Dandelion-Picking Legged Robot

Honors Capstone, Fall 2021 Design Exposition
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Presentation Overview

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    - Overview of BigAnt Robot
- Methods for cutting a dandelion stem
- BigAnt's unconventional approach to plucking dandelions
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- Algorithmic control scheme
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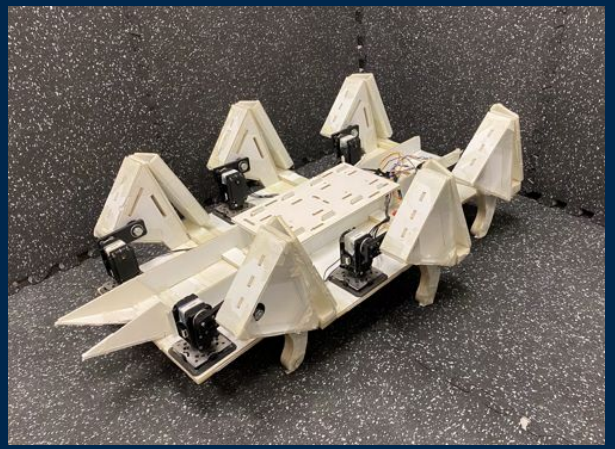
Introduction: Research Question

BIRDS lab

- Multi-legged robots achieve high stability due to spread-out posture[1]
- To explore and evaluate BigAnt robot's capabilities in a simulated agricultural environment
- How would legged robots perform in an agricultural setting?
- Dandelions were chosen as a starting point



Introduction: Brief Overview of BigAnt

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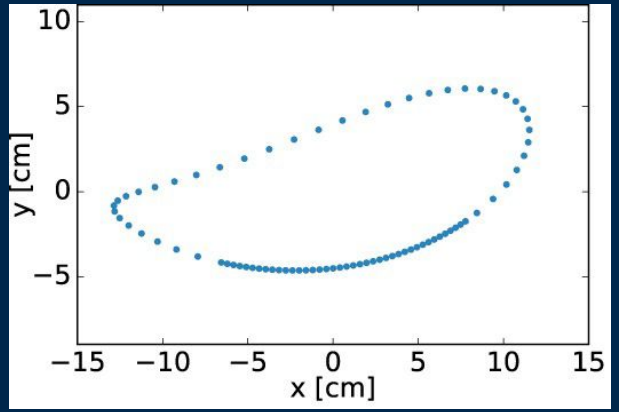
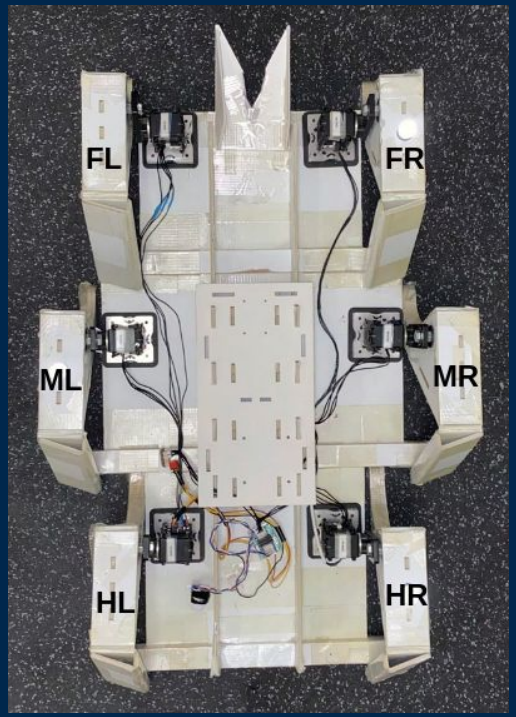
- Six-legged robot that is fabricated using Plate And Reinforced Flexures (PARF^2)
- Each leg has 1 degree of freedom (low-DoF robot)
- It moves its legs in an “alternating tripod” gait

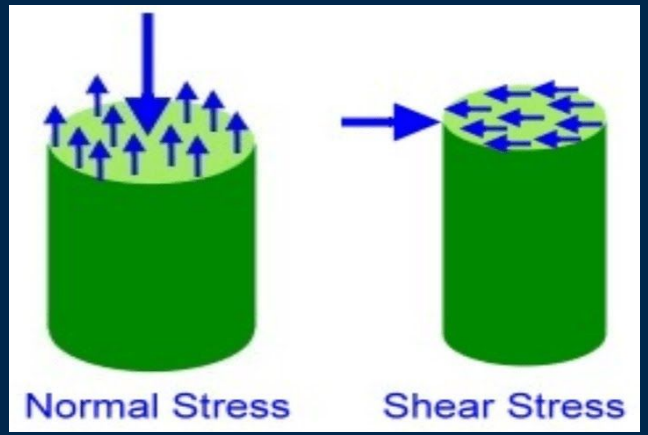




Methods for Cutting a Dandelion Stem: Chopping or Slicing?

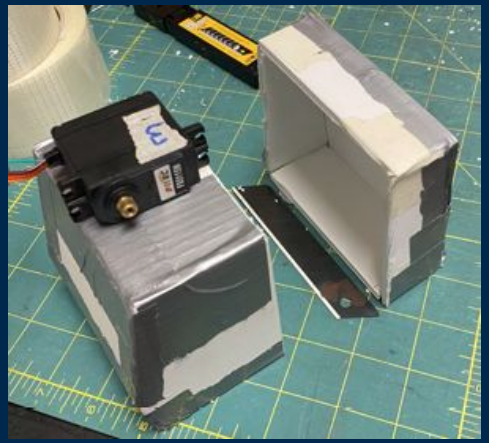
Chopping vs. Slicing a Dandelion Stem

- Chopping occurs when a normal stress is applied to the dandelion stem
- Slicing is a combination of applied normal stress and shear stress
- For soft matter such as a dandelion stem, slicing works better due to greater resistance to compressive (normal) stress



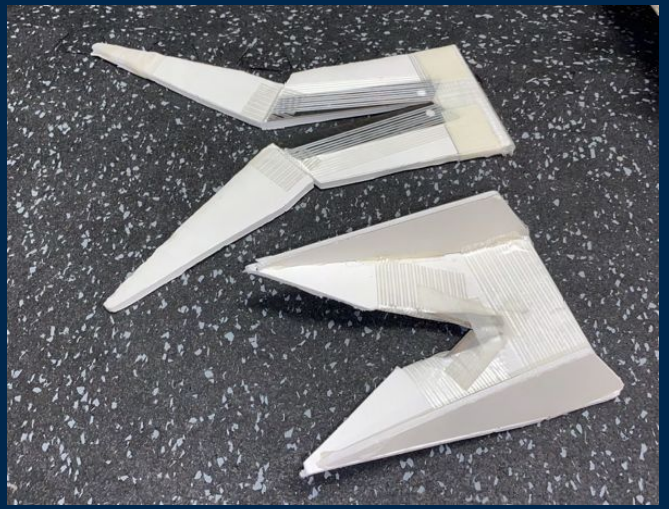
Chopping a Dandelion Stem

- A box-like enclosure was made using rapid prototyping
- Utility knife blades were attached to closing edges and a servo would be used for actuation
- To see if this was a suitable “end effector,” it was tested with dandelion stems and it failed



Slicing a Dandelion Stem

- To test slicing dandelion stems, a V-shaped cutting appendage was fabricated using rapid prototyping
- The cutting appendages were tested with real dandelions
- Dandelions were sliced consistently after a second iteration for design improvements



Slicing a Dandelion Stem

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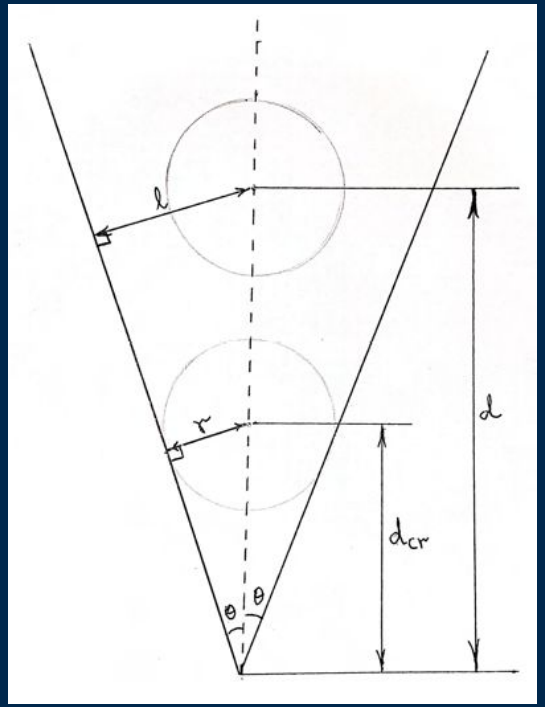

An Unconventional Approach to Picking Dandelions

Choosing a Dandelion Picking Method

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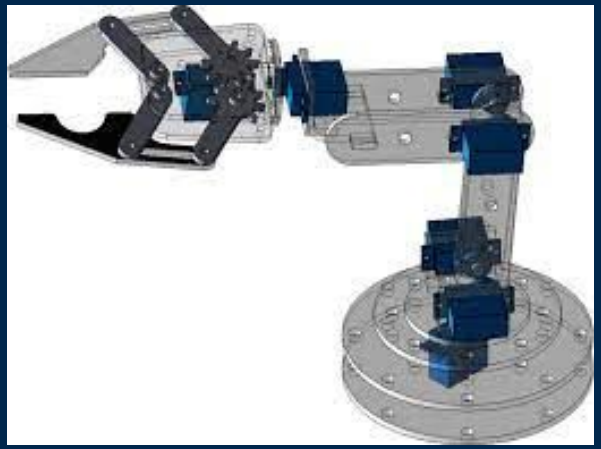
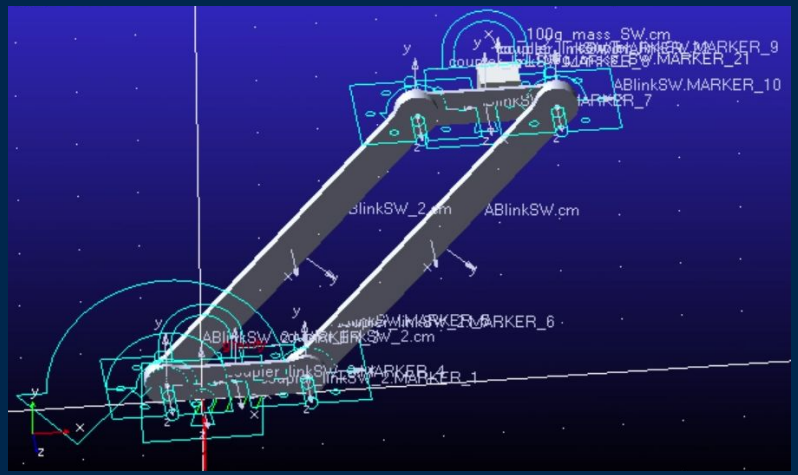
- We considered adding a robotic attachment to BigAnt's chassis
- Initial ideas for the attachment were a 4-DoF robotic arm and a 4-bar linkage
- One of the goals was to minimize the number of DoFs we add to BigAnt





Choosing a Dandelion Picking Method

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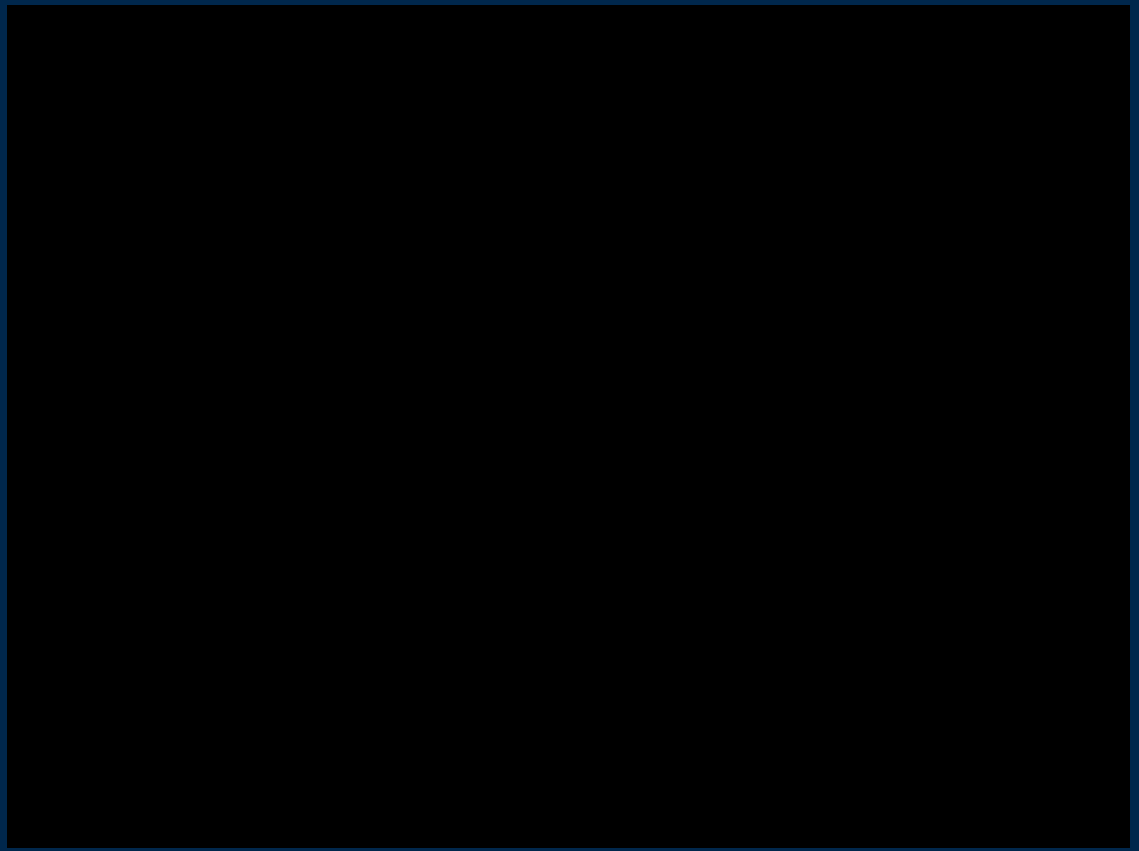
- We found a solution that involves no additional DoFs on BigAnt to pick a dandelion (uses BigAnt's 3.5 DoFs)
- BigAnt successfully moved the V-shaped cutting appendage through a concave-up trajectory ("swooping" motion)

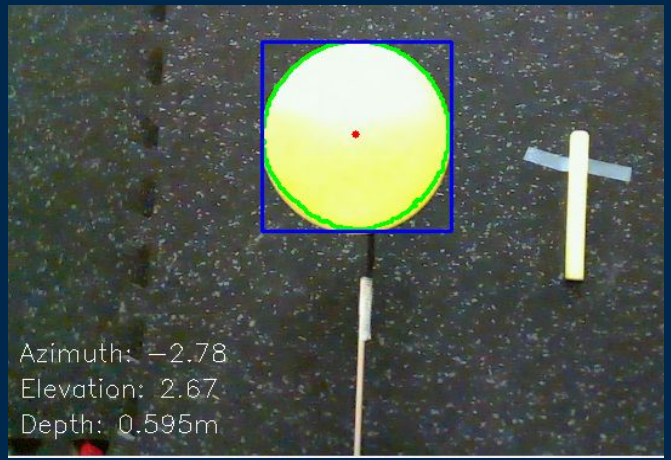
Testing the Swooping Motion



Computer Vision for Detecting Dandelions

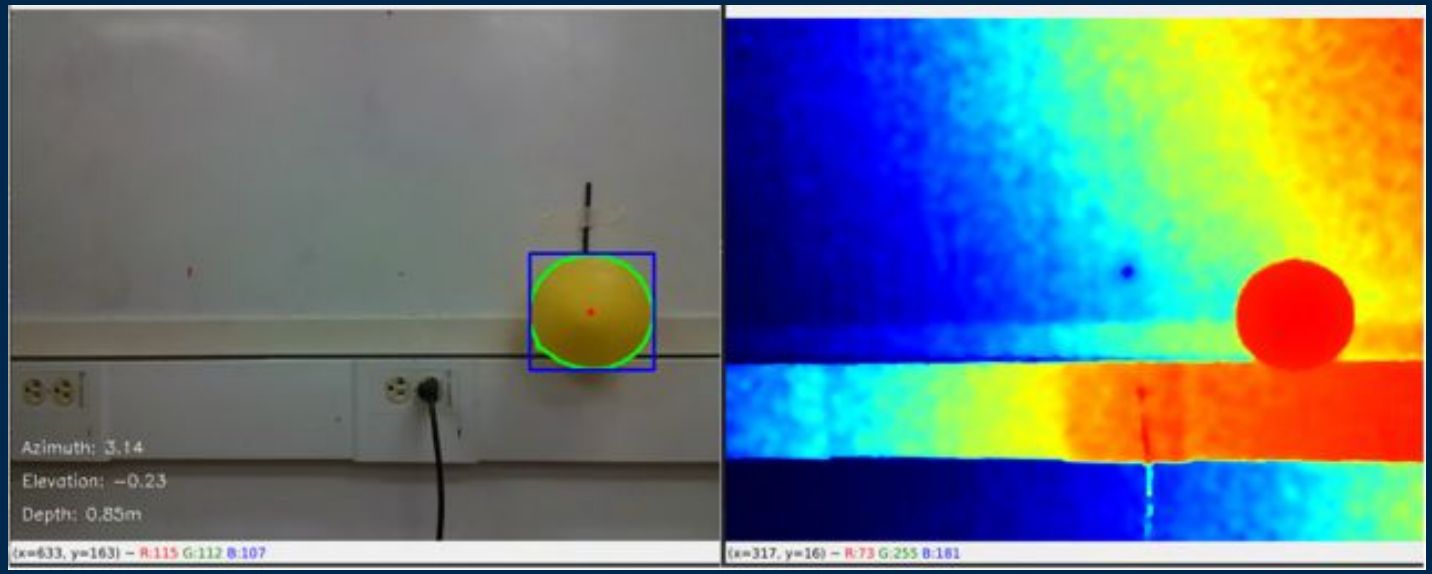
Computer Vision for Dandelion Detection

- The Intel Realsense L515 RGB-D camera was mounted onboard BigAnt
- Dandelion simplifications: rendered as a yellow spherical object with dimensions comparable to those of a real dandelion



Computer Vision for Dandelion Detection

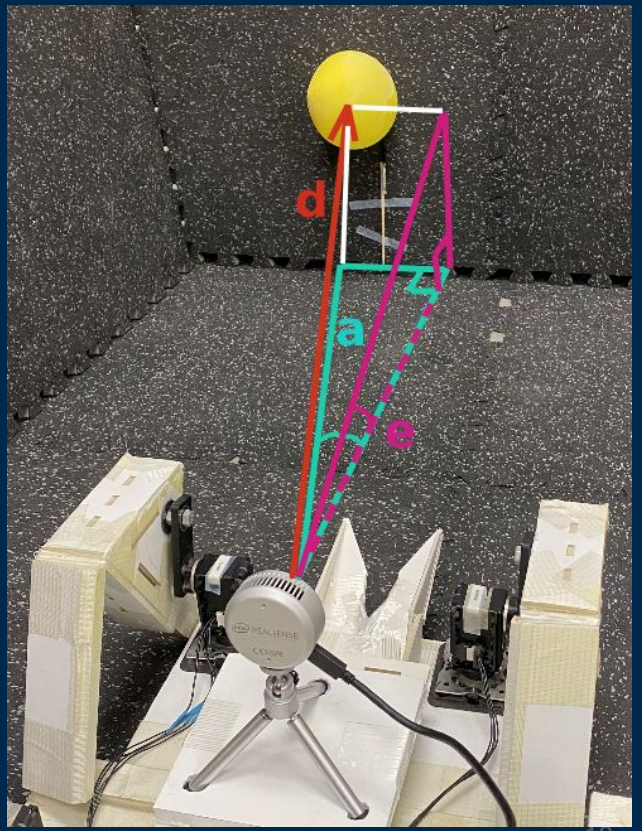
- Dandelion-detecting algorithm uses yellow color and sphericity (area and perimeter)
- Depth data was collected from the same bounding box on both frames; azimuth, elevation and depth data is returned



Algorithmic Control Scheme

Algorithmic Control Scheme

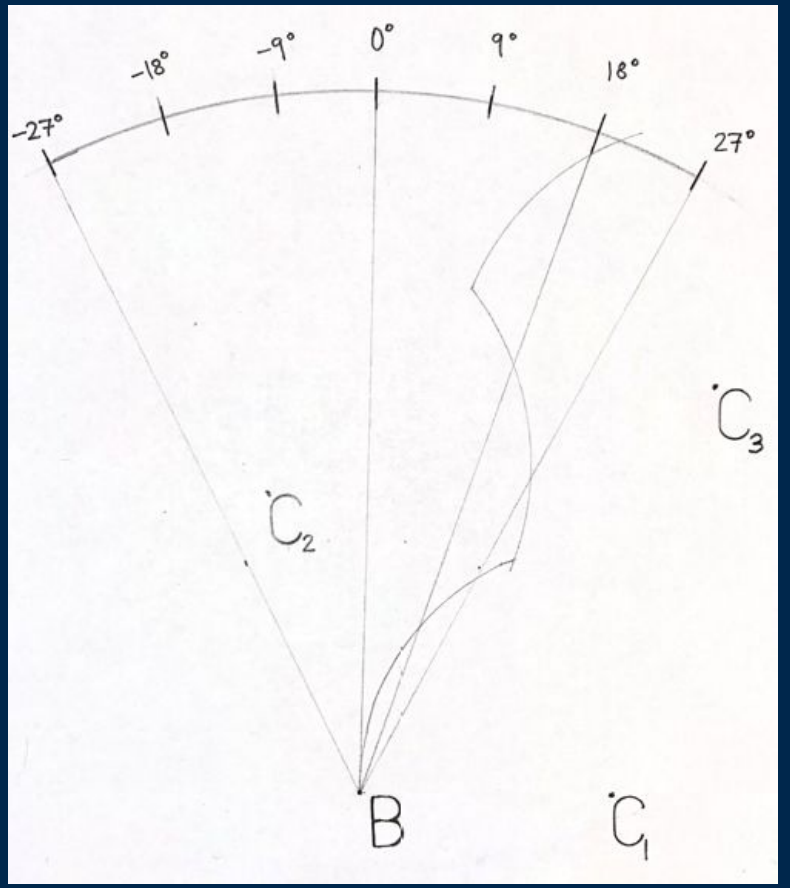
- The dandelion's azimuth, elevation, and depth data are used for path planning
- BigAnt uses a steering gait to approach the dandelion based on the remaining distance and azimuth
- A turn parameter is chosen automatically to adjust steering radius towards the dandelion



Algorithmic Control Scheme: Path Planning

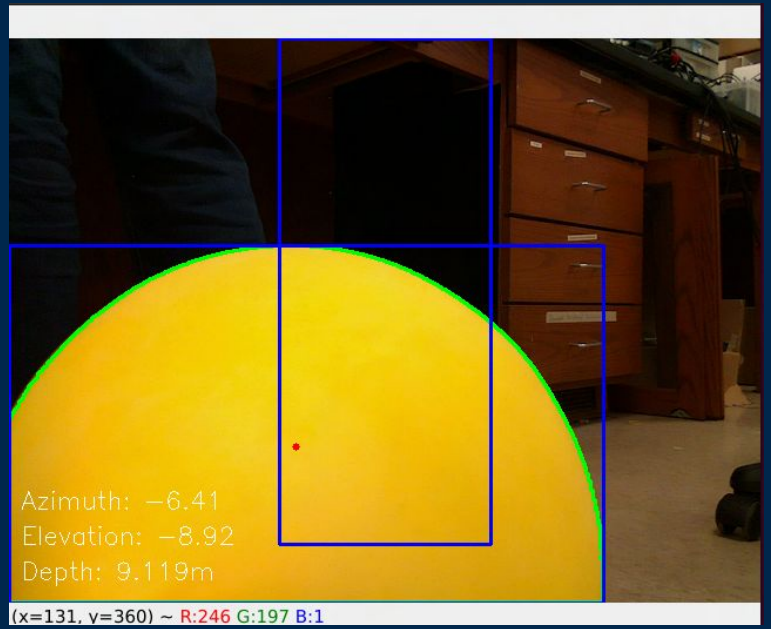
BIRDS lab

- The turn parameters were found experimentally in the lab arena
- While steering, BigAnt overshoots the dandelion (target) successively to reach it
- This is a control problem in which the error is the azimuth angle between the dandelion and the cutting appendage



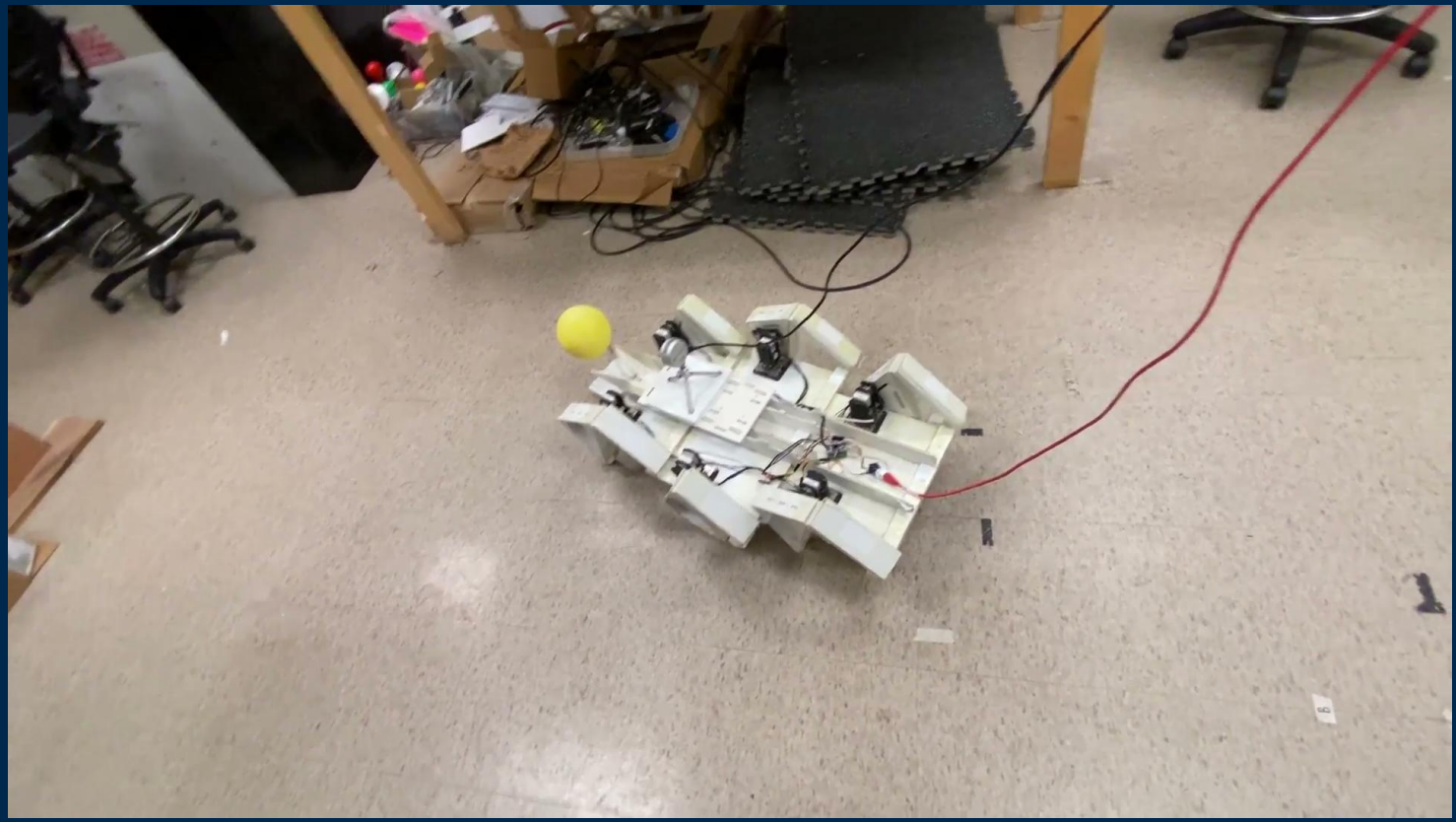
To Pick Or To Not Pick?

- BigAnt checks if the dandelion is within an acceptable bounding box before picking it
- If the centroid lies within the acceptable range, the dandelion is picked, otherwise further action is taken



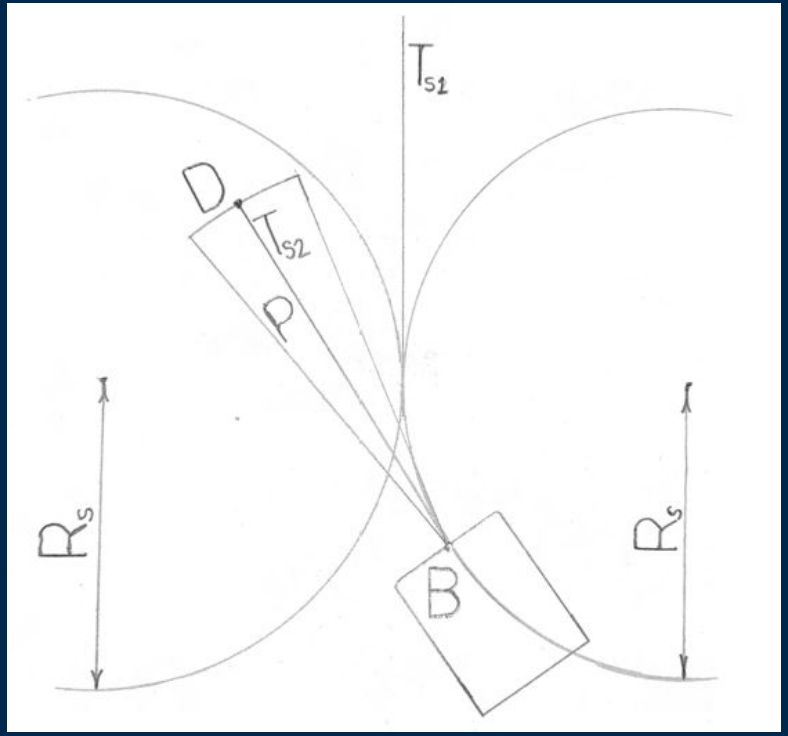
Algorithmic Control Scheme: Path Planning

BIRDS lab



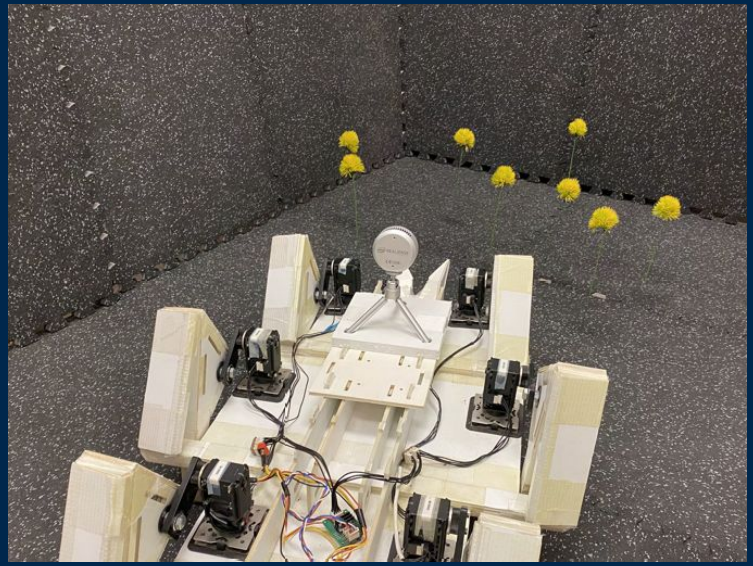
Algorithmic Control Scheme: Missed Dandelion

- If BigAnt misses the dandelion target, it steers backwards with the smallest turning radius
- Backwards steering is stopped when the dandelion lies within the narrow azimuthal picking range again
- BigAnt reapproaches the dandelion in a straight line



Future Work

- For real use, one improvement is the detection of multiple dandelions simultaneously
- The computer vision scheme can be upgraded to detect real dandelions
- After rigorous lab testing, the entire system can be made wireless



Picking Real Dandelions!

References

[1] D. Zhao and S. Revzen, “Multi-legged steering and slipping with low dof hexapod robots,” Bioinspiration & biomimetics, vol. 15, no. 4, p. 045001, 2020.

[2] I. Fitzner, Y. Sun, V. Sachdeva and S. Revzen, "Rapidly Prototyping Robots: Using Plates and Reinforced Flexures," in IEEE Robotics & Automation Magazine, vol. 24, no. 1, pp. 41-47, March 2017, doi: 10.1109/MRA.2016.2639058.

Questions & Answers