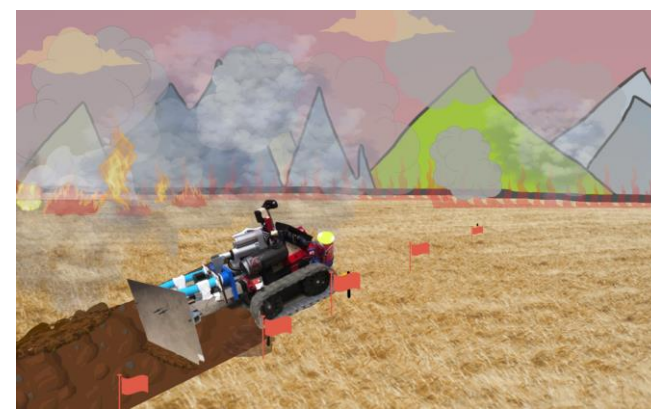




Abstract

With the increasing severity of wildfires across the western United States, robots can fill the gap in manpower needed to combat these fires. Our focus was to design and build a robot to help alleviate this lack of manpower in the Wildland Urban Interface (WUI) of California.

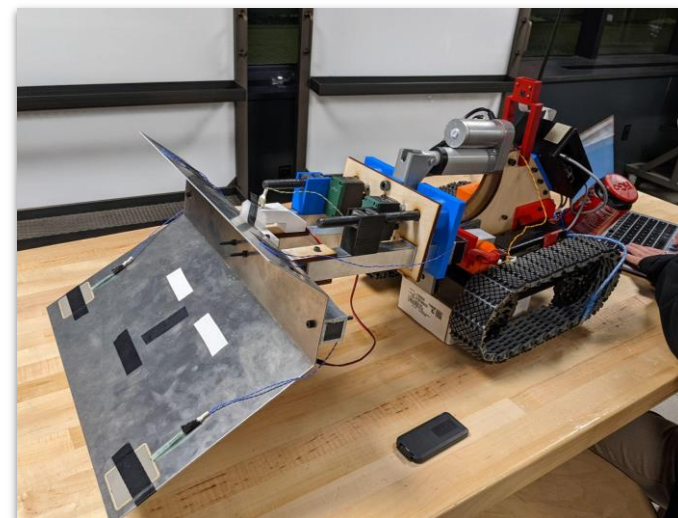


Our robot uses a plow to simulate the removal of flammable material on the ground to expose the mineral soil. We developed two subsystems to control the plow horizontally and vertically. Our robot is driven via teleoperation or by autonomously following flags. The goal of this project is to create a scaled robot that will lay the groundwork for effective autonomous indirect fireline construction.

Preliminary Study



Initial Small-Scale Zumo Prototype - "Starburst"



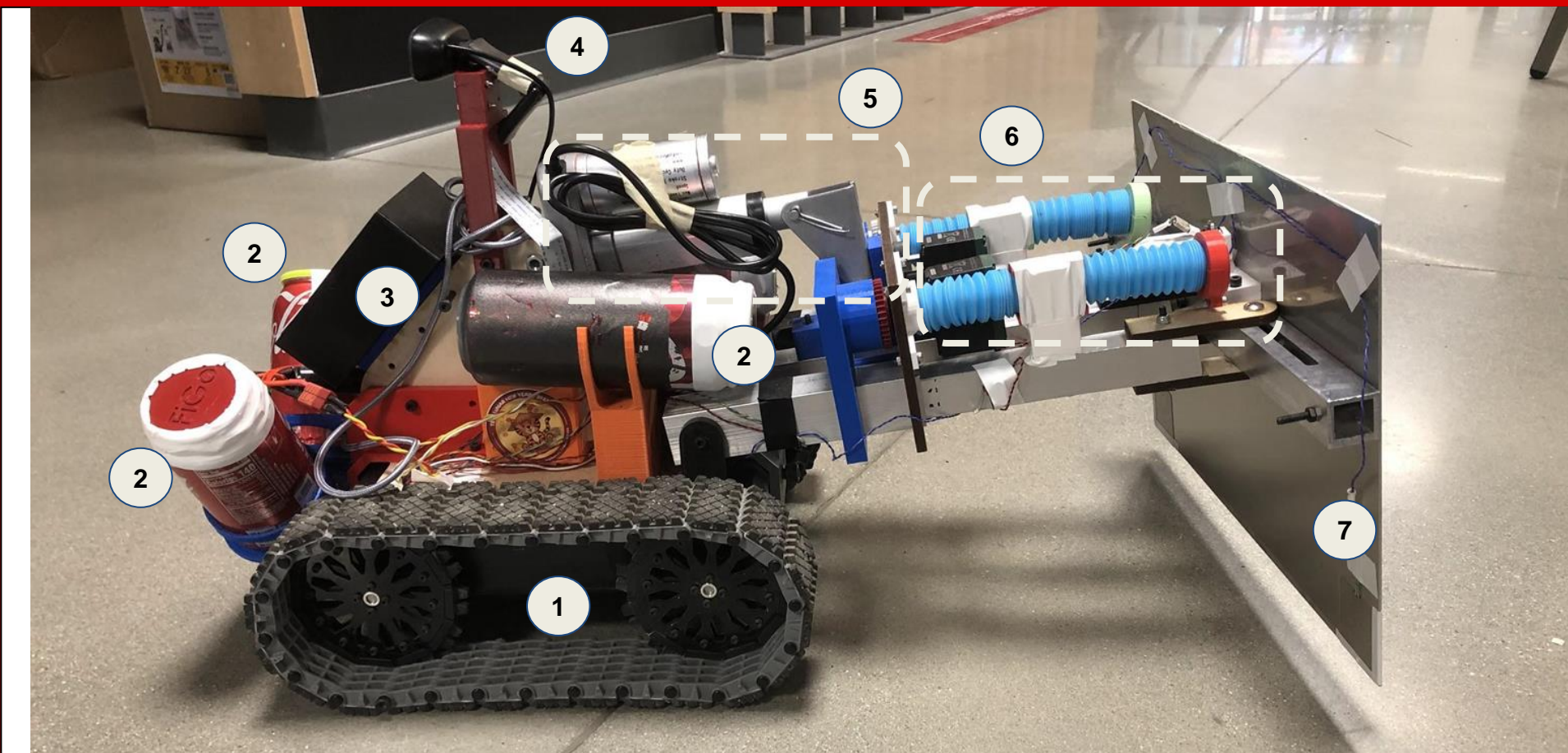
Scaled Robot Prototype - "Fire Goat (FiGo)"

We used two Zumo 34Us to conduct preliminary tests on:

- Plow design
- Locomotion on rough terrain
- Testing terrain (soil and sand)

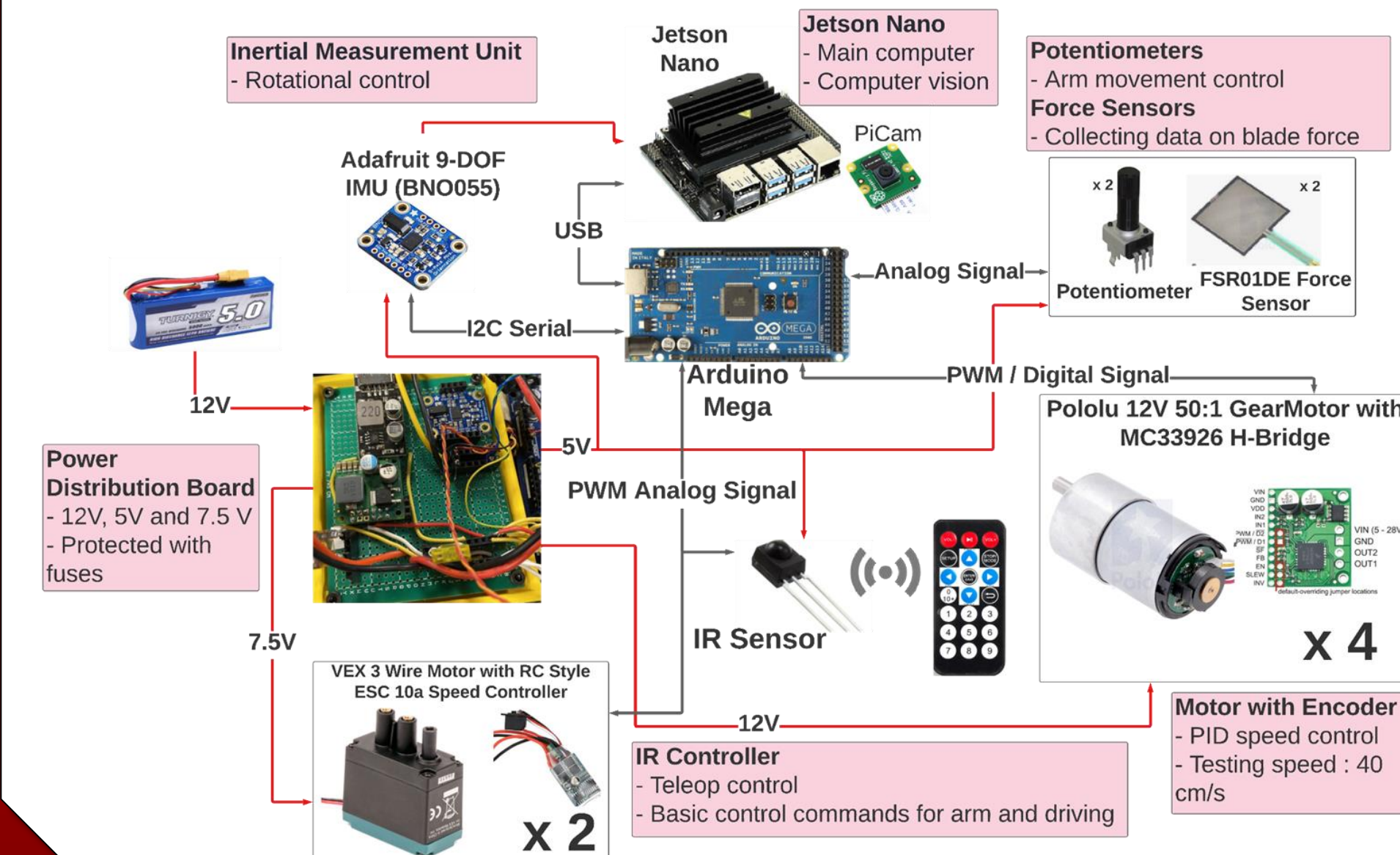
Key takeaways:

- Lead screw design confirmed in moving flow horizontally
- More effective plow mount placement for moment applied
- Added concave top curve on plow to stop overflow of sand onto robot
- Determined need for added weight due to oscillation when plowing

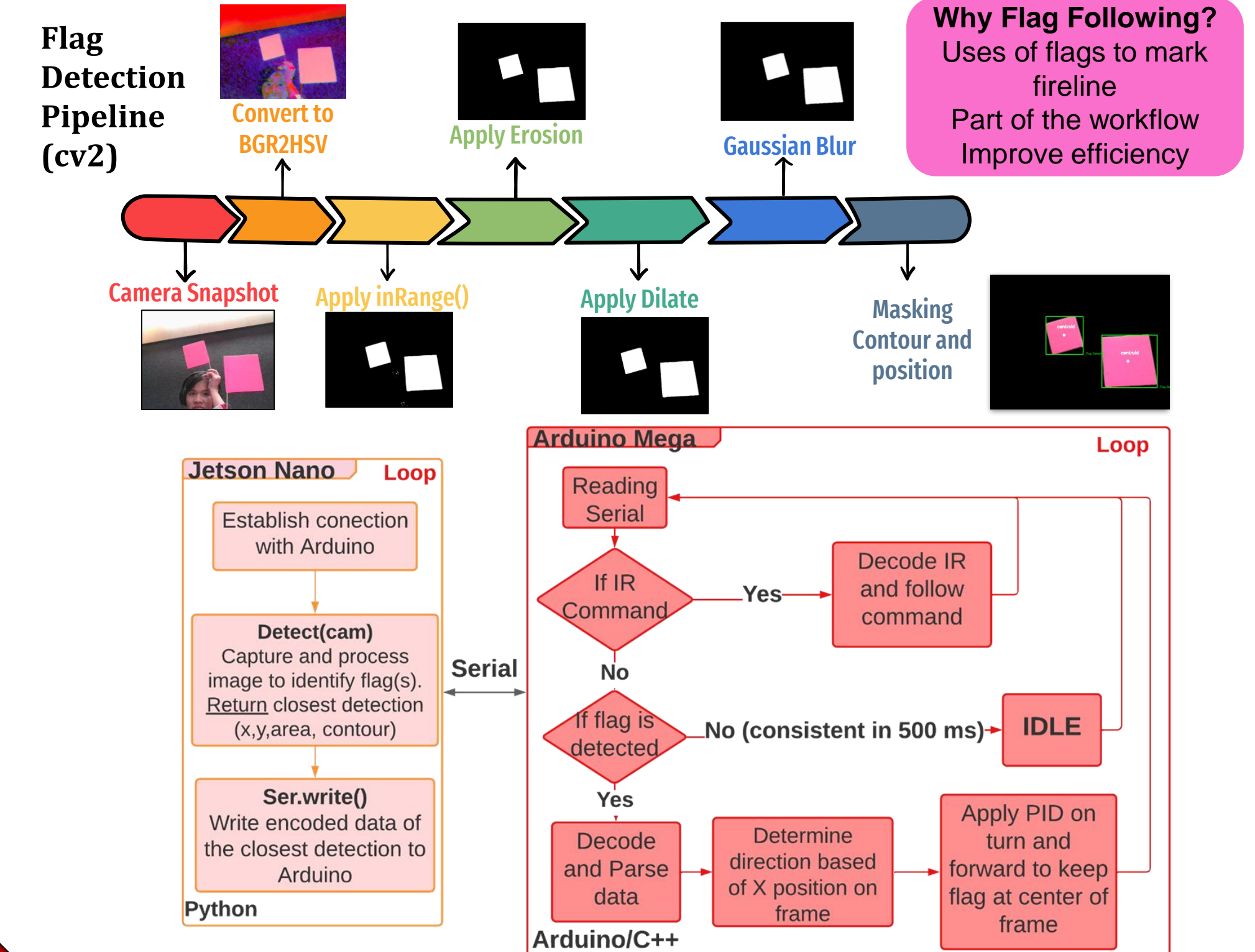


1. Chassis
2. Counterweights
3. Jetson Nano (Enclosed)
4. Camera
5. Vertical Actuation System
6. Horizontal Actuation System
7. Plow Blade

Electronics



Automation



Testing Results

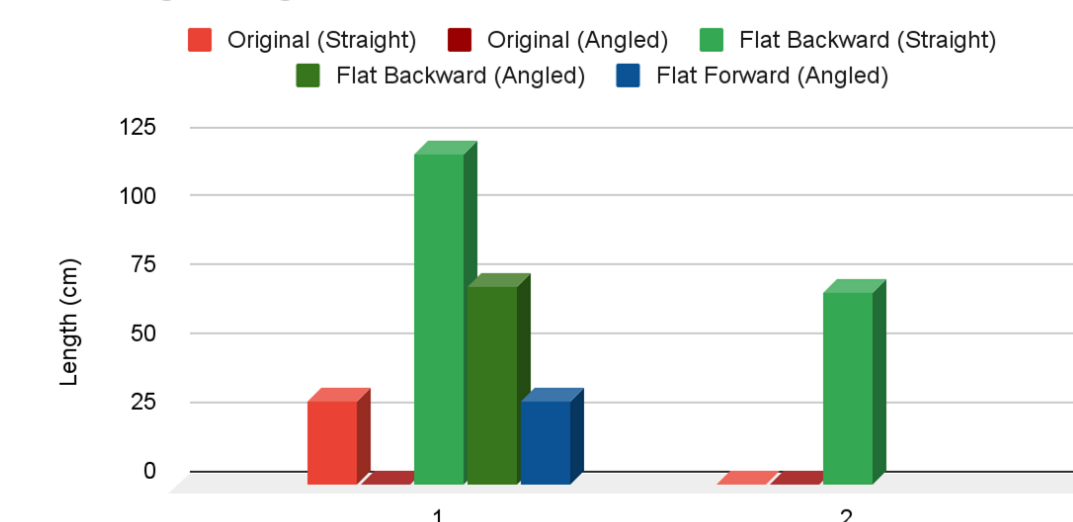
Fireline Cross-section:

- Full Scale: 100cm W x 15cm D
- FiGo: 30.5cm W x 5cm D

Original Blade Design:

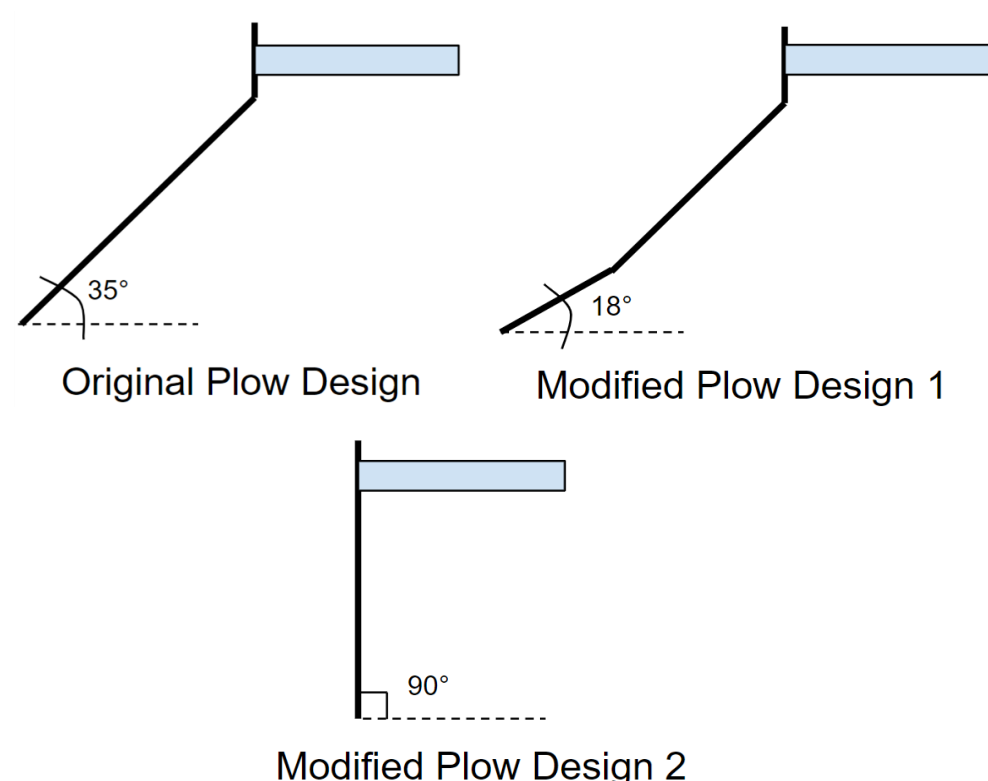
- Robot stalled often while trying to start plowing
- Electrical damage from stalls prevented by fuses
- Plow continued to dig deeper with forward motion

Average Length Plowed



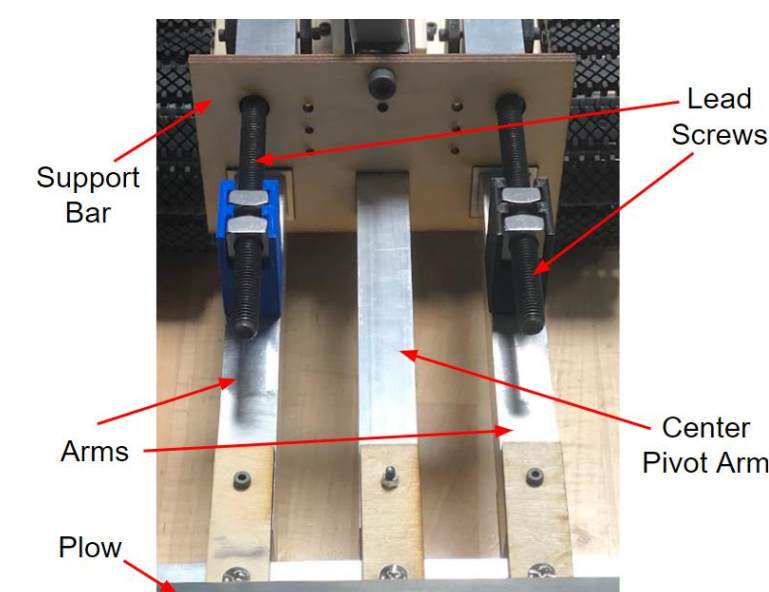
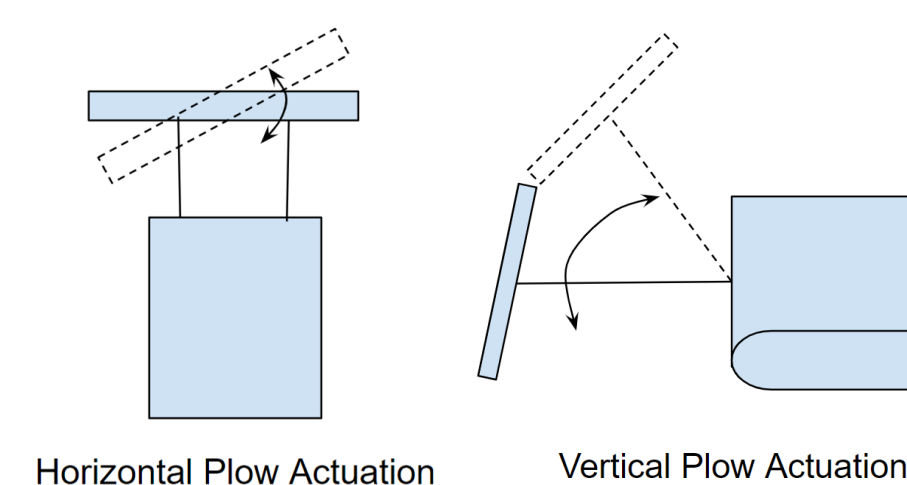
* all lengths depicted as 0 resulted from slipping or stalling

Plow Design



Plow Geometry:

- Move topsoil to a specified side of the fireline
- Adjust fireline width and depth
- Modular mounting system

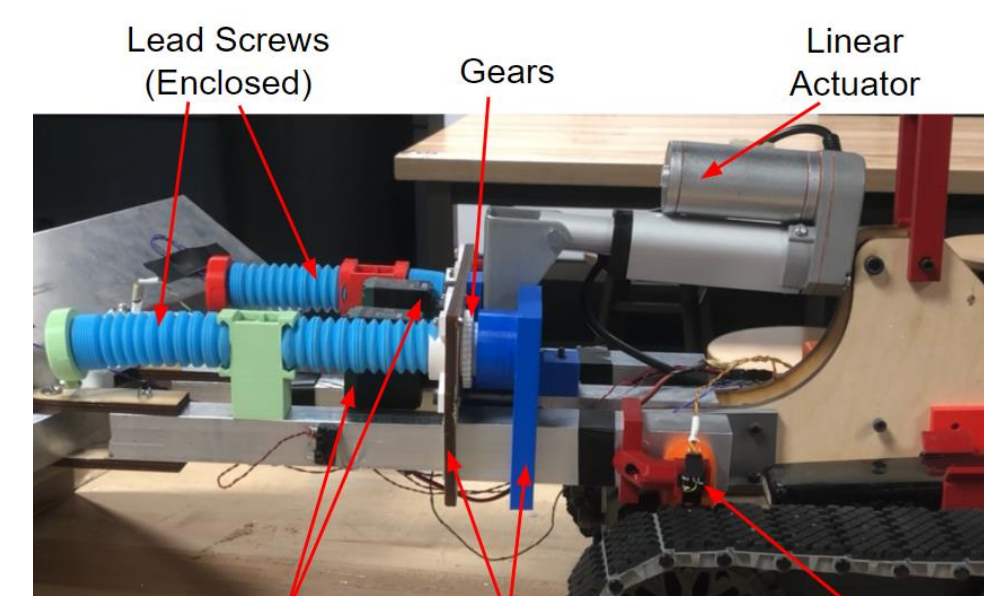


Horizontal Plow Actuation:

- Lead screw design
- Non-backdrivable

Vertical Plow Actuation:

- Linear actuator to accommodate the plow arm moving upwards and downwards
- Range of motion ± 15 degree

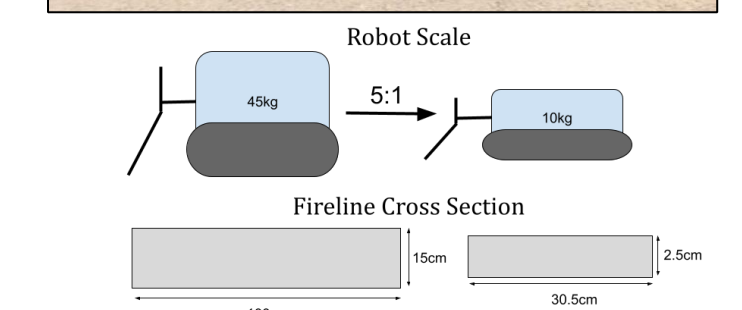
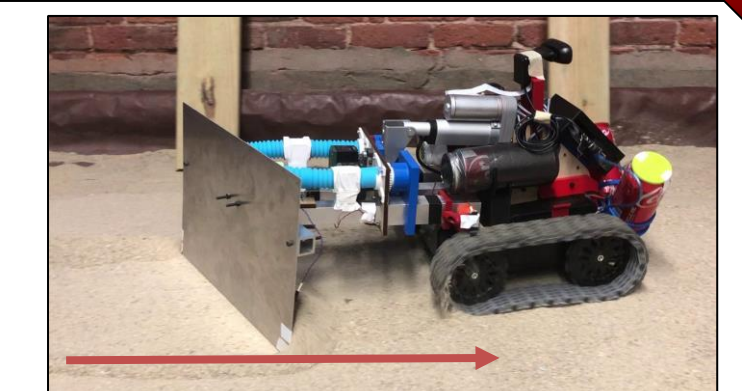


Revisions:

- Scale by robot weight (5:1) instead of robot width (3:1)
- Fireline depth reduced from 5 cm to 2.5 cm
- Flat blade design
- Towing instead of pushing



Plow Configuration	General Performance
Original Blade	Constant stalling and digging deeper during forward movement
Forward Flat Blade	Slight slipping, oscillations in fireline depth
Backward Flat Blade	Slight slipping depending on depth, constant fireline depth



Future Work

With our scaled robot, FiGo:

- Testing with different plow designs and modular front-end components (e.g. blades, mulcher, trencher, etc.)
- Navigating based on a predetermined GPS route and better vision processing
- Adaptive response based on terrain
- Expanding operation for other tasks (e.g. ash pit detection, UAVs for mapping, patrol routes, etc.)

Acknowledgements

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- Lucas Buermeyer ME/RBE '22
- FiGo & Starburst