Reason

In agriculture, many farmers use the same treatment (for example watering or fertilizing) for large areas of crops, which may consist of several acres. This results in:

- The overuse of water
- The overuse of resources like fertilizer
  - Resources are not very inexpensive
- Nitrogen runoff caused by excess fertilizer
  - Raises the possibility of water contamination

Reason

Even for the farmers who check each section of their fields and administer resources accordingly, the task is extremely tedious and repetitive, taking several hours or days. They need to:

1. Take samples of each section
2. Send the samples to a lab
3. Wait for an analysis
4. Use the analysis data to take the appropriate measures

In addition, sending it to a lab costs farmers as much as **$600 every season**.

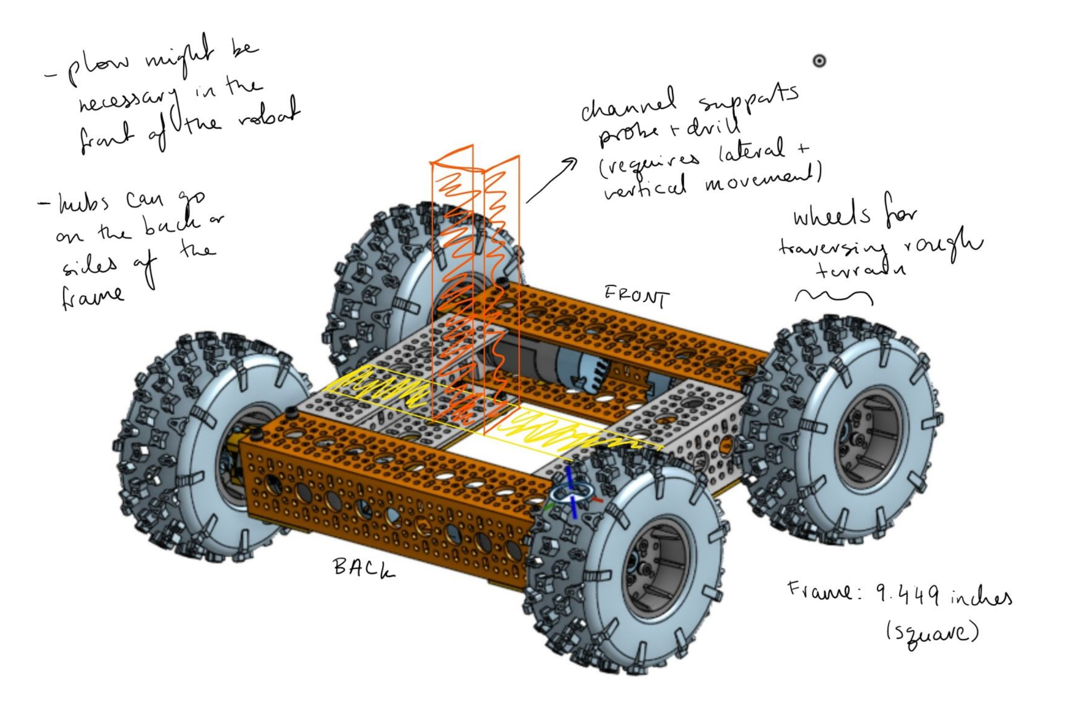
Reason

While several innovative techniques are being explored including the use of robotics, drones, and hand-held devices, the mechanisms are quite large and expensive. Small- and medium- sized farmers, who make up about **80% (USDA) of the farming population** and **50% of the industry**, cannot afford to use these solutions; <u>they are simply not designed for their category of farms</u>.

Research

- Referenced online research papers and projects related to **precision agriculture**
    - In particular, the RAPID project by UC Professors Carpin, Goldberg, and Vougioukas
    - Reached out to Professor Stefano Carpin of UC Merced
    - Held a video conference call to ask the professor questions concerning his project
- Visited a local farm to understand the process involved in farming
    - Learned about NPK (**Nitrogen, Phosphorus, Potassium**) concentration
    - Discussed crop spacing, types of crops, seasonality, etc.
- Reached out to Princeton and Rutgers University professors to learn more about agriculture

Design - CAD



1. Basic chassis
2. Compact base to easily navigate through rows
3. Large wheels to allow traction on rough terrain
4. 4-wheel drive to aid movement

Design - Control Systems

1. Considered using REV Control Hubs (similar to those used in FIRST events)
    - Looked at alternatives due to lack of cost-efficiency
2. Looked at Arduinos and Raspberry Pi
    - More cost-efficient and powerful (more operations can be performed)
3. Settled on Raspberry Pi
    - GoBilda motors, servos, and battery were connected using Dupont cables
    - Connected a camera to get readings
    - Connected a touch screen interface that would allow a farmer to select a configuration

Design - Sensor

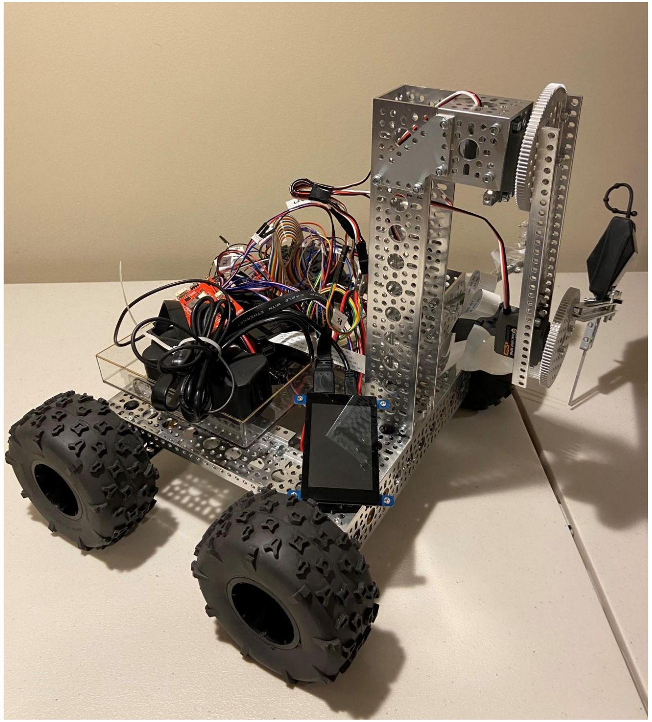
- Looked for sensors available online that would analyze soil for NPK
  - No cost-efficient alternatives
- Considered separate sensors for N, P, and K each
- Found a sensor that could be toggled between four modes:
  - Light
  - Fertility
  - Moisture
  - pH
- Mainly focused on Moisture and Fertility → encompasses NPK and water

Design - Algorithm

1. The robot uses a set of pre-entered points based on farm dimensions to plot a path
2. The farmer selects a mode (either moisture or fertility) depending on what they want the robot to test for
3. After the robot initializes, it drives to each of the points, lowers its arm (which carries the sensor), and tests the soil
4. The camera is activated and the picture is stored, along with the information of what point and what mode
5. On the robot's return, the farmer is able to access the pictures the robot took of the sensor at the points

Results

1. 4-wheel drive
2. Control system centered around Raspberry Pi
3. Thick tires to increase elevation
4. Breadboard to keep wires organized
5. Program generates a report for the farmer to view upon the robot's return



Farm soil fertility and moisture report

Date	Time	Test	Result
2022-02-18	1927	F	reports/2022-02-18/1927-F-image_0_0.jpg
			reports/2022-02-18/1927-F-image_0_0.1.jpg
			reports/2022-02-18/1927-F-image_0.1_0.jpg
			reports/2022-02-18/1927-F-image_0.1_0.1.jpg
	1911	F	reports/2022-02-18/1911-F-image_0_0.jpg
			reports/2022-02-18/1911-F-image_0_0.1.jpg
			reports/2022-02-18/1911-F-image_0.1_0.jpg
			reports/2022-02-18/1911-F-image_0.1_0.1.jpg
	1834	F	reports/2022-02-18/1834-F-image_0_0.jpg
			reports/2022-02-18/1834-F-image_0_0.1.jpg
			reports/2022-02-18/1834-F-image_0.1_0.jpg
			reports/2022-02-18/1834-F-image_0.1_0.1.jpg
2022-02-17	1902	F	reports/2022-02-17/1902-F-image_0_0.jpg
	1900	F	reports/2022-02-17/1900-F-image_0_0.jpg
	1727	F	reports/2022-02-17/1727-F-image_0_0.jpg
			reports/2022-02-17/1727-F-image_0_0.1.jpg
			reports/2022-02-17/1727-F-image_0.1_0.jpg
			reports/2022-02-17/1727-F-image_0.1_0.1.jpg
	1705	F	reports/2022-02-17/1705-F-image_0_0.jpg
			reports/2022-02-17/1705-F-image_0_0.1.jpg
			reports/2022-02-17/1705-F-image_0.1_0.jpg
			reports/2022-02-17/1705-F-image_0.1_0.1.jpg
	1658	F	reports/2022-02-17/1658-F-image_0_0.jpg
			reports/2022-02-17/1658-F-image_0_0.1.jpg
			reports/2022-02-17/1658-F-image_0.1_0.jpg
			reports/2022-02-17/1658-F-image_0.1_0.1.jpg
	1652	F	reports/2022-02-17/1652-F-image_0_0.jpg
	1648	F	reports/2022-02-17/1648-F-image_0_0.jpg
			reports/2022-02-17/1648-F-image_0_0.1.jpg

Report Example

Summary

- This project aimed to create a solution capable of aiding small farmers in checking the moisture and fertility content of their crops
  - This would allow them to efficiently manage their resources, specifically water and fertilizer
- This project resulted in a robot capable of driving to pre-selected points, testing the soil at each point, taking a picture of the sensor reading at that point, and storing that point
- Through the reports generated, farmers can view a progression at any particular point over numerous tests, as well as any drastic changes in crop health

Future Work

- This solution is a minimum-viable product; based on the time constraints, the supplies available, and the resources at hand, this was the closest possible product to an actual solution
- With more resources and time, a more comprehensive solution would be possible
- A future solution could use databases or some other structure to efficiently store tens of hundreds of tests, which would quickly fill up the memory of any computer
- Another addition to the solution could help the farmer make use of the data collected by the testing, such as connecting the data to large irrigation pumps, which would allocate resources as needed
- An addition should be the use of a GPS to aid the robot's navigation