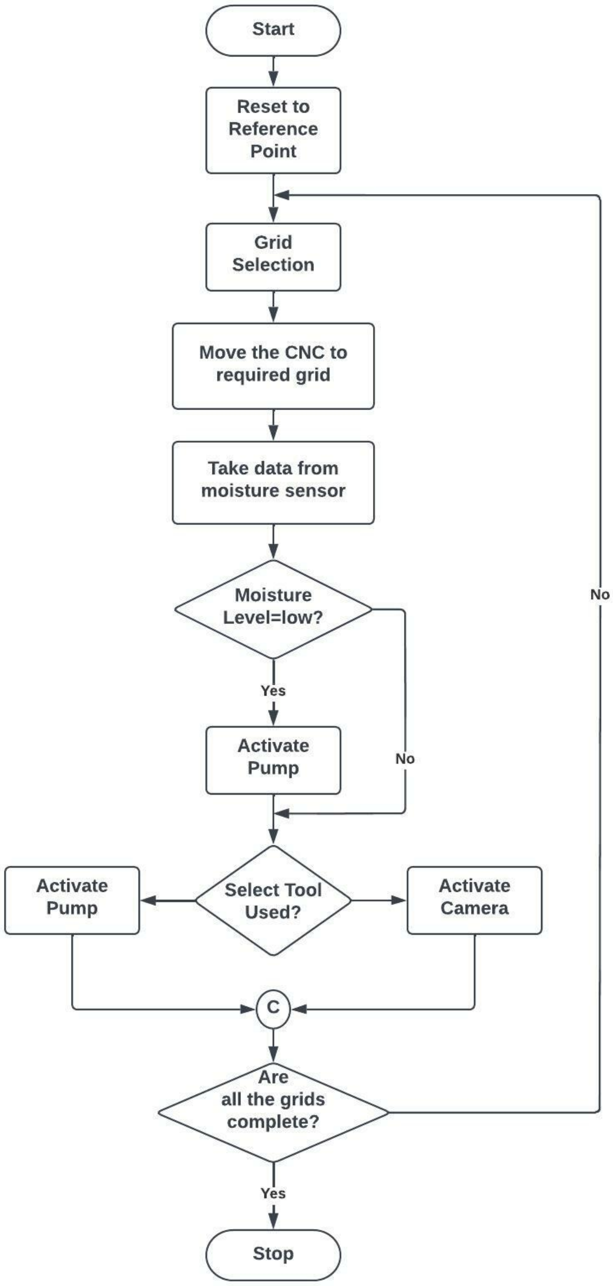

Figure 4.3: Flowchart for CNC based Automated Farming System

CHAPTER 5
PROJECT PLAN

5.1 Gantt Chart

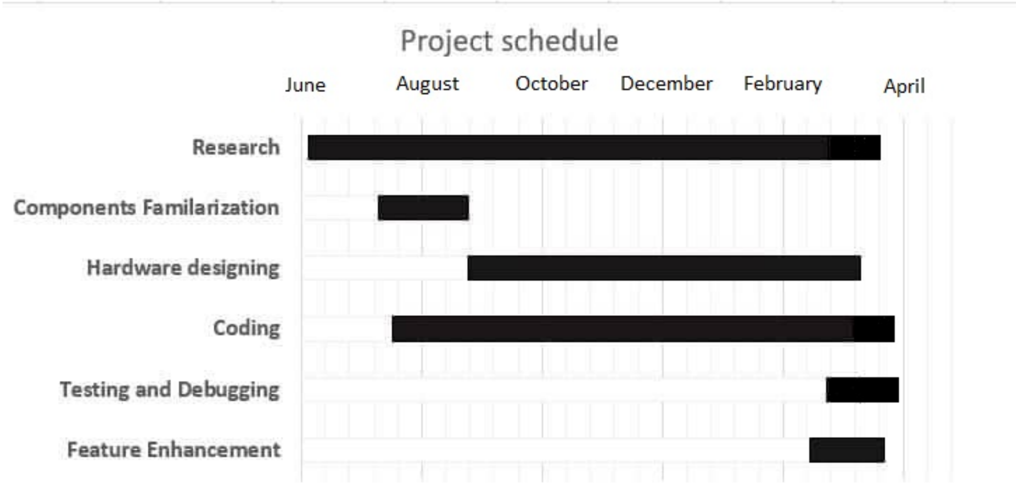

Figure 5.1: Project Plan Chart

5.2 Cost Estimation

Components	Quantity	Price (Rs)
Raspberry Pi 4	1	7000
L293D motor driver	1	550
Arduino Mega 2560	1	1700
Stepper Motor Nema 17	2	1200
Relay RAS-0610	2	1000
Water Pump	1	500
Linear Bearings	6	600
Pi Camera Rev 1.3	1	2000
Shaft Coupler	2	340
Moisture Sensor	1	1000
Total Price	•	15890

Table 5.1: Table for Cost Estimation

CHAPTER 6
EPILOGUE

6.1 Result And Discussion

After successful designing and assembly of hardware and programming the required components, we saw that the system works effectively and efficiently as per the requirement. Our farm was divided into four grids. The system operates in two modes, automatic and manual. During automatic mode, the moisture sensor continuously reads data and if it detects low moisture level, stepper motor 1 and 2 moves the nozzle to 1st, 2nd, 3rd and 4th grid respectively. Then motor pump was activated in each grid for 5 seconds. During manual mode, user selects the required grid in the app and the system moves to that grid, the user selects the required activity to activate the pump or the camera.

The interfacing between Arduino and Raspberry Pi was done serially using as USB cable. A cable of USB type B and USB 3.0 was used to connect the two systems. The protocol used during this communication is UART.

We studied about different vegetables which are feasible to grow using our project. The different types of vegetables we study was cabbage, tomato, capsicum, carrot, coriander and spinach. The necessary growing conditions, moisture parameter and height of the plant were studied. The specification of different vegetable are given under the table:

Vegetables Name	Plant Height	Moisture Parameter
Cauliflower	30cm	1.5 inches per week
Tomato	40cm	2 inches per week
Bell Peppers	30cm	2 inches per week
Carrot	15cm	1 inches per week
Spinach	25cm	1.5 inches per week
Chillies	30cm	2.5 inches per week

Table 6.1: Specification of different vegetables

We studied about the different types of tools required in farming which are compatible for our project. The different tools studied were seed injector, water nozzle and weed killer. The tools that we designed was irrigation tool which consist of water nozzle that spray the water.

The input power given to our system is 12V DC. It is transffered using SMPS. Each stepper motor uses 1.2 amp current and has power of 11.5 watts. Arduino Mega uses 9V and Raspberry Pi uses 3.3 V with 4 watt power. Water pump of 12V is used to pump the water for irrigation.

6.2 Advantages

Some of the advantages are listed below:

- Greatly reduces the human effort in the agriculture.
- High accuracy
- Optimized operations by remote access.
- System can be designed within budget.

6.3 Limitations

Our system is introduced to reduce human effort and save time. However, it has some limitations. They are as follows:

- Not suitable for continuous operation due to heating.
- No protection for rain and dust.
- Requires high power for large farms.
- Suitable for only agriculture and not harvesting.

6.4 Problems Encountered

The problems encountered in our system are:

- **Lack of availability of materials:** A severe lack of materials concerning different manufacturing processes was immensely felt ever since the design phase began. The design had to be revised several times concerning the availability of parts and construction material as per design. These includes frames,motors,drivers and even appropriate mounting screws. This has caused the design to be reconsidered several times depending on whether a material could be procured.Hence this has caused great schedule delays and brought upon multiple restrictions.

- **Inaccuracy in assembly:** The design process is as deceptive as they come. During design all components are envisioned to fit perfectly and exactly with 0.1 percentage error tolerance which is not a lot of wriggle room. The components fabricated are allowed to deviate from their original design by 1/1000 of their original design which is only possible with industrial grade manufacture. The design of system which is operated by human operators lacks the accuracy due to errors.

- **Physical realization of design components:** There are many aspects to a mechanical build many of which are not obvious during the design phase. The many parts designed, though simplistic in thought and inception; prove a great difficulty to be manufactured because of the lack of the right tools and physical restraints and inabilities.

- **Electromagnetic Interference:** The current in the wire induces parasitic voltages and current s in the limit switches due to magnetic fields and minor electronic components wiring which is designed to carry current in milliampere levels. This cause unnecessary triggering in the electronic circuits.

6.5 Future Enhancements

- Implementation of multiple tools for sowing and fertilization.
- Use of image processing for plant disease detection.
- Use of steel or aluminum frames instead of wood.
- Expansion of working based platform.

- Use of Nema 23 or higher stepper motors instead of Nema 17 for better load capacity.
- Creation of a central server to control and optimize multiple systems.
- Use of higher quality bearings and belts to reduce friction.

6.6 Conclusion

After some reasonable researches the project of designing and finally crafting a prototype of CNC based automated farming seemed definitely possible. Due to availability of parts and most important which are available within the budget allocated, this project is feasible. The system will automate the watering and monitoring of crops. The system works accurately and efficiently thus introducing a revolutionary change in current agriculture practices. As for the applicability for our country , this system will be milestone in agriculture as it can be easily operated. The technology is set up as a challenge and lets students go their own direction. Seeking to influence the next generation of food production, this system is the open-source, small-scale farming machine which gives individuals the power to create and manage a garden.

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ANNEX