Deep Tunnel Mobilization
Team 26
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Introduction

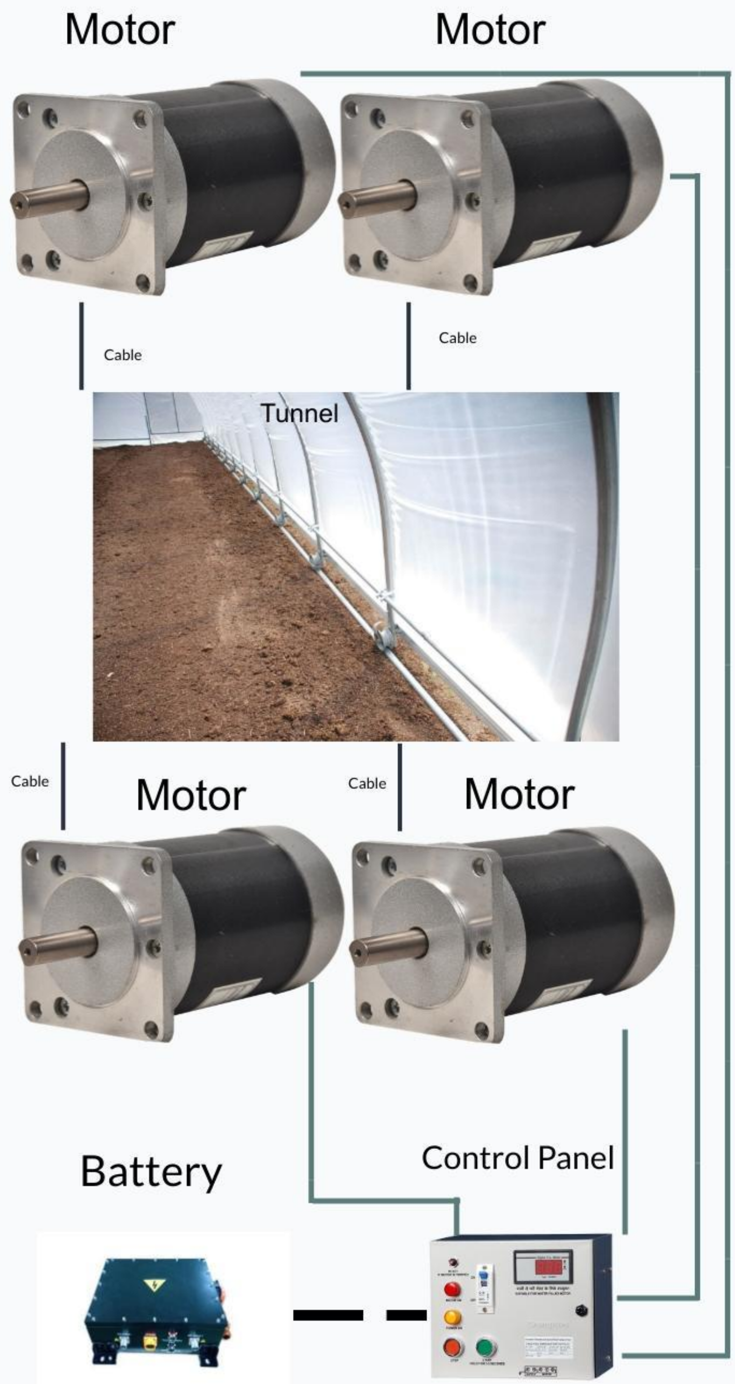
a. Problem

Late in the season, most vegetables are done for the season except some cold hardy crops. A hoop house or deep tunnel can be used to extend growing periods. A hoop house or deep tunnels, equipt with UV resistant polyethylene plastic, can be used to extend growing periods by protecting them from direct sunlight. If deep tunnels are moved, one deep tunnel can be used as an incubator for more crops in a given season than if it is not moved. Currently 10-12 volunteers are needed to move these deep tunnels at the sustainable student farms which is an inconvenience. Ideally it would only take 1-2 volunteers to move these deep tunnels so the farmers are not dependent on having a large group congregate to move the tunnels. This problem was pitched by Professor Ann Witmer during lecture.

b. Solution

We plan on using a feedback system that measures the location of a deep tunnel and controls two electric winches to pull it the fixed, appropriate distance down its track before stopping. The two winches will be fastened to the single side of the tunnel. The system will be made portable so that it can be moved and set to pull from either side of any one of the three tunnels.

Visual Aid


Motor
Motor
Cable
Cable
Tunnel
Cable
Motor
Cable
Motor
Battery
Control Panel

c. High-level Requirements

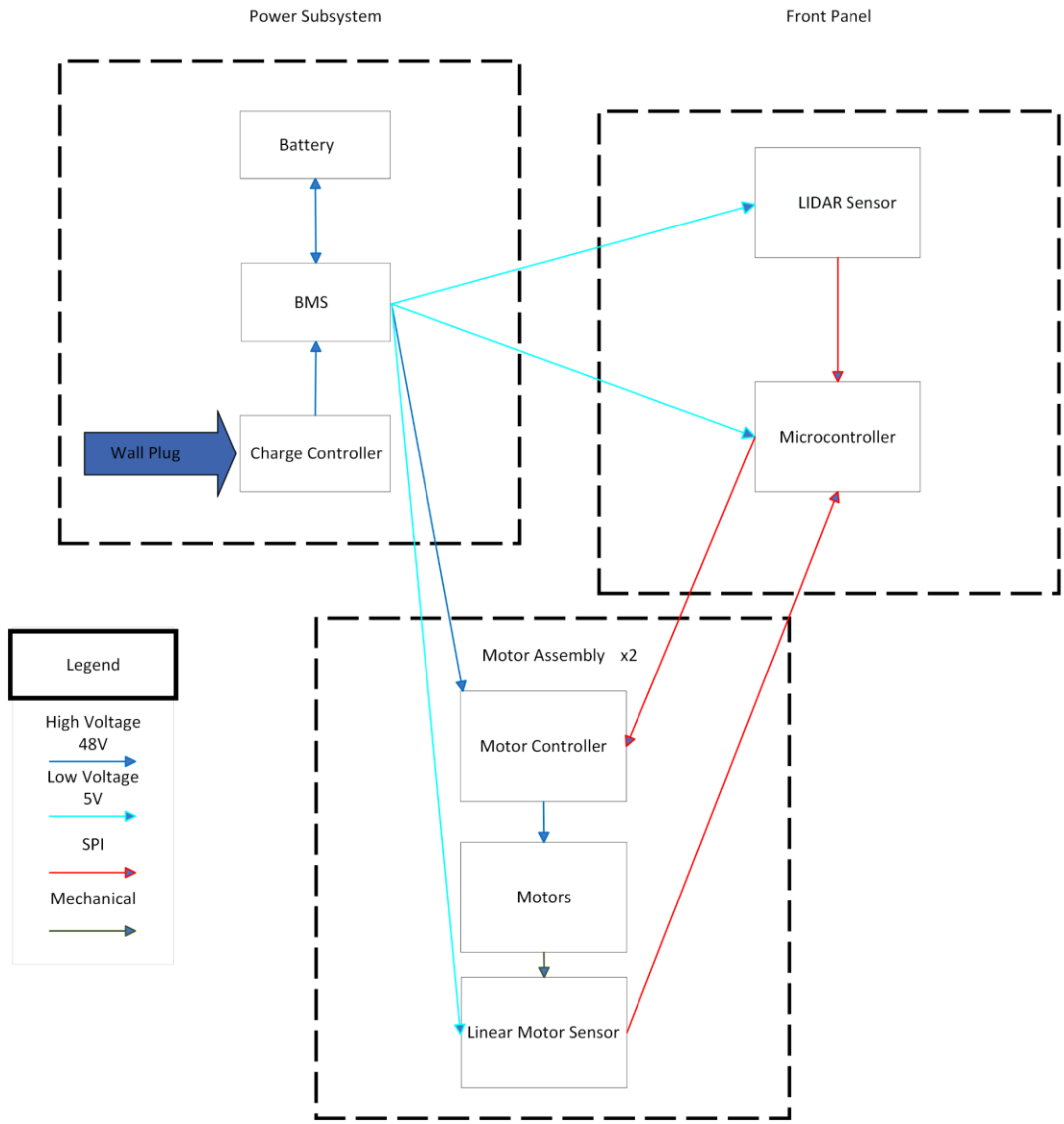
i. The tunnel is able to move by operating a switch. The speed of the tunnel is expected to be able to move around 1 or 2 miles per hour. The tunnel should have an operating temperature between -20 degrees Celsius to 40 degrees Celsius.

ii. The battery delivers power through the control panel and is able to receive charge while maintaining a temperature of 60 degrees Celsius or lower.

iii. The control panel is able to display the relevant information to the operator like the battery State of Charge, Power indicators, motor information. The control panel should be able to pull this information from the sensors at least every 3 seconds while the system is operating.

Design

d. Block Diagram



e. Subsystem Overview

i. Power subsystem

High voltage lines (48V) will run from the charge controller to the BMS and between the battery and BMS. In addition, high voltage lines will run from the BMS to the motor controller and to the motors.

Low voltage lines (5V) will run from the BMS to the LIDAR and linear motor sensors, and to the microcontroller. The low voltage lines will be used to transmit the signals from the sensors to the microcontroller.

ii. Front Panel Subsystem

The front panel is how the user operates the system. Because there is only one axis for motion, the controls will be straightforward. The motors are either on or off, which will be dictated by a switch. If the deep tunnel is at the end of the track, even if the switch is in the on position the motor will stay off. An indicator light will display whether the system is on or not. The front panel will also house the MCU.

Requirements:

- The panel takes up less than a cubic foot and weighs less than 10 pounds so that it is easily transported.

iii. Motor and Structure Subsystem.

The two motors will wind a cable to pull the tunnel down the field. Each will be connected to their respective anchor point and corner of the tunnel.

Requirements:

- The motor moves at a rate such that the tunnels are pulled 96ft, to their next position, in under 20 minutes.

iv. Battery Management Subsystem

The purpose of the BMS is to regulate and control the flow of power to the battery. This is responsible for ensuring that the battery can safely charge and discharge without overheating. The other goal is that it can safely change the voltage to the high voltage for the motors and low voltage for the sensors.

Requirements:

- The BMS can output 48V ±5% for the high voltage lines and 5V ±1% for the low voltage connections.
- The BMS can accept 48V ±5% to charge the battery

v. Battery and Charge controller

The Battery and charging system is the power source for the entire project. It has to deliver high voltage for the motor controllers as well as low voltage for the microcontroller and other sensors that make feedback control possible.

Requirements:

- The battery must be able to maintain its rated voltage within 1% while under load.
- The charger must be able to accept 110V-240V AC at 50Hz to 60Hz and output 48V ±1% for the BMS.

vi. LIDAR sensor

The LIDAR sensor senses the distance that the high tunnel is away from the front panel which is mounted at the end of the field. The power used to sense the high tunnel comes from the BMS and the data communication is over SPI to the microcontroller.

Requirements:

- Reads the correct distance of the high tunnel within 0.5 inches when the high tunnel is within 20 feet of the sensor.

vii. Microcontroller

The microcontroller is the main processing unit in the system. It is responsible for polling the sensors to have the most updated information and calculating the new value of control for the motors and the front panel.

Requirements:

- It must be able to send and receive data without any loss of information.
- Must be able to store and display the relevant system information.

viii. Motor Controller

The motor controller drives the motor and controls how much power the motor puts out based on the commands from the microcontroller.

Requirements:

- Must be able to control the motor power output within 5% of the reference that is given to the motor controller by the microcontroller.

ix. Linear Motor sensor

The linear motor sensor measures the amount of cable that has been wound around the winch. This measurement of two linear motors on either side of the high tunnel can let the microcontroller know if one side of the high tunnel is closer than the other.

Requirements:

- Must be able to measure the amount of the cable that has been wound up within 1 inch.

Tolerance Analysis

There are concerns about maintaining the structural integrity of the deep tunnels. If too much strain is applied in the wrong fashion, the tunnel could be compromised. Having the two winches oriented so that the force of the rope pulls the tunnel strictly in the direction of motion is optimal over permitting some pulling force in the direction perpendicular to the direction of motion the tunnels will take not only from an efficiency standpoint but as a preventative measure for the tolerance of the structure. The trade off is that if the motors are not operating synchronously so that the left side is not being pulled the same as the right we risk breaking a deep tunnel. We believe that pulling unevenly will contort the tunnel in a manner it is not built to tolerate.

Ethics

Considering this project is aimed to help make sustainable agriculture easier, the implementation should maintain this sustainable ethos. A portable electric power supply, instead of a combustion generator would allow for the possibility of sustainably sourced power. Energy is only one resource involved, others are rare earth metals and other materials. A design that is modular, so that one system can be applied to each of the three deep tunnels, would not only be fiscally beneficial but ethically responsible as well.

One of the goals listed in section 7.8 of the IEEE code of ethics is, “to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies.”(IEEE 7.8) The technology we are developing enables farmers to utilize the most out of their season without needing to rally or hire a large group of people to move their deep tunnels. It is important to emphasize that this convenience advances our ability as individuals to produce agriculture independently so that we are no longer dependent on unsustainable corporate food chains to feed us. People are becoming aware of the societal and environmental benefits of such a shift into local, owner run farms. As the code suggests, it is important to make sure that people are aware that with agricultural and technological advancements, running a farm has become more manageable and its yields will be plentiful, if people invest in tools like the one we are proposing.

Safety

As far as safety is concerned, commercial electric winches operate at usually no more than 10 feet per minute. Though this pace may require some patience, it has the benefit of making the system safer to operate. Another safety concern would be in the construction and testing of the system. Despite the fact we will try to consider all variables in preventing the deep tunnel from breaking, in the case in which it does break, it is important that no one is right next to it. Before operating no one should be on or right next to the track. A good idea would be to add a buzz sound and delay before the tunnel makes its journey down the track. We will also add a switch to kill the power going to the motors as another safety feature.

Citations and References

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[2] “High Tunnels: University of Illinois Extension,” *extension.illinois.edu*. https://extension.illinois.edu/blogs/garden-scoop/2017-11-29-high-tunnels (accessed Feb. 11, 2022).

[3] “IEEE code of ethics,” IEEE, Jun-2020. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 16-Sep-2021].

[4] K. Jacobsen, B. Wolff, and T. Coolong, “Movable High Tunnels: Opportunities and Challenges for Producers,” *Center for Crop Diversification System Profile*, Sep. 2019. https://www.uky.edu/ccd/sites/www.uky.edu.ccd/files/MovableHighTunnels-CCD-SP-15.pdf (accessed Feb. 10, 2022).

[5] “The code affirms an obligation of computing professionals to use their skills for the benefit of society.,” *Code of Ethics*, 2018. [Online]. Available: https://www.acm.org/code-of-ethics.