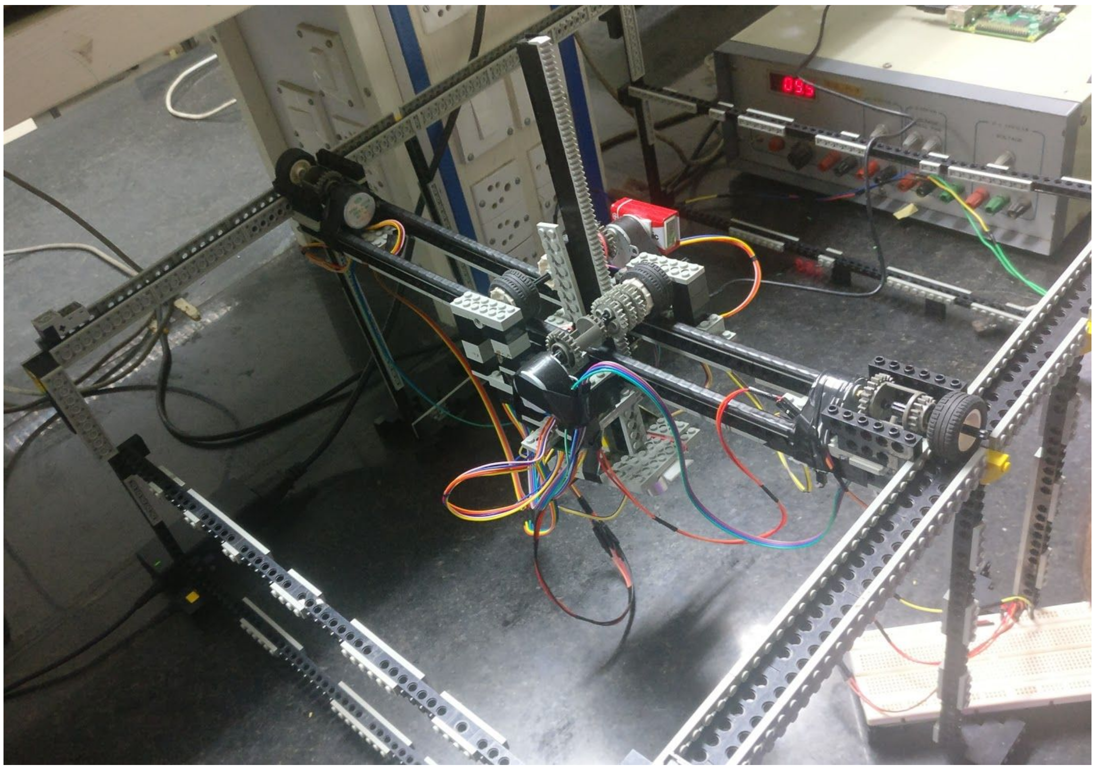
CS321 - Peripherals Lab
Final Project

Kisaan: A Farm-Monitoring System



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1. **Project Idea**

With rapid technological development, traditional occupations such as farming have greatly benefited. Modern irrigation systems, fertilizers and harvesting methods have changed the agricultural landscape. With increasing automation in our day-to-day lives, the need for a remote monitoring system arises on the farm as well.
As CEO of Decisive Farming, a agritech startup that has raised $7 million in funding, Remi Schmaltz writes [1], "..Many farmers are facing a dilemma between wanting to produce more, higher-quality crops and finding the workers to plant, maintain, and harvest those crops… In the face of labour shortages, farmers are turning to technology to make farms more efficient and automate the crop production cycle."
Kisaan is a farm-monitoring tool which aims to automate farm monitoring while minimizing labour costs.
Kisaan aims to assist existing precision agriculture systems - defined as an approach to farm management that uses information technology (IT) to ensure that the crops and soil receive exactly what they need for optimum health and productivity [2].
Irrespective of farm conditions and terrain, Kisaan provides you with essential information about your farm. Kisaan works best in small farms and greenhouses.

2. **Features**

- **Independent of terrain type:**
  The mobile robot runs on overhead mounted tracks, allowing it 3 degrees of freedom. This provides it with the ability to cover your entire farm bypassing terrestrial obstacles. Kisaan calculates its distance from the ground and stops descending only when it is sufficiently close to the ground. This ensures crops are not harmed while maintaining accurate readings.

- **Cost-effective:**
  In present farm-monitoring systems, hundreds of sensors are scattered throughout the farm which is extremely expensive. Compared to this, Kisaan only uses one set of sensors to scale the length of the entire field. Since the sensors are together, they can be easily replaced in case of any failure.
  We perform a cost analysis with an existing commercial product, in a later section.

- **Automatic Monitoring:**
  Farmers may not be present on the field everyday. Kisaan has an automatic mode where the bot will traverse the entire field and collect the data at points specified by the grid.

- **Manual Monitoring:**
  If the farmer wants to monitor a specific part of his farm, he can send Kisaan directly to that part to collect data.

- **Reliability:**
  Data is logged and piped all the way to external servers - logs are consistent, and appropriate data-validation is present at each layer.

- **Power Fault Recovery:**
  In case of any fault in power supply Kisaan has mechanisms to recover its position and resumes its work from that point only - avoiding redundant work.

3. Equipment and Electronics Requirements

1. Stepper Motor (28BYJ-48)	Quantity: 4
2. Stepper Driver (ULN003)	Quantity: 4
3. Ultrasonic Sensor (HC-SR04)	Quantity: 1
4. Grove Temperature and Humidity Sensor (DHT11)	Quantity: 1
5. Grove Air Quality Sensor	Quantity: 1
6. Raspberry Pi v2	Quantity: 1
7. Arduino Mega 2560	Quantity: 1
8. LEGO MindStorms Kits	Quantity: 3
9. Constant DC Voltage Source - 12V max	Quantity: 1

4. Software Requirements

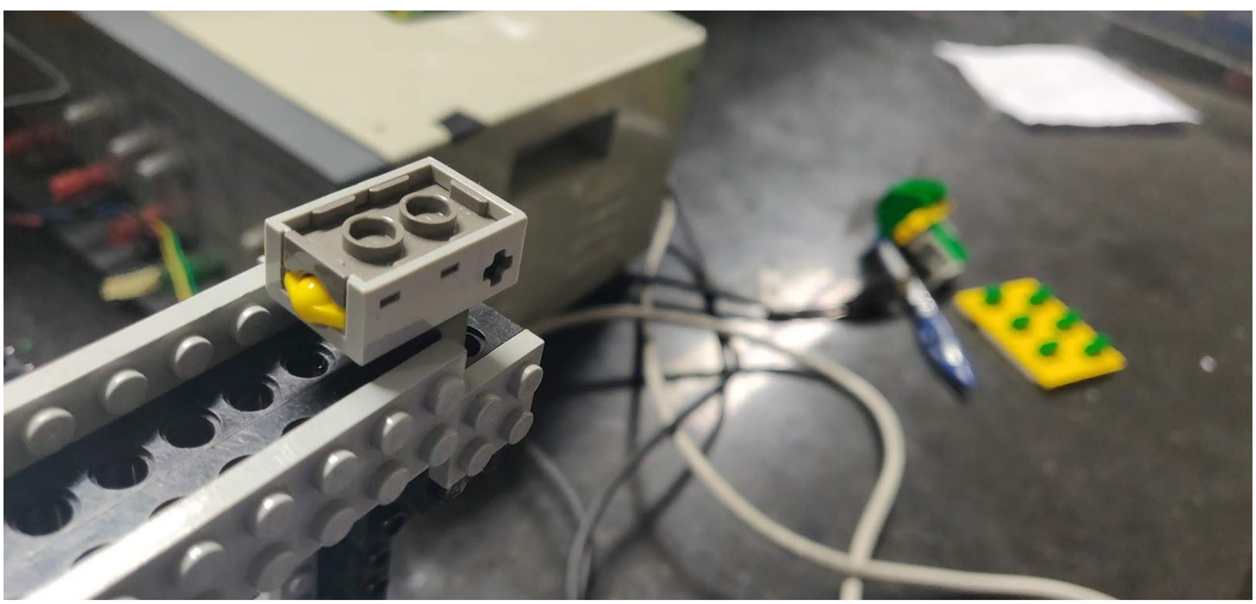
Raspberry Pi:
Install the Arduino IDE on the Raspberry Pi.
Run the following commands at the command-line to install the MQTT servers on the Raspberry Pi:
sudo apt-get install mosquitto
sudo apt-get install mosquitto-clients
sudo pip install paho-mqtt

Arduino:
Install the libraries for the sensors:
AirQuality.h https://github.com/Seeed-Studio/Grove_Air_quality_Sensor
DHT.h https://github.com/Seeed-Studio/Grove_Temperature_And_Humidity_Sensor

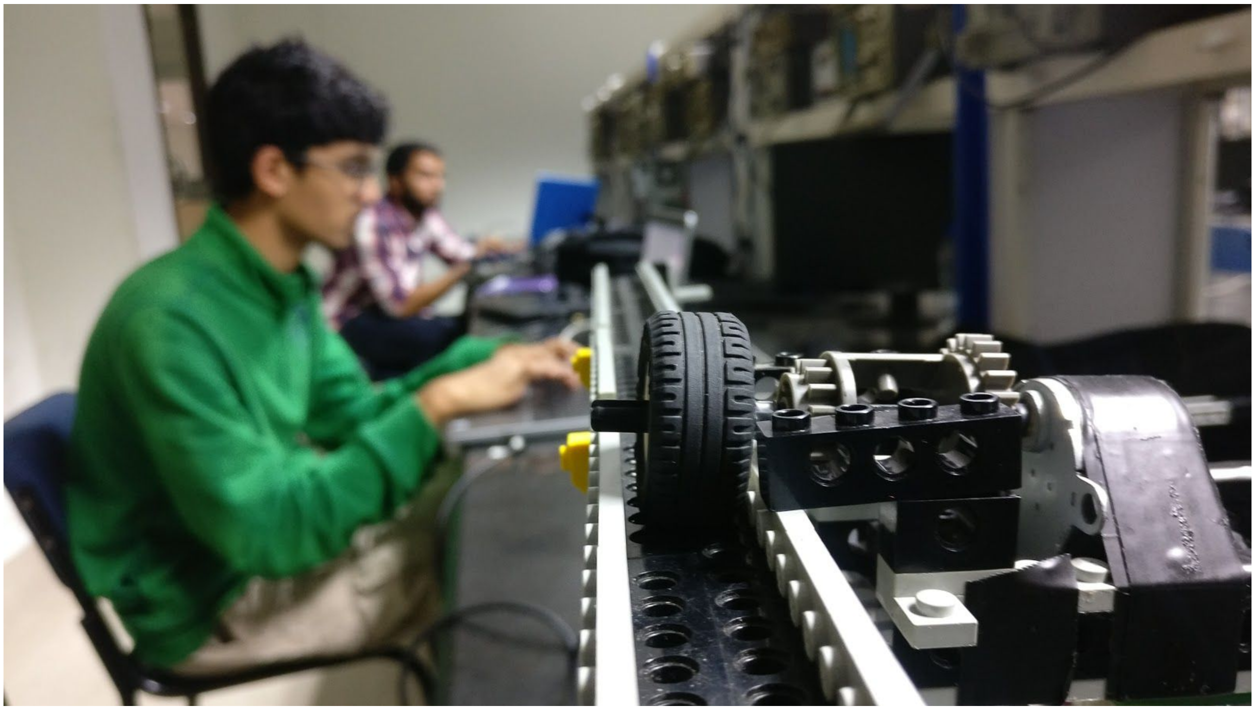
5. **Starting up Kisaan**
   Install the required software and set up the connections as shown below.
   Upload *automatic.ino* to the Arduino board.
   Start *demo_server.py* and *test_mq.py* on the Raspberry Pi.
   Start *broker.py* on the PC.
   Provide input either through the web interface or by running *coords_input.py* from the command line.
   Choose mode (manual (0) or automatic (1)) and input the x, y, and z coordinates as required.

6. **Model Description**
   In manual mode, Kisaan will move to that specified position and will take all the sensor readings. In automatic mode, Kisaan will traverse the entire grid repeatedly.
   A video demonstrating Kisaan in action is here:
   https://www.youtube.com/watch?v=P3L9CK3gKvA

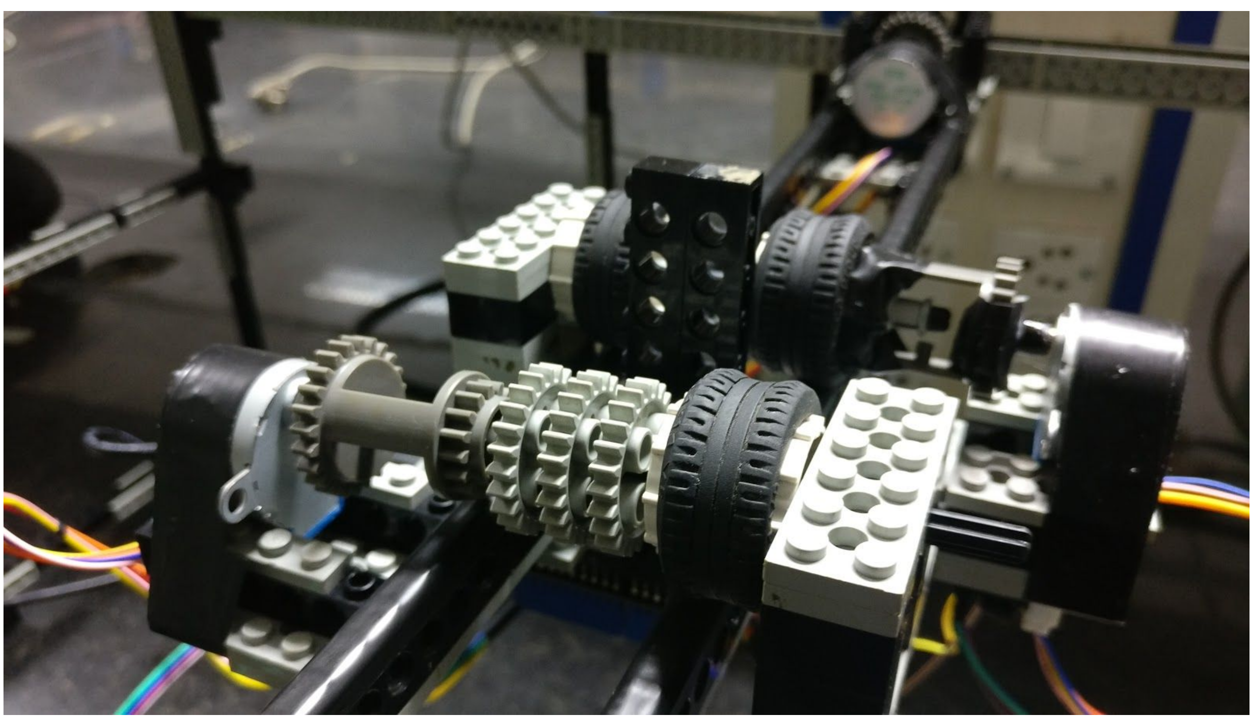
   To protect against going off the grid, we've used stopper pins to send a signal when the end of the frame is reached.



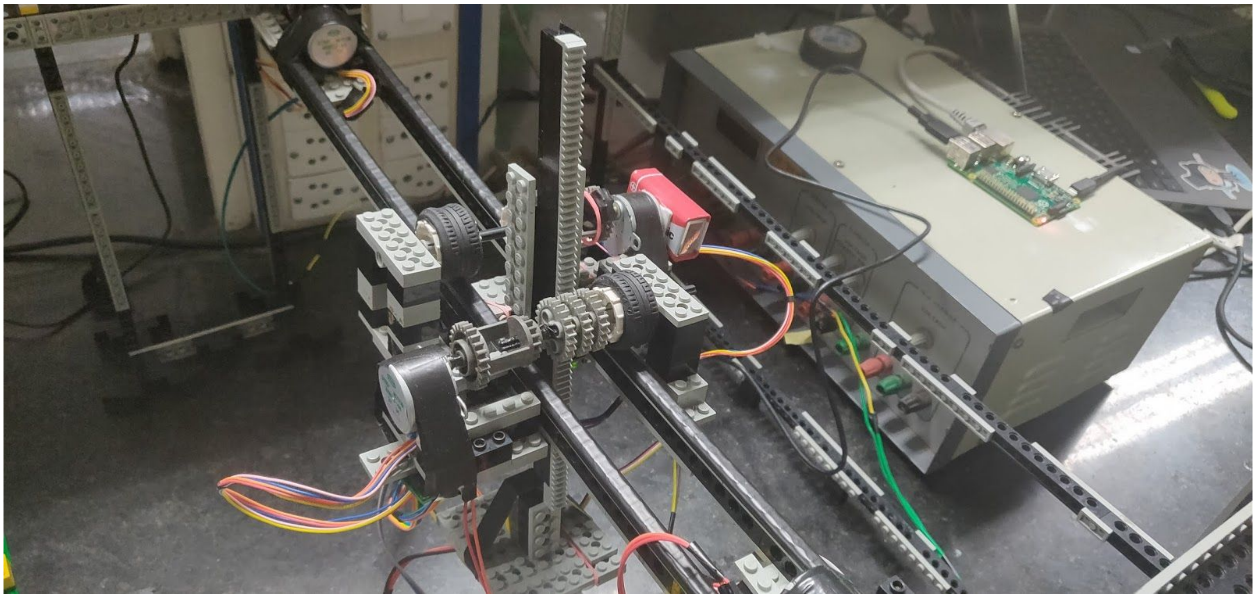
Kisaan uses stepper motors to count rotations along each of the x, y and z axes.



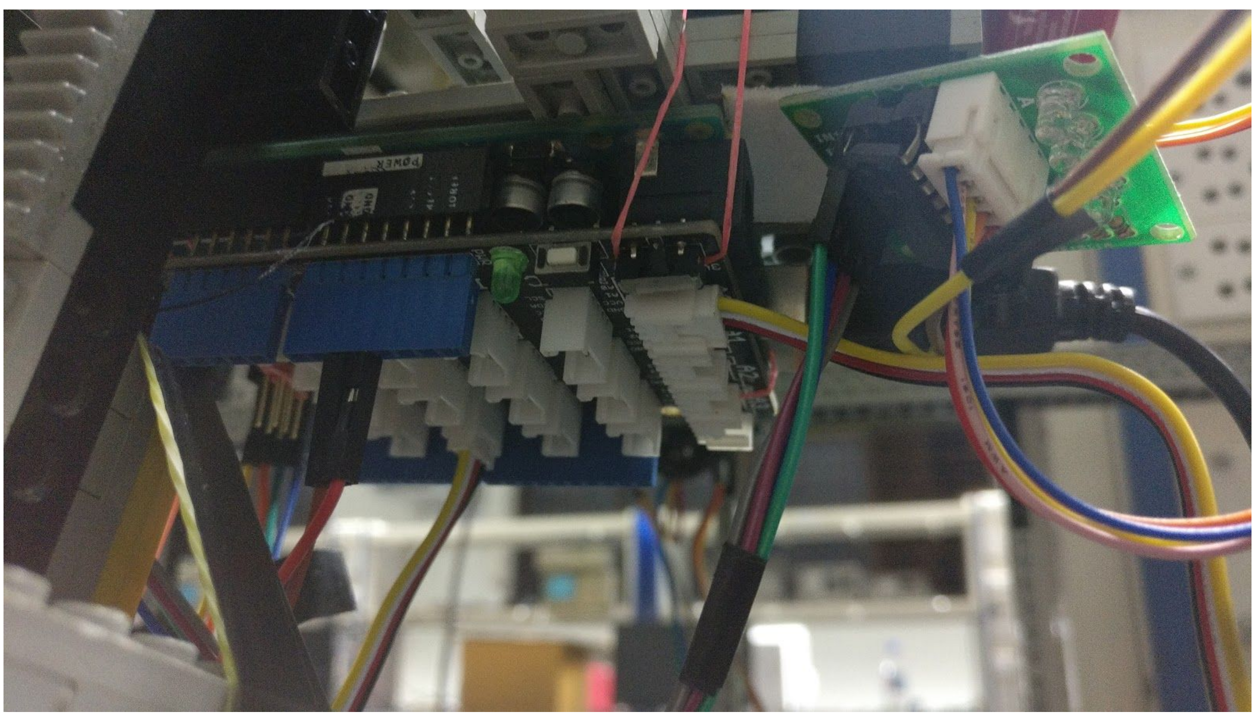
The platform that moves along the y-axis has the Arduino attached, but still manages to weigh only around a kilogram.



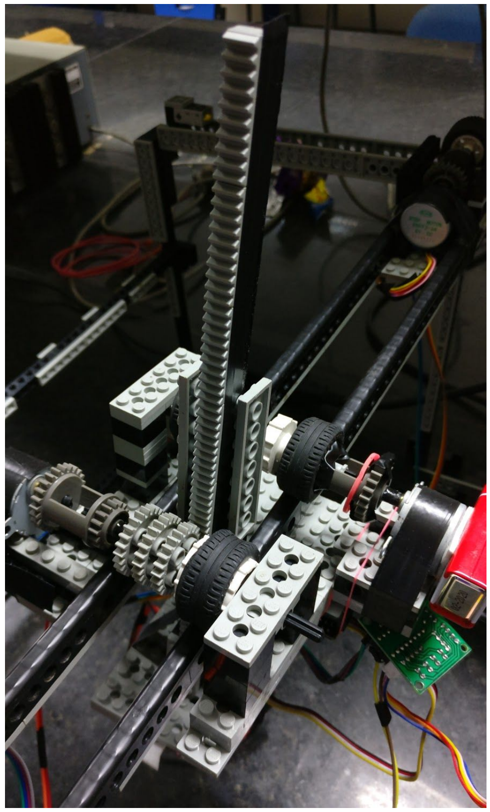
The support rods for the y-axis movement is shown below, with the platform on top.



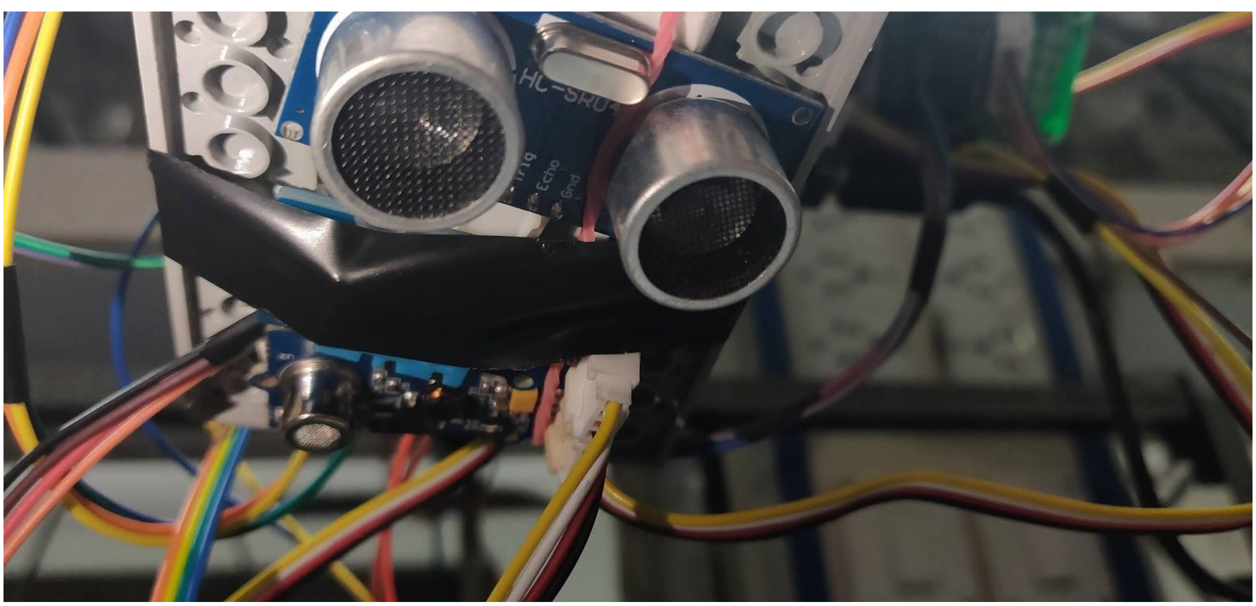
The Arduino is taped under the platform, and connects to the sensors on the probe.



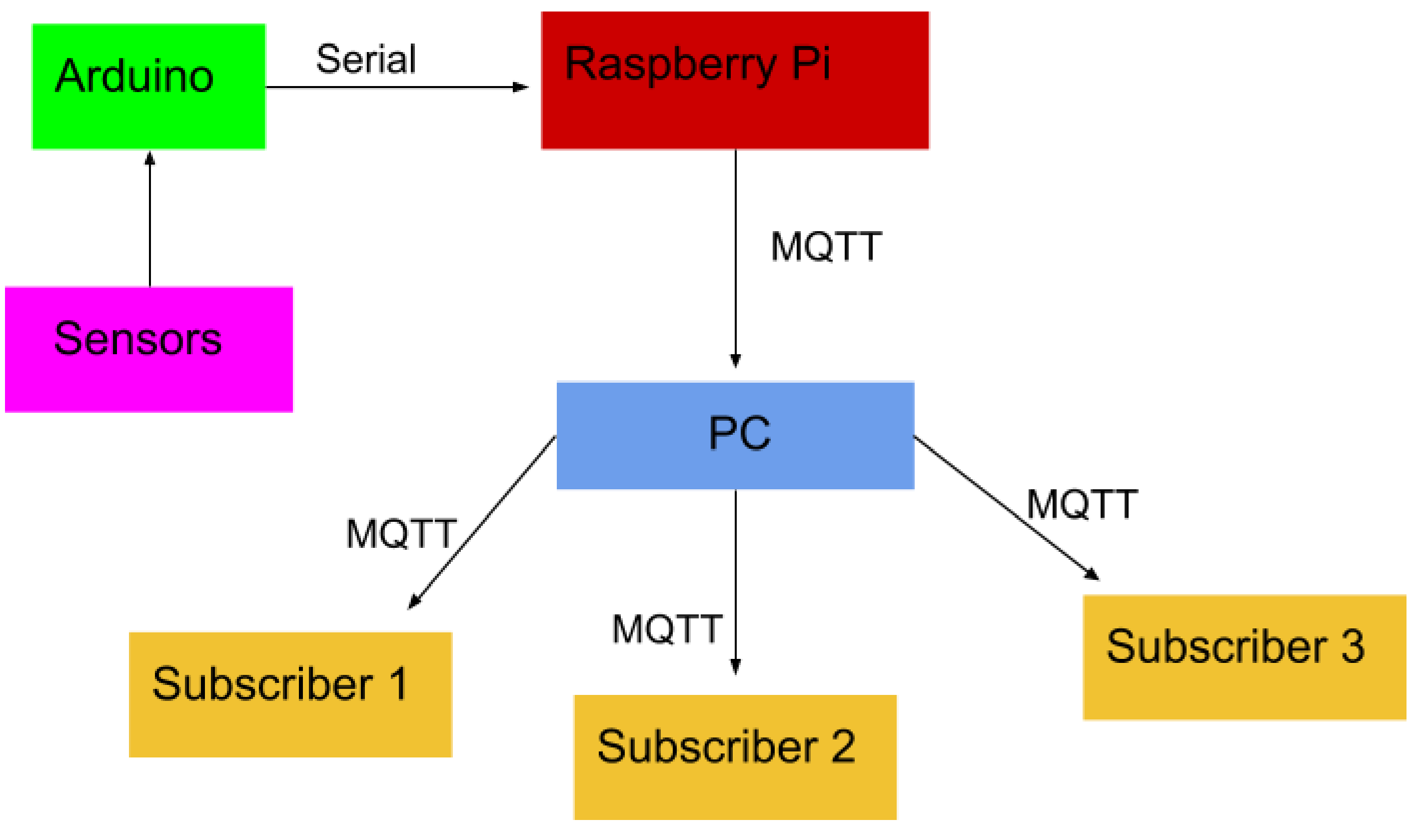
The probe with sensors moves downwards utilizing a rack-and-pinion mechanism.



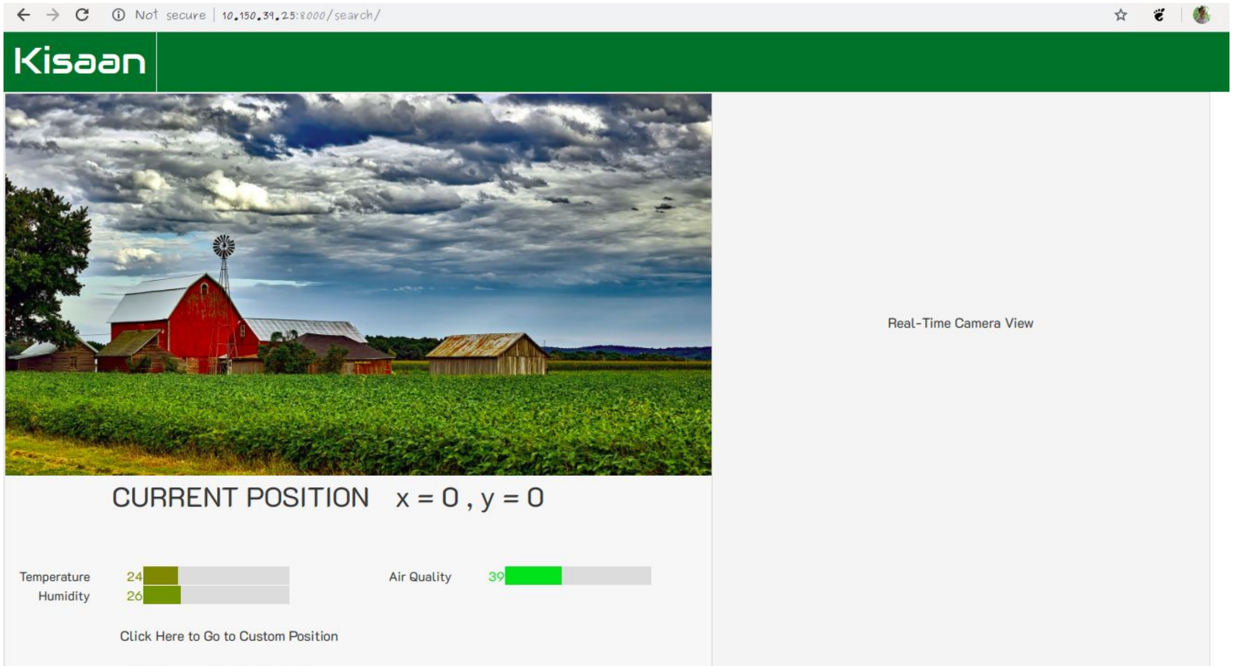
At the bottom of the probe is a UV ping sensor to prevent it from hitting anything while descending.

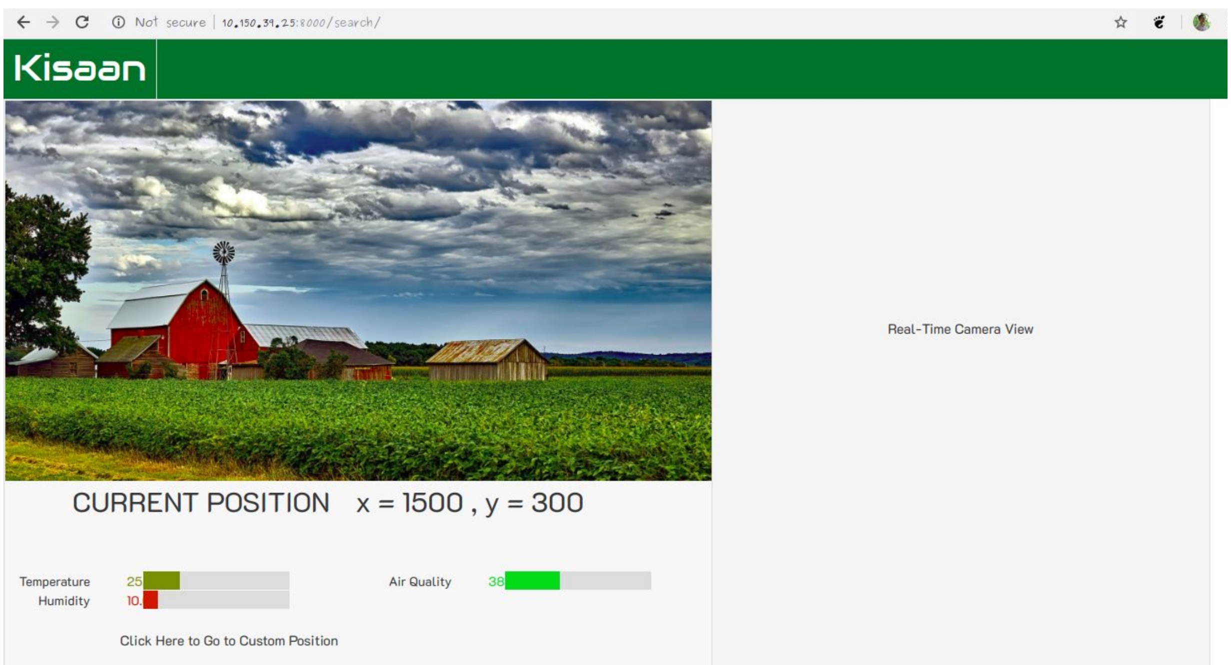


All sensor readings are transmitted by the Arduino, forwarded serially to the Raspberry Pi, and this sends it further to the PC using the MQTT protocol from where it is again published using MQTT under the topic **broker_data** on the local network. Because of issues with the proxy, this doesn't work on the IITG_WIFI network; a mobile hotspot has to be used.



Data Flow Diagram





The web portal indicating the temperature, humidity and air quality readings after moving to a specified location.

6. Hardcoded Values

- The size of the grid on which the robot moves was calibrated according to wheel size and motor rotation.
- The step values in the automatic traversal are also fixed.
- The threshold distance upto which the probe descends has been hardcoded to a particular distance found by trial and error.
- The time for which the probe remains down has also been hardcoded.

7. Cost Analysis

Greenhouses

Kisaan is better suited for greenhouses, where the dimensions are not as large as traditional farms, and where existing infrastructure can be reinforced to be used as support rods. The average greenhouse is around 50 square metres in area. Assuming dimensions as approximately 8 metres x 8 metres, the cost of a frame is only Rs. 2,560 using existing motors.
This cost is an overestimate as it does not consider the possibility of using existing structures in the greenhouse.
The stepper motors of the required power will cost Rs. 2000, individually [7].
The electricity costs were measured by scaling the power our model used and multiplying by the standard electricity rates of Rs. 5 per kWh.
An estimate of electricity costs is at Rs. 1,000 per month.
The initial cost to implement Kisaan in a greenhouse is approximately Rs. 11,000.

Farms

The average Indian farm is a hectare in size, according to government surveys [3].
Our current system cannot be implemented directly in a farm of this size, because of the physical constraints on the material as well as the power required by the motor.
However, Kisaan can be implemented in traditional farms by dividing it into smaller pieces of dimensions approximately 10 metres x 10 metres. Kisaan can then be deployed wherever it is required the most, making it ideal from the point of precision agriculture.

8. Comparison with Commercial Products

As discussed in agrotech articles such as [4], there is a need for systems that can perform ‘Real-Time Monitoring and Analysis’. Drones are mentioned as an example. However, the article mentions that the cost of usual drones used is around $25,000 (which is approximately Rs.18,00,000) which is astronomically more expensive than Kisaan, even when implemented on a full-size farm.
Some commercial products [9] involve burying sensors at positions across the farmland. While such sensors may be able to collect more data about soil characteristics, above-soil factors (humidity and temperature) which most of the plant body is exposed to, will not vary too much from soil level to 2-3 feet above the soil.

For greenhouses specifically, the article here [6] describes several temperature and humidity monitoring systems, such as Growlink System and Growtronix, costing approximately $900 (or Rs. 63,000). However, unlike Kisaan, these systems are essentially static and do not have any mechanisms to measure local conditions, and hence cannot be used for precision agriculture. Kisaan lacks some of the precise sensing capabilities that these systems have, but is also only a sixth of the price.

9. Assumptions and Limitations of the Design

- Over large farms, a structure has to be made with aluminium profiles - to maintain strength as well as to avoid bend in the tracks. We've used LEGO bricks here for our model because of the strength they provide considering their low weight, but this will not scale.
- The recovery process can be made more robust by installing colored checkpoints on the platform and using an IR sensor to detect them.
- We have used only the humidity, temperature and air quality sensors. Commercial products as discussed above use light sensors, cameras and soil moisture sensors.
- Our current model can only be used with crops that grow above the ground.
- Kisaan does not touch the soil, hence obtaining soil moisture is impossible. For water-intensive crops such as rice and cotton, for which soil moisture is valuable data, this reduces the effectiveness of the system.
- The height to which the farmer wants Kisaan to descend down to must be set manually. The ping sensor might not always pick up obstructions while moving downwards if they are thin enough.
- The current model has only one ping sensor. If moving obstructions are present, the probe might not detect these and hit them.

Kisaan could be improved in the future according to the limitations above.
Other improvements include:

- A camera to take pictures of soil and crops. This would enable a wide range of features - such as using computer vision techniques to identify plant diseases [8] and QR codes placed at soil level to perform specific actions at specific locations.
- Connections to the irrigation system - according to local conditions, we could start irrigating plants.
- Faster motor movements - our current system takes time to move from one position to another.
- A stronger, more precise platform to place fertilizers and seeds at specified locations.

Despite all of these limitations, we believe that the cost-effective, end-to-end system that Kisaan is, has a place in any modern farm.

10. References

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