eYSIP2018

CNC Growbox

Intern 1 Devang Joshi
Intern 2 Ujwal Pawar
Intern 3 Harsh Lunia
Lohit Penubaku, Kedar Anavardekar, Ajit Harpude
Duration of Internship: 21/05/2018 – 06/07/2018

2018, e-Yantra Publication

CNC for Growbox

Abstract

The present revolution in agriculture(Agri 4.0), demands food for next generations. As a step towards contributing to the revolution we had a GrowBox designed, which enabled us to grow selected veggies indoor inside a box. But what it would be like to see a box that can seed and water the plant, and notifies us to harvest the produce, won't it be awesome? This is what this project will be addressing.

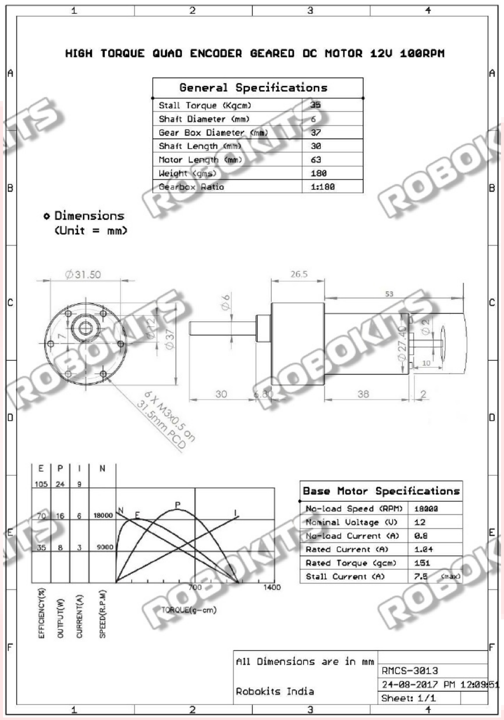
Completion status

- Mechanical
  - We accomplished designing as well as analysis of the CNC system considering all the aspects required for its reliable functioning.
  - From the hardware side we build a structure with all the mechanism mounted over it, for the motion of the tool in different directions.
- Electronics and Computer Science
  - From electronics side we completed interfacing of electronic components with mechanical parts and thus, tested various computed program on it.
  - Through image processing we are able to detect any random position and orientation of the trough placed inside the mechanical structure and eventually plot grid points on it for placing as many seeds required by user.
  - We created a simple yet friendly GUI using tkinter module in python. This easy to use interface saves user the trouble of going

to the source code and meddle with it to make it suitable as per his or her needs.

1.1 Hardware parts

- DC Motor with gearbox and encoder:



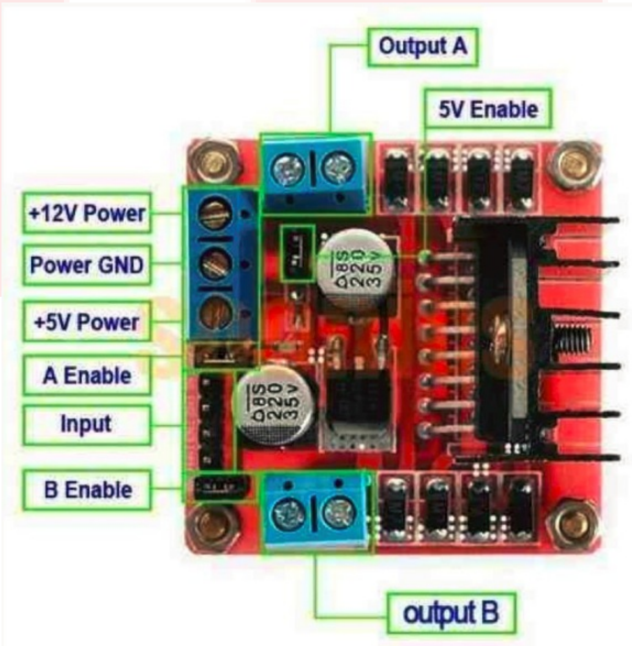
Features

- Motor with Quad encoder
- 100RPM 12V DC motors with Metal Gearbox and Metal Gears
- 18000 RPM base motor
- 29520 Counts per Revolution.
- 6mm Dia shaft with M3 thread hole
- Gearbox diameter 37 mm.
- Motor Diameter 28.5 mm
- Length 63 mm without shaft
- Shaft length 30mm
- 170gm weight
- 35kgcm torque
- No-load current : 800 mA, Load current : upto 7.5 A(Max)

Encoder Motor Pinouts

- Black: Gnd
- Brown: Vcc
- Red: EncA
- Orange: EncB
- Yellow: Motor+
- Green: Motor-

- Motor Drivers pinouts:



- Raspberry Pi:

Raspberry Pi 3 Model B

Specifications	
Processor	Broadcom BCM2387 chipset. 1.2GHz Quad-Core ARM Cortex-A53 802.11 b/g/n Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE)
GPU	Dual Core VideoCore IV® Multimedia Co-Processor. Provides Open GL ES 2.0, hardware-accelerated OpenVG, and 1080p30 H.264 high-profile decode. Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA infrastructure
Memory	1GB LPDDR2
Operating System	Boots from Micro SD card, running a version of the Linux operating system or Windows 10 IoT
Dimensions	85 x 56 x 17mm
Power	Micro USB socket 5V1, 2.5A
Connectors:	
Ethernet	10/100 BaseT Ethernet socket
Video Output	HDMI (rev 1.3 & 1.4 Composite RCA (PAL and NTSC)
Audio Output	Audio Output 3.5mm jack, HDMI USB 4 x USB 2.0 Connector
GPIO Connector	40-pin 2.54 mm (100 mil) expansion header: 2x20 strip Providing 27 GPIO pins as well as +3.3 V, +5 V and GND supply lines
Camera Connector	15-pin MIPI Camera Serial Interface (CSI-2)
Display Connector	Display Serial Interface (DSI) 15 way flat flex cable connector with two data lanes and a clock lane
Memory Card Slot	Push/pull Micro SDIO

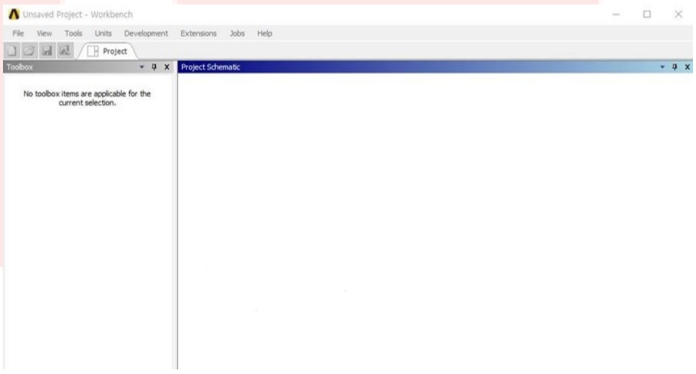
- Arduino Mega board

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
LED_BUILTIN	13
Length	101.52 mm
Width	53.3 mm
Weight	37 g

1.2 Software and libraries used

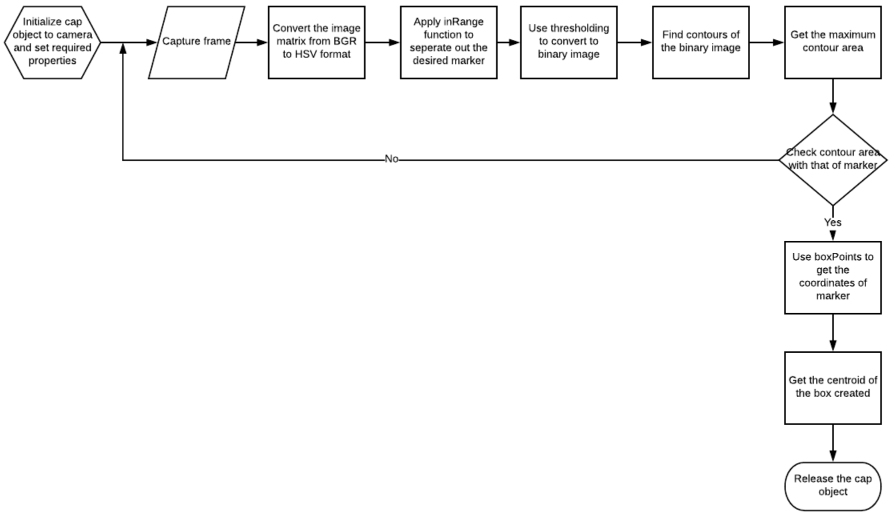
- From mechanical side we have used:
  - Solid works software:

    - This software is a product of Dassault Systemes.
    - This software is used for mechanical designing.
  - Ansys software:

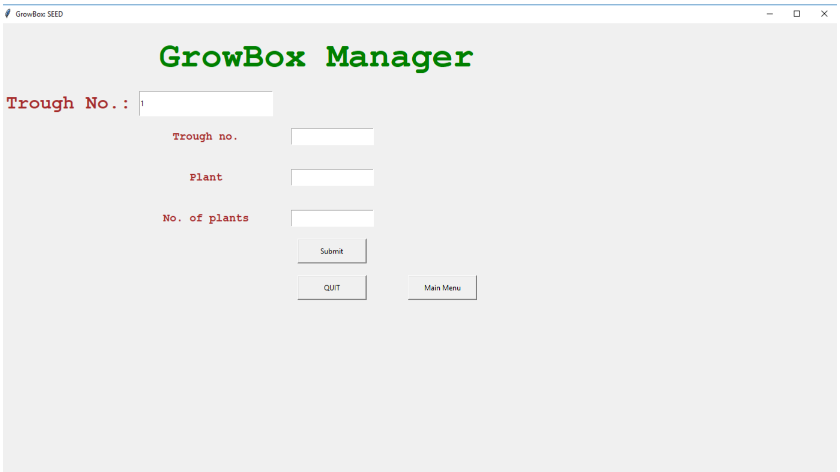


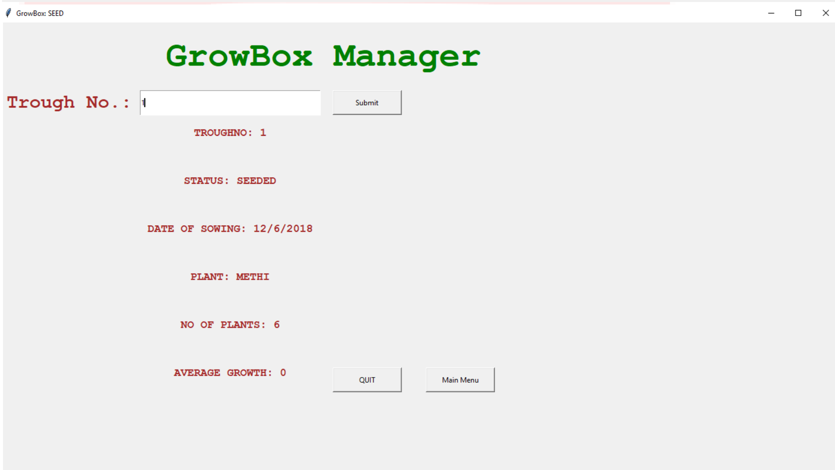
    - This software is a product of Ansys, Inc..
    - This software is used for doing analysis which helps to find out the failure of the part at which particular load.
- For image processing:
  - OpenCV 3
    - This library was made use of for handling all the image related processing.

* To detect the corners of the trough and hence its location with respect to the frame.
* To initialize the coordinate system with help of red marker denoting the origin of the whole system.

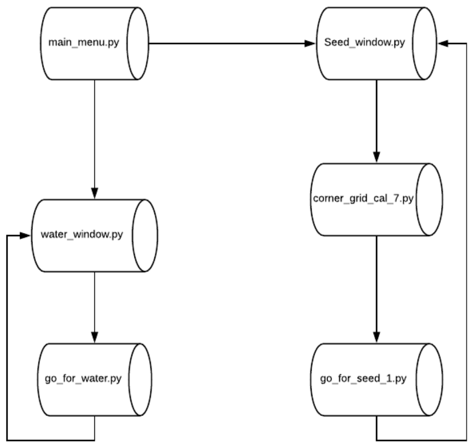


– tkinter library
  * This library was used to create a windows application for user to interact with and fill in his or her requirements.





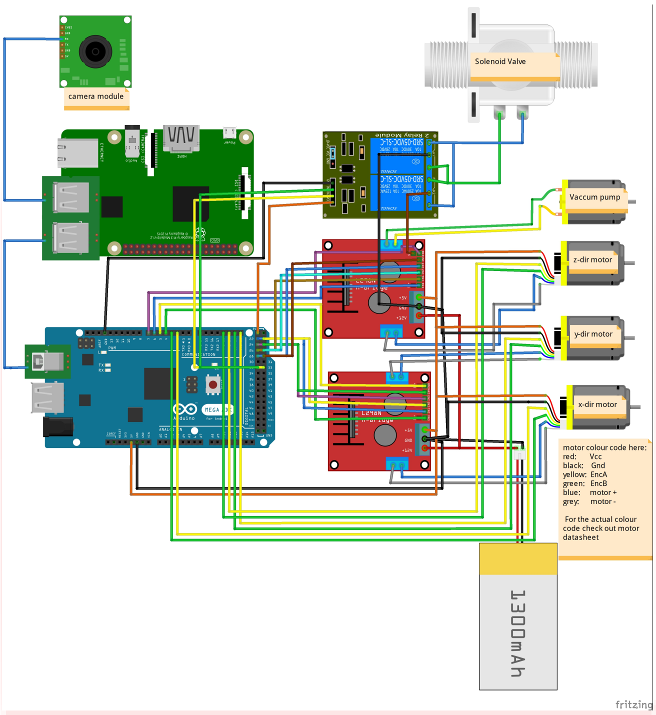
– GUI file execution flow



1.3 Assembly of hardware

Below link guide about the whole mechanical assembly of the CNC. CNC for Growbox (assembly)

Circuit Diagram

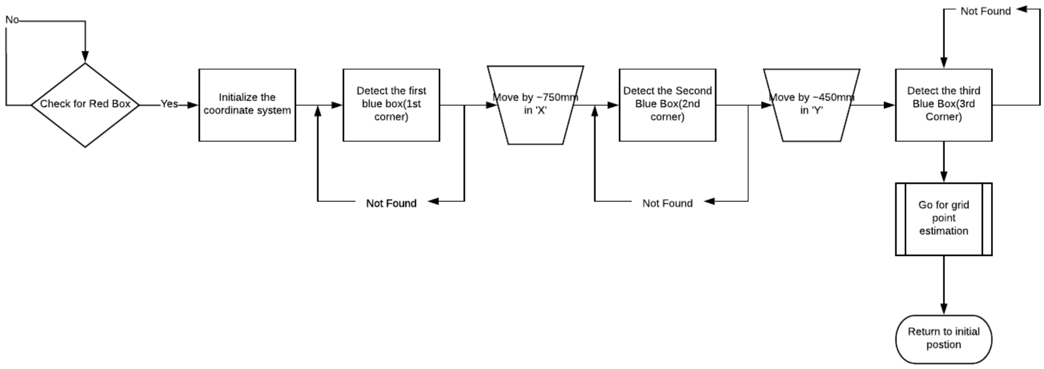


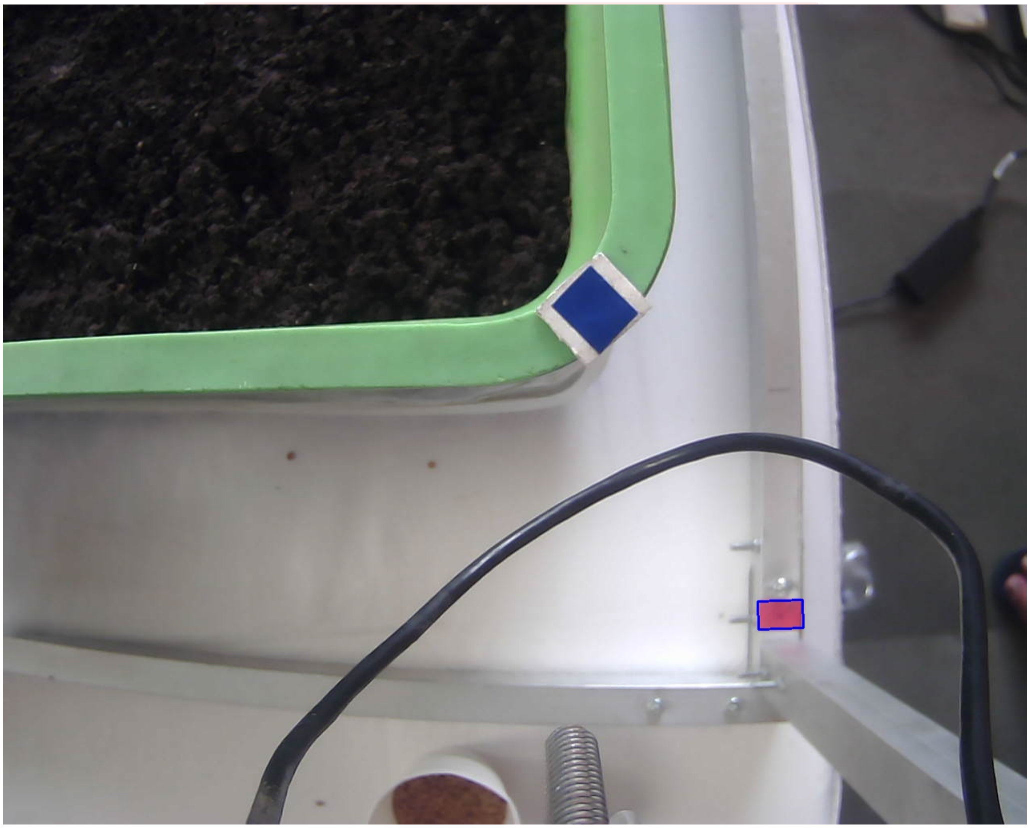
1.4 Software and Code

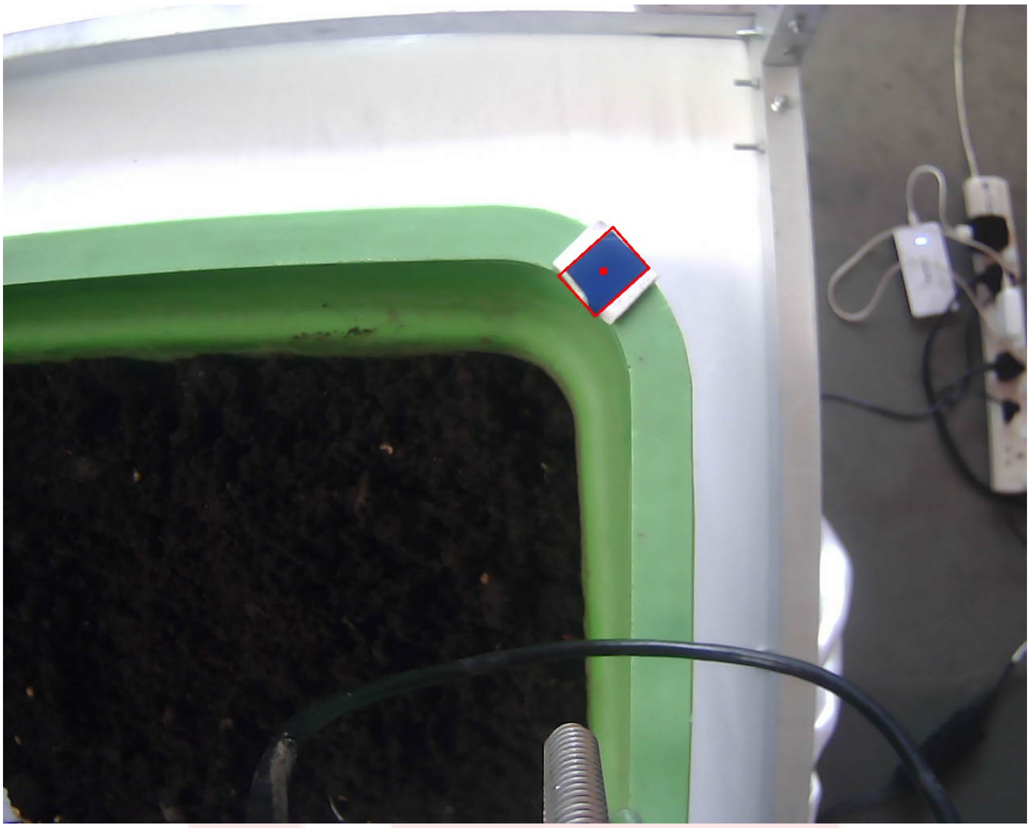
Github link for the repository of code

Corner Detection and Coordinate initialization

The flow chart of the program is as follows:

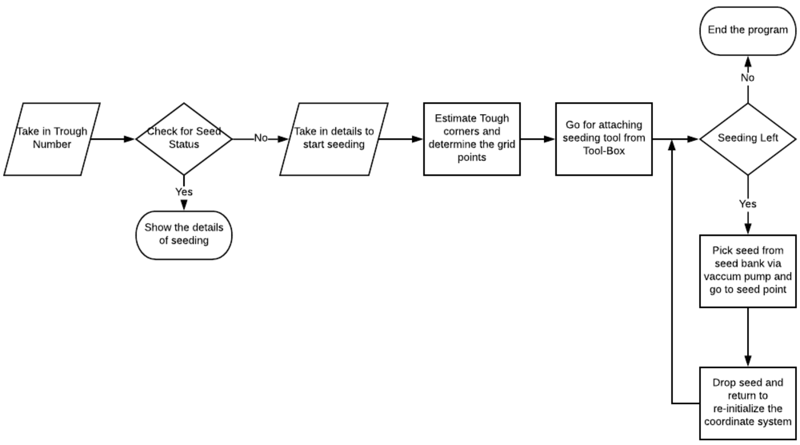

No
Check for Red Box
Yes
Initialize the coordinate system
Detect the first blue box(1st corner)
Not Found
Move by ~750mm in 'X'
Detect the Second Blue Box(2nd corner)
Not Found
Move by ~450mm in 'Y'
Detect the third Blue Box(3rd Corner)
Not Found
Go for grid point estimation
Return to initial postion





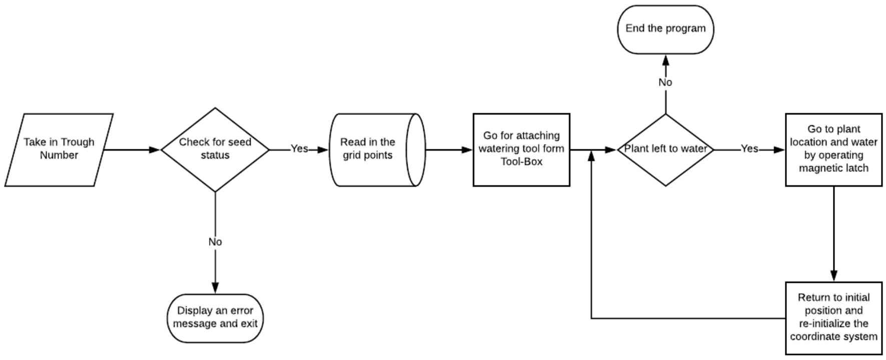
Seeding

The flow chart of the program is as follows:

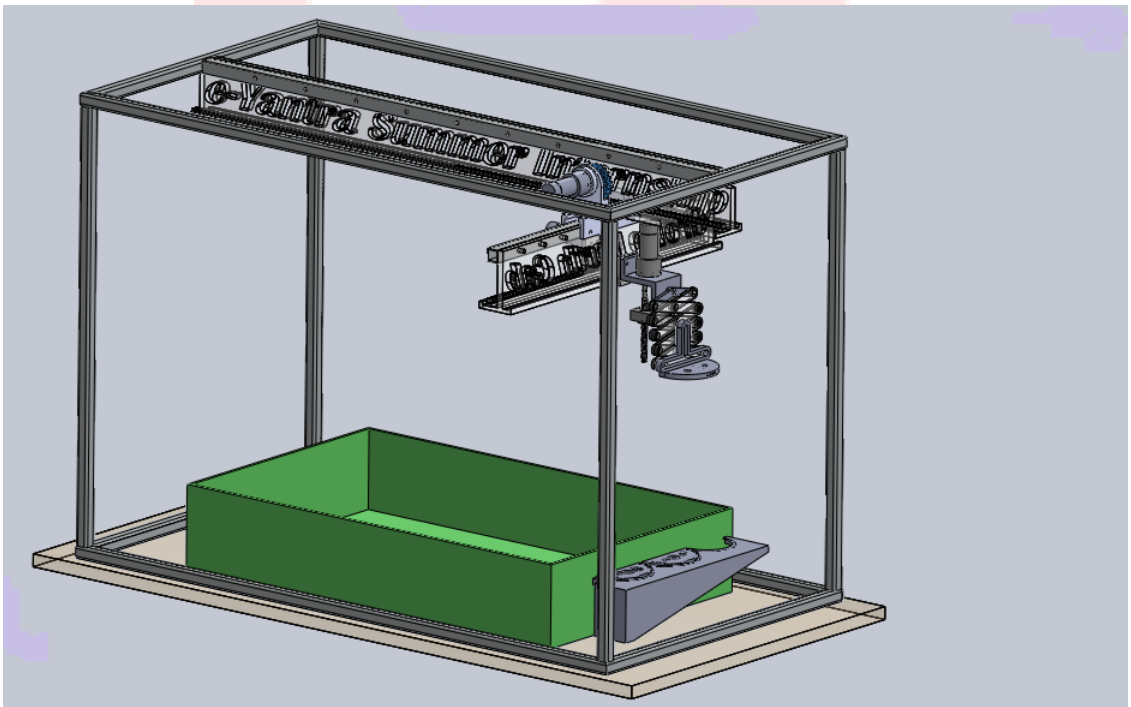


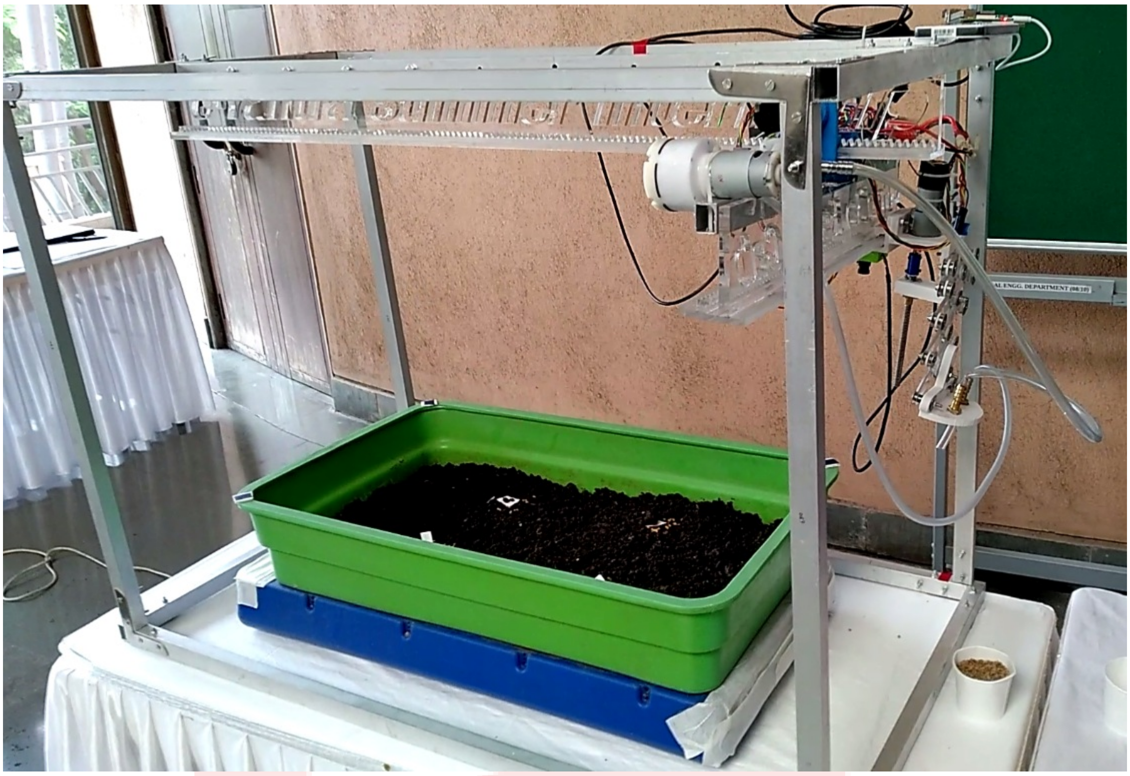
Watering

The flow chart of the program is as follows:



1.5 Use and Demo





CNC for Growbox (working) of demonstration video

1.6 Features

- It has the ability to serve multiple groboxes placed in a row.
- It can seed as well as water them automatically.
- Light in weight and thus easy to transfer it from one place to another.
- You can place trough at any place and orientation inside the frame.
- We can input the number of plants to be seeded through the GUI we created.

1.7 Future Work

As there is always a room for improvement; there are some of them in our project too:

- Firstly, we need to make this whole mechanism as compact as possible so less room is required for its placement.
- We needed to give either two supports instead of one at the top or figure out some other mechanism which can give rigid support to the whole CNC without vibration.
- We can add detachable tools instead of universal one for different actions such as watering, seeding, etc.
- Position of all the tools and seed carrying container should be fixed so tool head will be able to collect them automatically as per requirement.
- Instead of picking single seed in one go we pick whole bunch of seeds and place it individually at every different place of the grid point.
- It can also be designed to shift grow boxes in rows as well as columns thus covering growboxes in large area.
- It should also be able to monitor the plant growth and identify the seeds and make the grid points such that it should satisfy the need of minimum space requirement for that particular plant.
- There should be an user friendly android app which can help to operate the CNC by sitting any corner of the world.
- This system should be able to pick seeds in its proper orientation and drop at the depth required by that kind of seeds for its proper growth.
- Plant health monitoring can be achieved with the help of machine learning and image processing.

1.8 Bug report and Challenges

Challenges faced in Hardware design:

- Due to the single L-clamp used for fitting of the frame, causes vibration of the whole structure.
- As while designing we gave single support to the CNC mechanisms from the top and that too, was very bulky after manufacturing it, whole mechanism was vibrating.

- Also, we didn't give any support to the lead-screw for the z-axis motion(vertical) thus lead-screw was bending alot.
- We also designed watering and seed picking tools but were not able to avoid the leakages.
- We didn't attach any kind of stoppages on the rails which are used for x and y-axis motion due to which many of the times during malfunctioning error whole mechanism came out of the rail.

Challenges faced in Electronics

- We used pin to pin connectors and motor relimates which created problem of loose connections.
- We forgot to use input pull-ups for encoder pins that wasted our time.
- Solenoid has to be run through separate driver with high current power supply instead of using relays with 5V supply from motor driver.

Challenges faced in Image Processing

- Initially we had planned to use pi camera which had issues like the soldering was not robust enough leading to no collection of sensor data several times or in some cases, not even capturing a frame.
- The grid point estimation had to be dynamic, i.e., should not depend on orientation and placement of the trough with respect to the frame.
- The camera would take either a lot of time to adjust to ambient light or it would just capture photos dull enough to fail the image processing to give desired result. An experimental exposure value had to be set to make the whole process robust.
- Trough corner detection was first decided to be dependent on the actual border, whose contour would be extracted and an approximate polygon would be found to extract a point for future grid calculation. However, this approach was giving a lot of uncertainty to whole process, therefore blue markers were used to get corner coordinates. This helped us to estimate the grid coordinates very accurately.

Bibliography

[1] Ad Kamerman and Leo Monteban, *WaveLAN-II: A High-Performance Wireless LAN for the Unlicensed band*, 1997.