INDIAN INSTITUTE OF TECHNOLOGY, PATNA

Inter IIT Tech Meet 8.0

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DIC'S TERRACE FARMING ROBOT FOR HILLY AREAS
MID TERM EVALUATION REPORT

Overview

Cultivation in terraces is an outstanding example of an evolved, living cultural landscape that can be traced as far back a few millennia ago. Records suggest that terraces have been in practice in Tanzania for about 300–500 years; in Peru, Guatemala and Mexico for about 2,000 years; in Cyprus for approximately 3,000 years; in China for about 4,500 years; and in Yemen for the past 5,000–6,000 years. Improving land productivity is essential to meet increasing food and forage demands in hillside and mountain communities. To achieve this, it is necessary for the farmers to have access to affordable and adequate farm tools required to increase crop yields.

The objective of our project is to design an innovative, low-cost robot which is equipped with the features that can face the agronomic challenges for terrace farming to intensify terrace agriculture and hence improve the livelihoods of the local farming community. The challenges of automation and mechanization in terrace farming include the unpredictable nature of the terrain, looseness and instability of soil, high rugged topography of the terraces and illiteracy of the farmers.

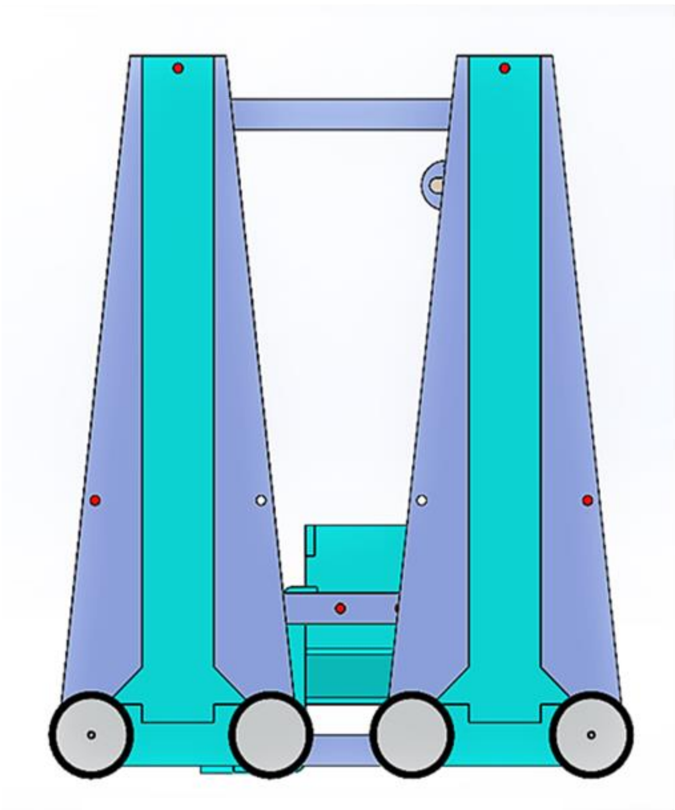
Problems identified

After studying the terrace farming practices of various parts of the country and analysing state of art techniques we identified the following problems:

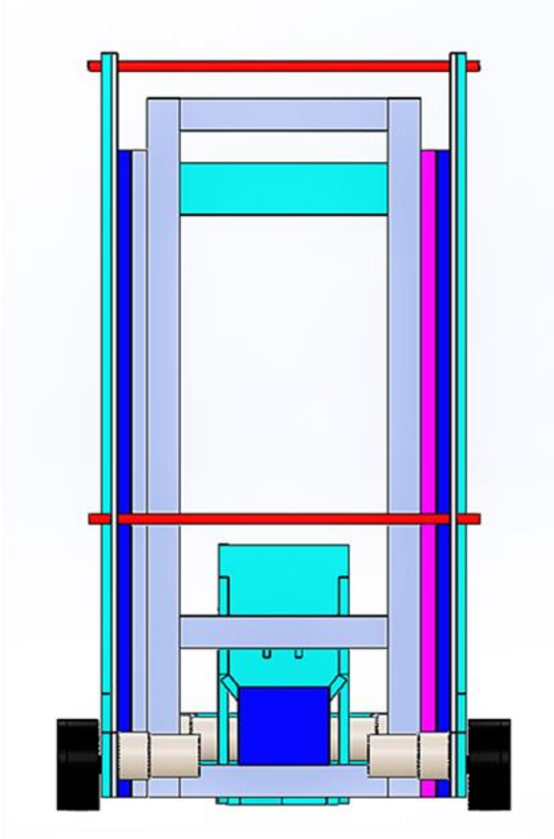
- *Height of steps:* Clearly the first problem to overcome was coming up with an effective climbing mechanism, robust enough to carry the weight of bot and tools attached. Also the speed and cost associated were taken care while designing the same.
- *Variation in step heights:* In most areas the step size (length and height) varies, hence the bot must be capable of detecting the alterations and perform the operations accordingly. This problem was taken care by incorporating positioning and measurement sensors.
- *Looseness of terrain:* Since the soil is loose in most areas the locomotion system was to designed taking care of the hindrance. Also, the locomotion of bot should not damage the existing plantation.
- *Shortcomings of existing solutions:* Most state of art techniques and solutions are expensive and require human inputs. As majority of the farmers only have access to a small farmland, this is the main reason why their semi-automation is relatively inviable. For them, such an investment would be impractical as they would still have extended efforts even after the purchase of the solution.

All of these factors make conventionally designed hard-coded robotic agricultural solution inviable. We have given an unorthodox approach to this problem statement by designing a distinctive robot model which is fully automated and is capable of accomplishing everyday tasks in such rugged terrains with ease, with minimal human input.

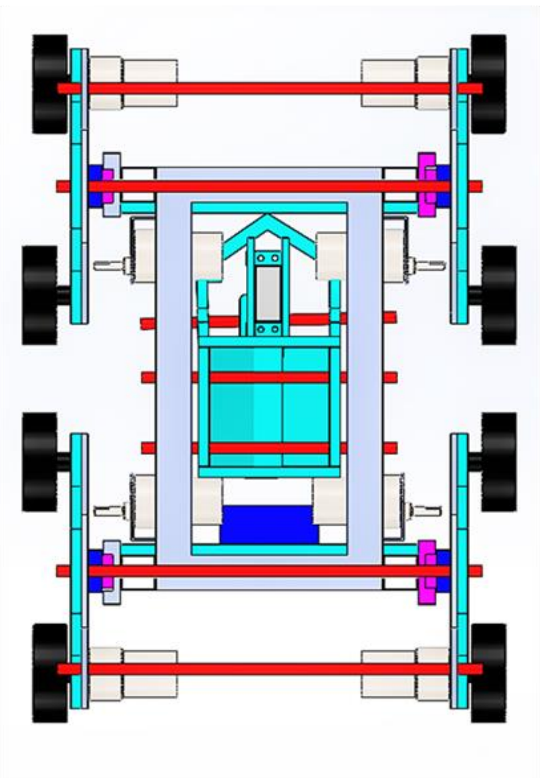
The model is capable of sowing and ploughing operations in any soil conditions (rough/loose) and is completely automated. Although the task of filling seeds in the container requires human input.



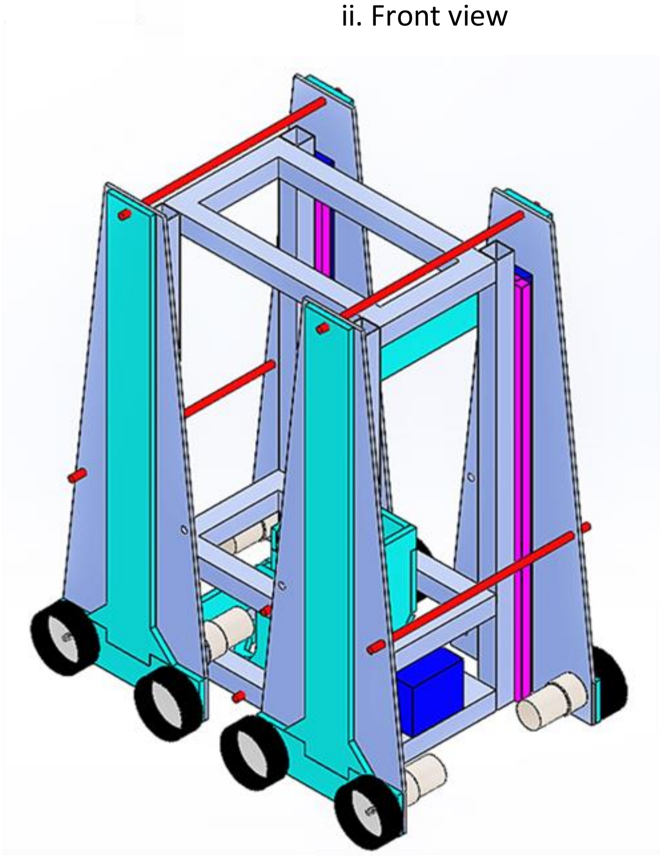
i. Side view



ii. Front view



iii. Top view



iv. Isometric view

Figure 1: CAD model of our proposed solution

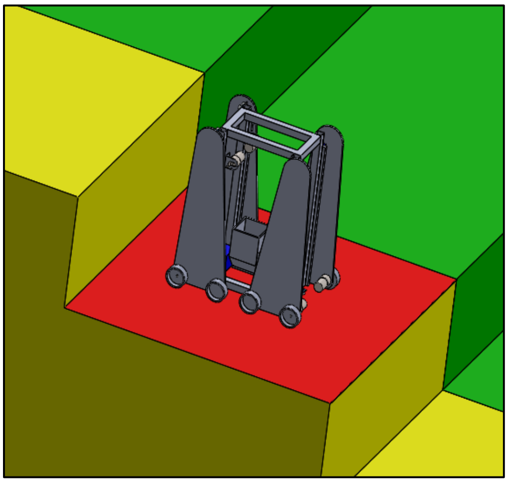
Solution Approach

Climbing:

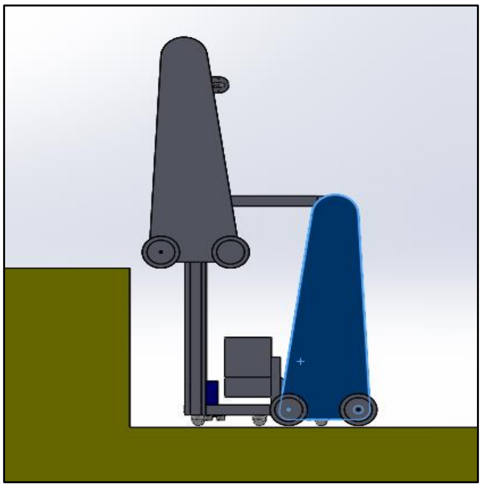
The *'climbing-up'* motion of the bot is explained in detail

Step 1: The ultrasonic sensor at the front senses the wall, this activates the front lift mechanism. The motors make the forward part of bot slide on the frame so that it reaches the upper step.
Step 2: Now the bot moves forwards until the wheels of the front frame touch the above step. The sensor on the lower part ensure that the wheels have landed on the step.
Step 3: Chassis frame starts coming up by the motor actuated rack until the height of the lower point of tyres is equal to the height of the step.
Step 4: The rear-wheels initiate motion in the forward direction until the chassis frame rests completely on the upper step.
Step 5: Now, the rear frame is at the lower step hence the rear frame will be brought to the upper step using motor actuated rack.

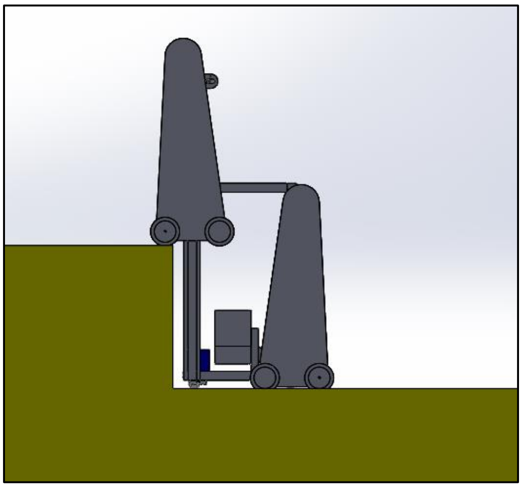
Similarly, the configurations in reverse order are followed for *'climbing-down'.*



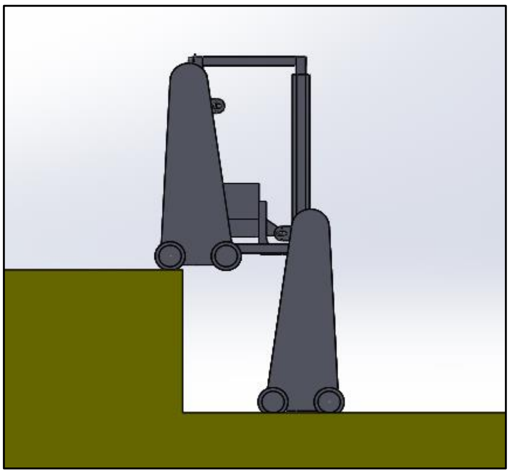
Configuration 1: The sensors detect the wall and align the bot



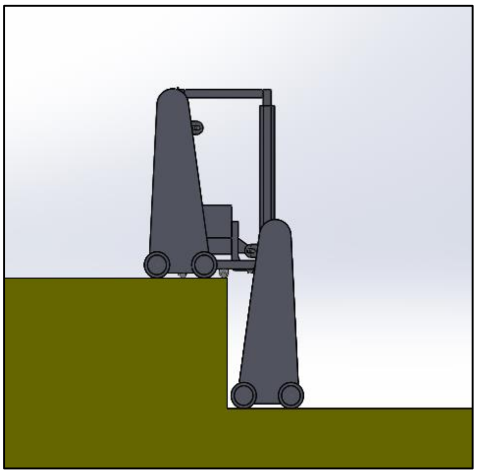
Configuration 2: The sensors detect a wall and align the bot.



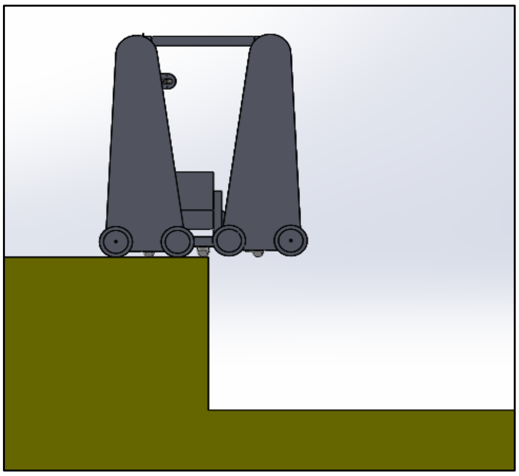
Configuration 3: The bot propagates so that the front-wheels land upper step.



Configuration 4: Rack and hence the chassis is pulled up along the slider.



Configuration 5: The bot propagates so that weight shifts on upper step.



Configuration 6: Finally, the rear part also climbs along the rack.

Figure 2: Various configurations in climbing up mechanism.

Movement on step:

The algorithm for horizontal motion is made considering the fact that step size may vary in a field. Ultrasonic sensors are used to take care of that, thus providing a low-cost and light solution than most positioning and alignment sensors.

- When the bot climbs up, it rotates 90° clockwise and ultrasonic sensors aligns it parallel to the step.
- The bot moves forward until the ultrasonic sensor at the bottom detects an abrupt change, which marks the end of step.
- Now it turns around and traverses in straight line until it detects the other end of the step.
- This cycle continues until the top sensors detects a wall. The bot then goes for a last time on the step. Perform the operation on the specific line.
- Then it turns back and reach the starting position where the climbing mechanism is activated and the cycle continues.

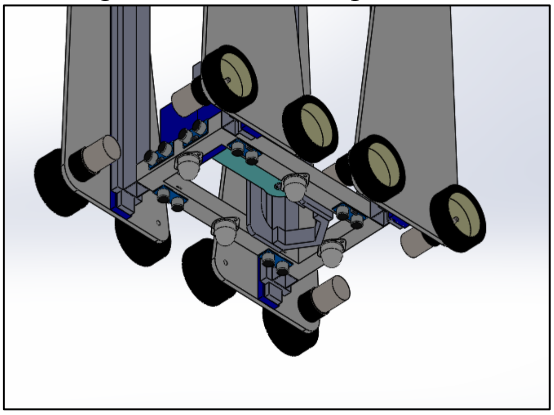
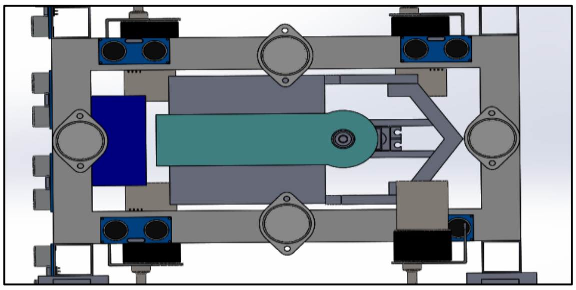


Figure 3: Bottom view of the bot, with ultrasonic sensors pointing downwards.

Job(Sowing):

Step 1: There is a container with seeds and a hole at the bottom which ensures the delivery of seeds in the field with the help of servo actuated flap.
Step 2: This flap oscillates with a particular time period as the bot is moving horizontally.
Step 3: The sowing tool at the back ensures that the ploughed sand covers the seed as the bot moves over them.



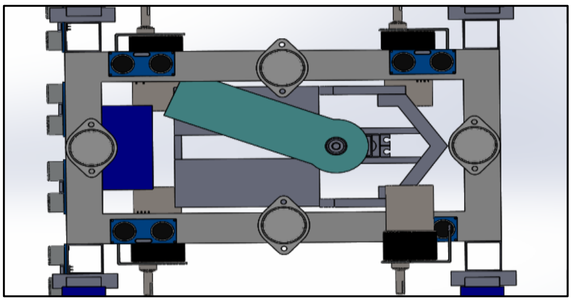


Figure 4: The flap close and open positions respectively.

#Tools:

As stated earlier, the bot is capable of sowing and ploughing operations. There are separate tools for the same and can be easily attached and detached when required.

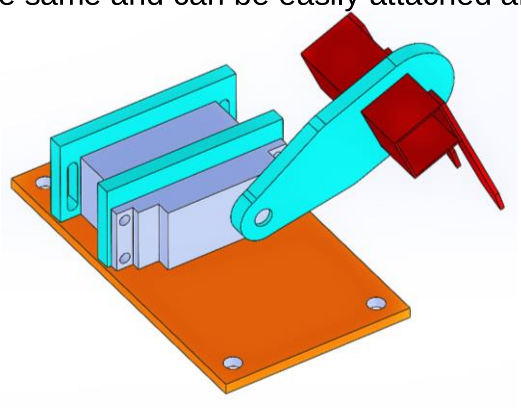


Figure 5: Ploughing tool

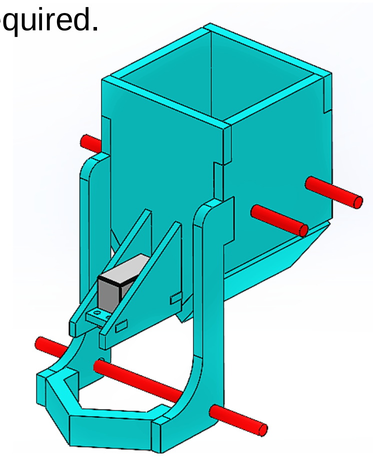


Figure 6: Sowing Tool