CS684 Project Report
GROUP 4
WEED CONTROLLER BOT

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Contents

1 Introduction **3**

1.1 Definitions 3

2 Problem Statement **3**

3 Overall Discription **3**

4 Assumptions **4**

5 Requirements **4**

5.1 Functional Requirements 4

5.2 Non-Functional Requirements 4

5.3 Hardware Requirements 5

6 Implementation **6**

6.1 Hardware Implementation 6

6.2 Software Implementation(To Run Hardware) 8

7 Testing Strategy and Data **8**

8 System description **9**

8.1 Important Problems Faced 10

9 Future Work **12**

10 Conclusions **12**

11 References **12**

1 Introduction

This project aims at using Firebird V bot as a weed controller. It would identify weeds, based on the height difference with normal crops, and uproot them.

1.1 Definitions

Firebird V: A robot indigenously designed at ERTS laboratory, IIT Bombay

ATMEGA2560: The microcontroller used by Firebird V bot

AVR GCC: The platform specific compiler which compiles C code to run various AVR microcontrollers developed by Atmel

WinAVR: Open-source software which uses AVR GCC Complier

ZigBee: is a specification for a suite of high level communication protocols using small, low- power digital radios based on an IEEE 802 standard for personal area networks.

2 Problem Statement

Given a greenhouse map and trough number, we had to build a bot that would identify the weeds in that particular trough and uproot them.

3 Overall Discription

Our weed controller bot was built with the following features:

- To identify the weeds, it has 3 sharp IR sensors- 1 in the front and 2 on either side of the bot (at height 15 cm) An arm mechanism to hold the weeds and uproot them- It has 3 motors:
  - 1 for the gripper
  - 1 for up and down motion of the gripper
  - 1 for to and fro motion of the gripper
- The bot moves parallel to the trough sensing for the weeds
- As soon as it identifies the weeds it turns 80 degrees and then again turns by a resolution of 7 degrees sensing for the presence of weed through front sharp sensor

- Then it moves towards the weed, grab it and uproots it through the arm mechanism

4 Assumptions

- Weeds are taller than plants: According to our build we are assuming that weeds are of height greater than 15 cm. This measurement is based on the height of the sensor mounted on the sides of the bot
- All the weeds are in a single line (because the readings form the sharp sensors were imprecise)
- The aisles in the greenhouse have black lines to help the bot navigate through it
- Checkpoints are provided between the trough in the form of an black horizontal line

5 Requirements

5.1 Functional Requirements

- Moving the bot to the particular trough
- Moving the bot parallel to the trough
- Identifying weeds on the basis of sensor reading
- Calculating distance of weed from the bot
- Go near the weed and remove it using gripper mechanism

5.2 Non-Functional Requirements

- The robot must move such that all the weeds are detected
- Every weeds must be removed
- The robot must not go inside the trough
- The bot must not harm the plants
- The power consumption should be minimum

5.3 Hardware Requirements

- Sharp IR Sensors

- Servo Motors

- Fire-bird

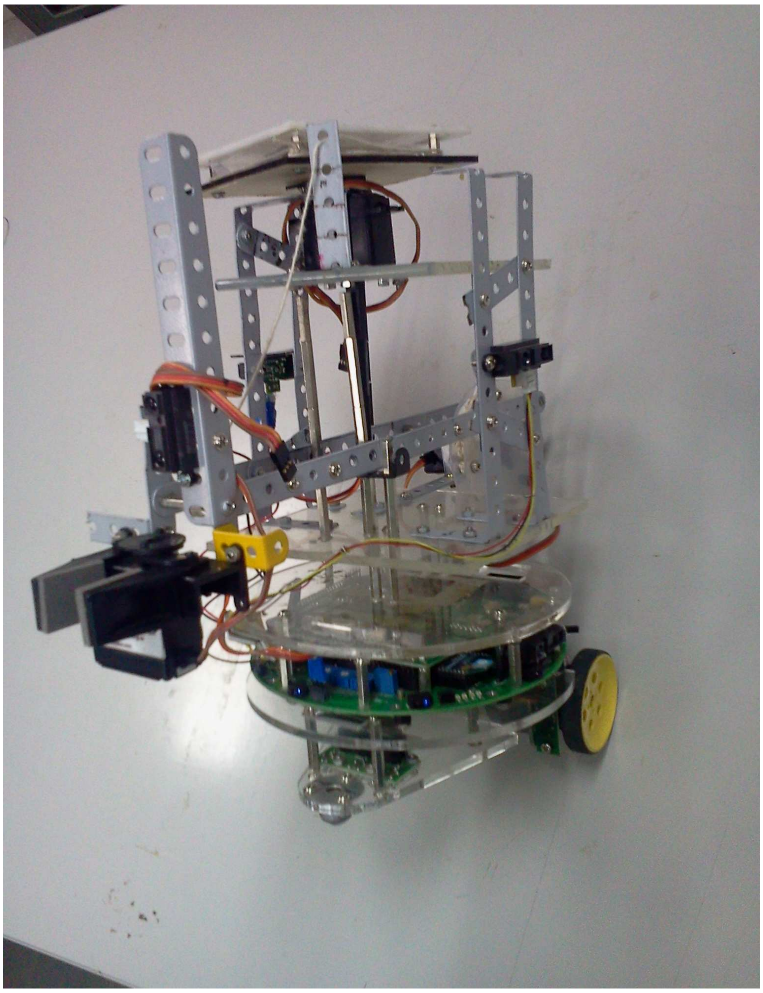
- Zig-bee Module

- Auxiliary Power Supply
- Gripper

6 Implementation

6.1 Hardware Implementation

To start building required hardware, we must have its proper design. Otherwise, it will be much difficult for us and will also take much time to build it. So, the first requirement is to think of functionalities that the hardware must have. Now, we should think of the design of hardware. But, its not easy to think of an efficient working design of hardware. Lots of expected or unexpected problems arise when we deal with hardware. So, we should identify risks (as much as possible) associated with our designes in advance.



According to our project needs, we have find out following requirements:

- Sensors for detecting weeds and positioning of these sensors.
- Gripper for removing weeds
- An arm to hold gripper
- A mechanism which will move the arm up and down
- Servo motors for gripper and arm mechanism
- Some structure on which arm mechanism will rest.

To meet all these requirements, we started working on the design of our bot. We have seen videos of several projects on

`http://www.e-yantra.org/home/interships/student-projects`

. We got many ideas after looking those videos.
As arm mechanism of previous projects was not available, we decided to build it. So, our first goal was to build arm mechanism. And to build required arm mechanism, we first build the gripper.
The gripper was made using :

- Two gears
- One servo motor
- And some other mechanical components like strips, plastic sheets etc.

After that we designed an arm which can hold the gripper. But, there was one problem. The gripper that we have built was heavy and that's why it was risky to use it. If we use heavy gripper, then the servo motor might not be able to lift it up. So, now we thought of using some light weight gripper. After attaching gripper to arm, we attached the arm on a motor which can move the arm forward and backward.

Now, our basic structure was ready. Next we built the component for lifting arm up and down. After building all necessary hardware components, we integrated all these components and other components like sensors.

During hardware design, we faced many problems. Several times we modified our hardware structure because of some problems. All these problems and their solutions are mentioned in later sections.

6.2 Software Implementation(To Run Hardware)

Initially the bot is at the starting point. To run the bot, we need to connect the bot to the common interface through zigbee. Then trough number and start command is given. The bot goes to that particular trough and executes the task of weeding for that particular trough and comes back to the starting point.

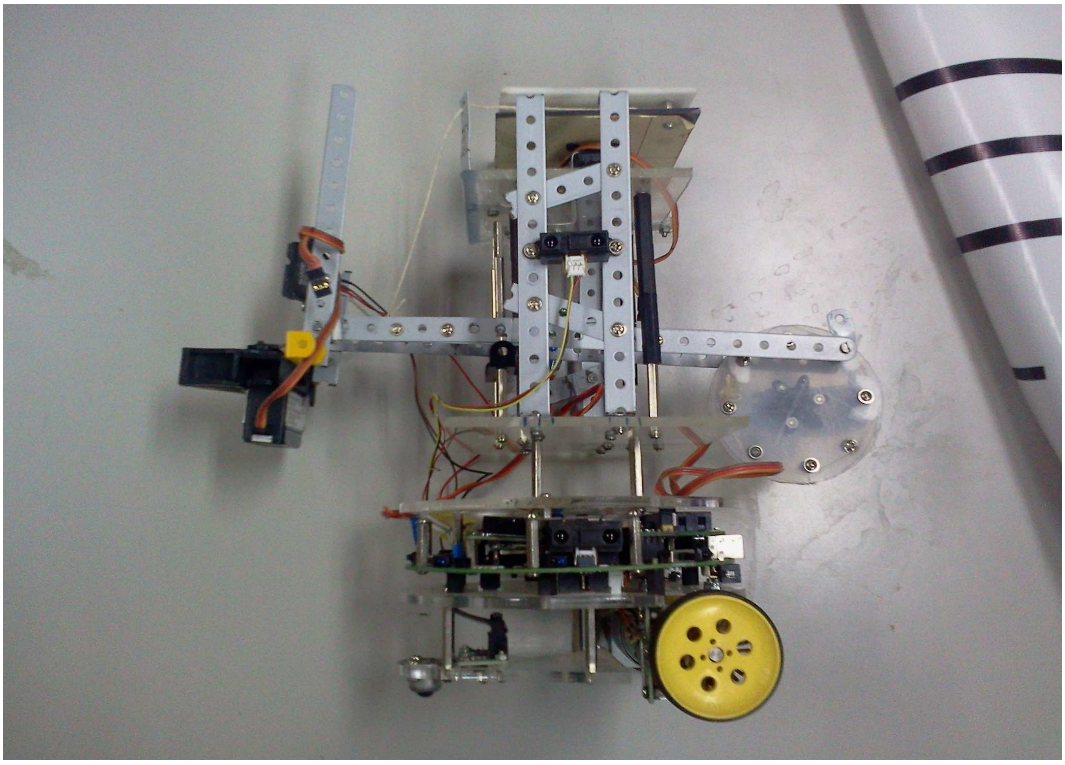
7 Testing Strategy and Data

We tested the bot for the following test cases

- **Weeds are scattered uniformly in a line along the trough**
  For this test data our BOT removed the WEEDS perfectly.
- **Weeds are closely spaced**
  Run fine for sufficiently spaced WEEDS
- **Weeds are scattered in the trough, not necessarily in a line**
  Only few times it fails to measure accurate distance from WEEDS.

- **No weeds**
  BOT scanned the whole trough and came back to home position without doing anything.

8 System description



The bot consist of following major components.

- **Gripper attached with one motor:**
  To hold and release weeds.
- **Arm attached with gripper on one side and wheel on other side:**
  Wheel attached with motor, is used to move arm forward and backward.
- **Front sensor:**
  To align bot exactly in front of weed.
- **Two sensors attached on both sides of the bot:**
  These sensors are used to sense weeds on either left trough or right trough. We used two sensors to save power, because if we use one sensor on one side of bot(say left side), and we need to sense weeds in trough right to bot then we have to move the bot to the end of that

trough and then turn it, so that left side sensor of bot comes toward the trough. But, as we have used two sensors, so we can directly start sensing weeds using right side sensor for trough to right side of bot.

- **A square shaped wheel attached with a motor:**
  This is used to move the arm in upward and downward direction using a thread attached with arm and a motor which rotates the wheel.

8.1 Important Problems Faced

- **Building gripper mechanism**
  We first used acrylic sheet to build gripper. It was very hard to cut the sheet in required shape and later we found that we need to make a hole of about 16mm in it. And also they were heavy. So, we then used plastic sheet. Even after using palstic sheet the gripper was good but it was little heavy. Since our gripper was ready, but we found a gripper which was also good and lighter in weight, we used the lighter one.

- **Building complete arm mechanism**
  We initially decided to build such an arm mechanism which can be moved forward and backward in horizontal direction and can also be moved vertically upward and downward. There was no such mechanism designed in past, which gives both the horizontal and the vertical motion to arm. So, it was most challenging for us.

  We thought of following designes for this type of mechanism:

  1. Using wheel
     This was our first design and we used this design in our project. We used a wheel and the arm was attached at its circumference. When the wheel is moved by motor, the arm moves. Now, we adjusted arm and provided support for arm such that the arm can be moved forward and backward, horizontally. The main problem with this design was the distance by which arm can be moved in forward and backward direction. This distance depends on the diameter of wheel. Using this type of design, the maximum distance of motion of arm is equal to the diameter of wheel as the arm is attached at its circumference. We can increase the size of wheel, but as we have to run our bot in green house which has width of aisle = 25cm, so we cannot use bigger wheel because if bigger wheel is used then there are chances of collision of bot with weeds and/or plants.Instead, we used other approach.

     We attached extra strip at circumference of wheel. By doing this, the diameter of wheel was now increased by twice the size of strip. So, new diameter of wheel = old diameter + (2 * length of strip)

After attaching extra strip, we attached one more strip to generate motion similar to the motion used in engines of vehicles. Now, the arm can be moved forward and backward by more distance. But, another problem raised. The problem was to keep the arm balanced. But because of weight of motor attached to gripper, it was tilting downward when we moved it forward.

Finally, due to lack of time, we again removed the extra strips and decided to work with the same wheel. This design was our best design to be used with firebird which was providing us both the vertical and horizontal motions.

2. Using sliding mechanism
   In this design, we have thought of using a slider on which our bot's arm slides. One motor attached to two wheels can be used to slide the arm forward and backward. The wheels are attached to each other using gears so that when one wheel moves clockwise then the other moves in anti-clockwise direction and vice-versa. Wheels are used to slide arm using threads. When motor rotates, let us say in clockwise direction, one wheel releases thread and the other wheel moves arm by winding the thread.
3. Using threaded rod
   This design was suggested by Piyush Sir. In this design, we have to first use bolts, a motor and a threaded rod. The bolts can be used to attach arm mechanism. When the motor rotates the threaded rod, the bolt moves and this helps in movement of arm in forward and backward direction. But, if pitch of threads on rod is small then the rod should be rotated more. That's why this is not power efficient.

- **Turning bot exactly by** 90°
  Due to some hardware constraints and inertia, it is much difficult to turn bot exactly by required degrees. Also, the friction between surface and wheels causes errors. That's why the bot sometimes turned by exactly 90°, sometimes more than 90° and sometimes less than 90°. To solve this problem we used an extra sharp IR sensor, which was attached in front of arm. First turn bot by 80° and then turn it by 7° repeatedly till object is sensed.

- **Getting accurate distance of weeds**
  Sharp IR sensors gives correct distance reading for wider and opaque objects. But, in our case, weeds were of small width. So, sometimes it gives incorrect readings of distance which affects the predictability and accuracy of the system. The distance of object was required only to measure the distsnce of weed from bot and then move the bot accordingly so that it can remove the weed. But as the readings from

sensor were not reliable, we fixed the distance of weeds from bot, i.e. the weeds are at an already known distance from bot, but can be anywhere in trough.

- **Using ZigBee for wireless communication**
The ZigBee was creating many problems as we were new to use this. We configured it correctly, it was working with bots of 11059200 Hz frequncy but not with 14745600 Hz frequency bot. It took much time to identify the solution. The solution was simple. We have to just set UBRR0L (baud rate low) and UBRR0H (baud rate high) according to frequency of bot.

9 Future Work

- More precise and sophisticated methods using image processing can be used to identify the weeds based on shape and size
- Proper mechanism to dispose off the weeds can be implemented
- Gripper mechanism can be improved so that it can cover more width of the trough

10 Conclusions

Manual weeding is a monotonous and frequent activity involving large amount of resources(labour, time and money). However, using an automated bot can do the same activity given energy requirements are taken care of. This way, not only manual labour can be put to more sophisticated work, but also using a bot for weeding will improve the yeild of the greenhouse.

The things that seem to be achievable using software simulation is not always accomplished as expected. So the feasibility of the project (especially an embedded project) should be analyzed from a hardware perspective ,Real time analysis. Simulation is essential. Consulting an experienced person in the same area shows the best path.

11 References

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