Team D: Autonomous Nitrate Monitoring in Cornstalks

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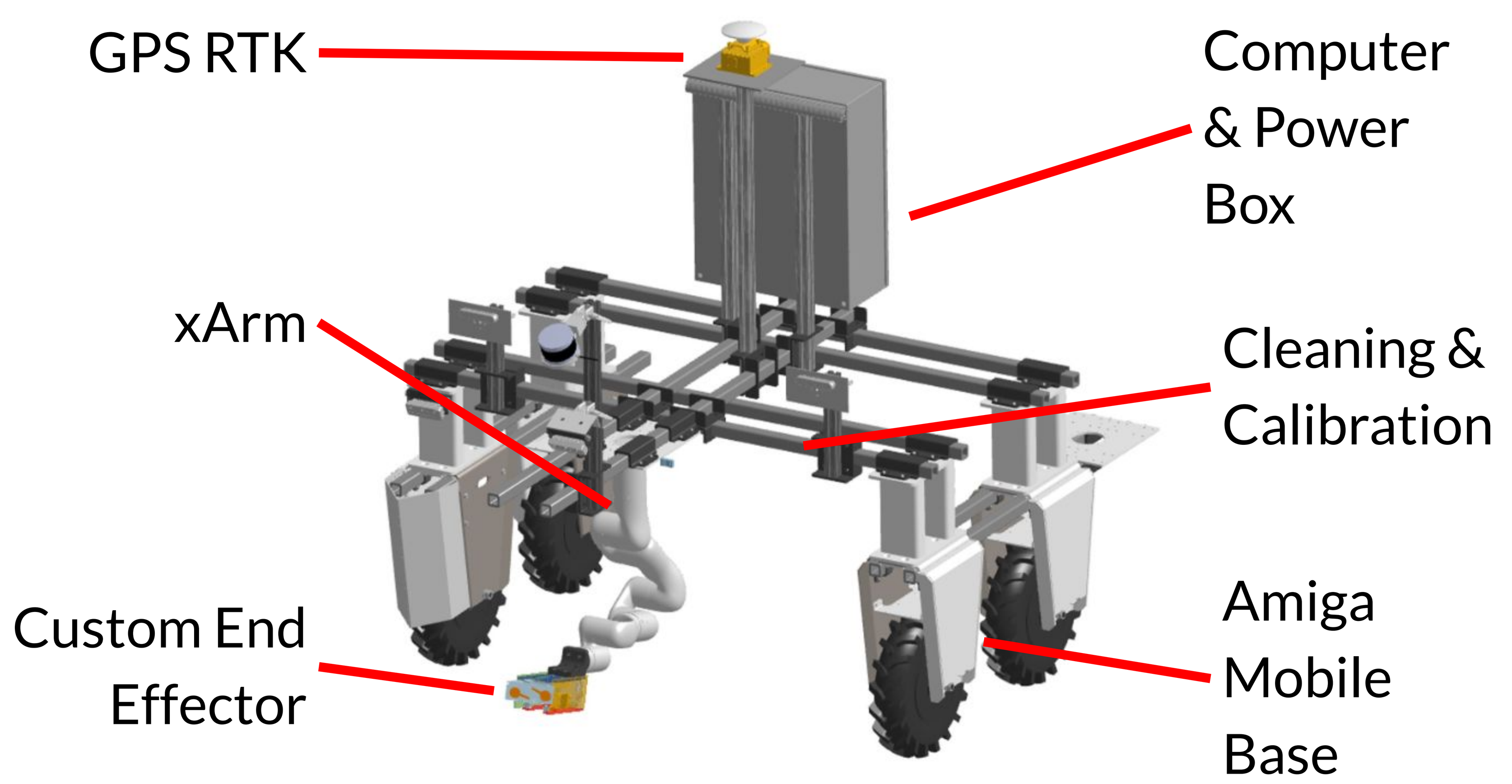
Background

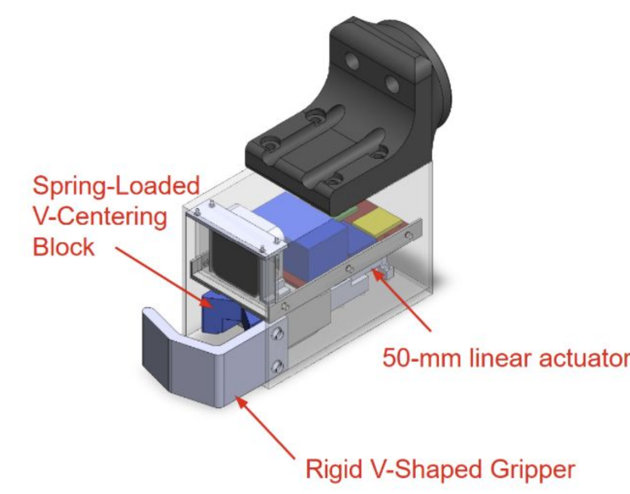
The over application of nitrogen-based fertilizer can harm animals, communities, and the environment at large. If farmers knew how many nitrates were being absorbed into their cornstalks, they could obtain the optimal amount for plant growth without harm.

We have developed an autonomous nitrate monitoring system which can be sent into a cornfield to insert a sensor within the base of a cornstalk to determine the amount of nitrates being absorbed.

Platform

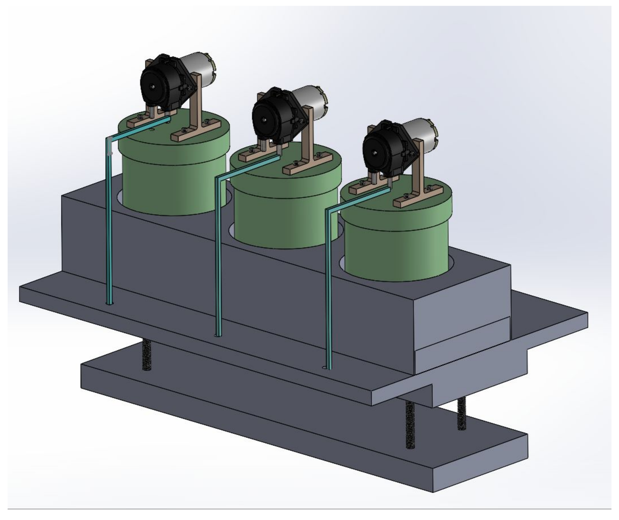


System Design



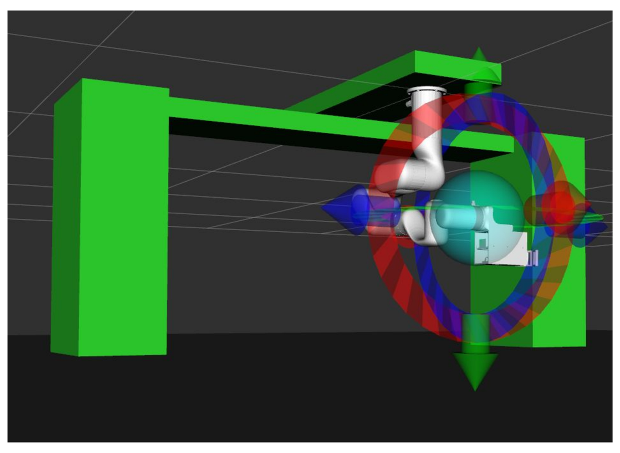
The custom NiMo **End-Effector** performs gripping of cornstalk and sensor insertion while handling niche edge cases, making it robust to different widths of cornstalks.

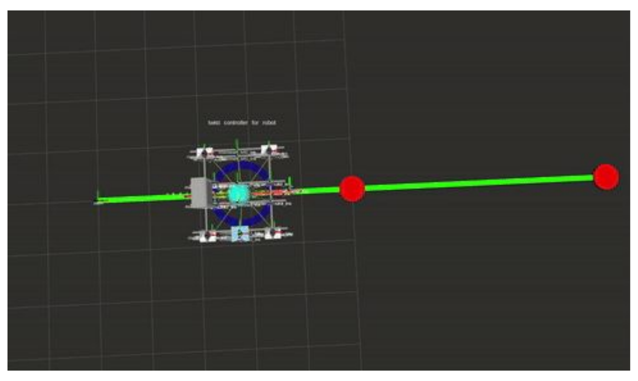
The **Cleaning and Calibration** system drips cleaning & calibration solutions onto the sensor to get accurate readings.



The **Perception** subsystem handles identification of cornstalks and width detection to find the most suitable angle of sensor insertion.

The **Motion Planning** subsystem performs the necessary movements to grip & arc around the corn. It also handles sensor cleaning & calibration.





The **Navigation** subsystem plans a path between pre-specified waypoints using model predictive control.

The **User Interface** allows the user to enter waypoints and gives feedback such as the robot location and nitrate readings.

Results

Spring + Fall Validation Demonstrations

Performance Requirement	Desired	Actual
Receive testing locations within 5 minutes	75%	100%
Maintain a lateral path error of less than 15cm over 5m	± 15 cm	± 3 cm
Reach testing locations within 2.5 m	70%	96%
Identify suitable cornstalk 50% of the time	50%	85%
Identify maximum width insertion angle 50% of the time	50%	65%
Sensor is cleaned 75% of the time	75%	95%
Calibrate the nitrate sensor 80% of the time.	80%	95%
Grip the selected cornstalk of suitable width 75% of the time.	75%	95%
Grip within 10 cm of the ground 80% of the time.	80%	95%
Insert the nitrate sensor 9mm into the cornstalk of suitable width 50% of the time.	50%	80%
Success rate of removing the nitrate sensor from the cornstalk is 90%.	90%	95%
Return nitrate readings within 5 minutes	75%	100%

Iowa State University Field Testing

Performance Requirement	Actual
Identify and localize the cornstalk	100%
Complete xArm Movements	92%

Conclusions

Over the course of 3 semesters, our team has developed an autonomous nitrate monitoring system which can measure the nitrate content of cornstalks. We validated this system in real and simulated cornfields. Our work shows an initial prototype for a system which could reduce costs for farmers while increasing the health and safety of our communities.

Acknowledgements

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