Project Title: Mechanism to Test Soil Fertility and Moisture in Small- and Family Owned-Farms

Research Plan

A. Question or Problem being addressed (Rationale)

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 and resources like fertilizer, neither of which are very cheap. In addition, nitrogen runoff caused by excess fertilizer raises the possibility of water poisoning. 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 take samples of each section, send them to a lab, wait for an analysis, and take the appropriate measures. In addition, sending it to a lab costs farmers as much as $600 every season. While several innovative techniques are being explored including the use of robotics and drones, 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; they are simply not designed for their category of farms. Hence, this project aims to do the following:

1. Build a mechanism to analyze a field for moisture and fertility.
2. The aforementioned mechanism should be small in size to ensure portability and prove cost-effective for small and family-owned farms.
3. This mechanism would be able to test each section of the field for water content and fertility as well as record data without the need for lab analysis or sample collection.

B. Goals/Expected Outcomes/Hypotheses (Research Questions)

1. What are the basic pieces of information (moisture content, nitrogen, ammonia, etc.) that are useful to a farmer that such a mechanism could be used for? Is there a seasonality to such requirements?
2. What are physical constraints in a field that should be considered while designing a mechanism?
3. What are the results that are useful to farmers for insightful decision making?
4. What is the economic aspect that should be considered while this mechanism is designed?
5. For the vectors that are shortlisted, what are the best ways to analyze on site without compromising portability, robustness of the mechanism?
6. What are the other design considerations while designing the mechanism?
    a. Robotic arm
    b. How does the mechanism move on a terrain and operate under various weather conditions
    c. Autonomous or not or both
        i. If humans, remote control (frequency, range, etc.)
        ii. If autonomous, boundaries? Obstacles? Which area has already been sampled? GPS enabled? Image recognition for detecting obstructions?
    d. How is the robot powered?
7. What are the other design considerations for sample analysis?
    a. Are there any existing sensors that can be used for this purpose?

b. What is being measured? Strength, abundance, etc.?
c. What are the possible sensory mechanisms which can be incorporated without compromising the physical aspects of the robot (vision, touch, smell, etc.)?

C. Description in detail of method or procedures

- Procedures: Detail all procedures and experimental design to be used for data collection

1. **A robot to analyze a field for moisture and soil fertility.**
   a. Contact a local farmer to schedule a site visit to gather information and data. Also contact a professor who specializes in robotics and environmental engineering to ask potential questions based on research papers on the subject and past projects that center around farm engineering.
   b. Use OnShape or some other designing tool to design various robot chassis, mechanisms, or other features of the robot.
2. **The aforementioned robot should be small in size to ensure portability and cost-effectiveness.**
   a. From the designs created in step 1, pick one that is feasible, cost-efficient, and practical.
   b. Prototype the design in step 2a, keeping in mind that this is a prototype and not a final version.
   c. Choose a design, create a part list, and order the necessary materials. <u>MAKE SURE THE DESIGN IS SUCCESSFUL PRIOR TO FINALIZING IT</u>.
3. **The robot should have sensors capable of conducting an on-site analysis. This mechanism would be able to test each section of the field as well as record data without the need for lab analysis or sample collection.**
   1. Repeat steps 1 and 2, this time designing the element sensors.
   2. Are there sensors available off-the-shelf that can be fitted to the robot? Or should they be designed bespoke?
   3. Evaluate options such as Arduino or Raspberry Pi and the components that integrate with them, such as servos, gear motors, cameras, etc..
   4. Develop the robot incrementally and iteratively to facilitate testing. If needed, return to the above steps for any possible adjustments or improvements. If it is possible, contact a farm beforehand to schedule a test on an actual setting.

Data Analysis:

- Site visit with a local farmer to learn about standard farming methods and techniques as well as to answer basic questions about the logistics of the project.
- Discussion with UC's Professor Carpin, who previously did a similar project. Read a few other research papers and gather questions to ask the professor.
- Build the robot and run several tests, cross-checking to make sure the data is accurate.

D. Bibliography: List at least five (5) major references (e.g. science journal articles, books, internet sites) from your literature review. If you plan to use vertebrate animals, one of these references must be an animal care reference.

- Choose one style and use it consistently to reference the literature used in the research plan
- Guidelines can be found in the Student Handbook

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Jain, Ira. "Smart Farms? How AI Can Solve Water Wastage." *Earth.org*, 10 Apr. 2019, earth.org/smart-farms-how-ai-can-solve-water-wastage-%EF%BB%BF/. Accessed 23 Jan. 2022.

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