NRI: COLLAB: Leveraging Environmental Monitoring UAS in Rainforests

NSF Award Number: 1925368, 1925262, 1925148

Drs. Brittany Duncan and Carrick Detweiler

School of Computing

Co-Directors, Nebraska Intelligent MoBile Unmanned Systems (NIMBUS) Lab

University of Nebraska

Dr. Joshua Peschel

Agricultural and Biosystems Engineering

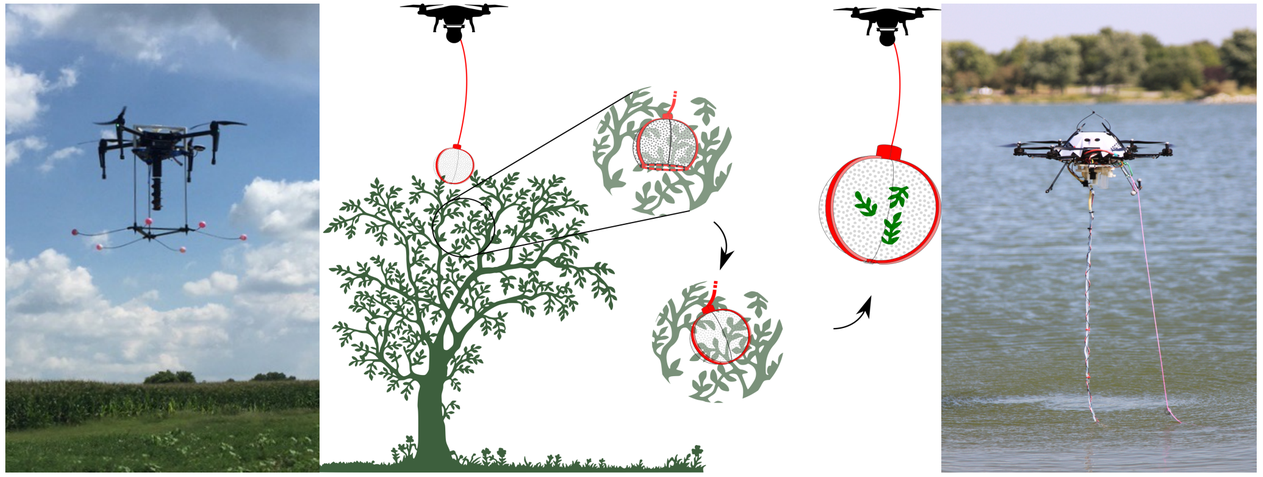
Iowa State University

Dr. Gretchen Miller

Civil and Environmental Engineering

Texas A&M University

Improving Rainforest Sampling with Drones for water, leaf, and soil collection



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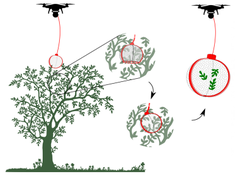

Conducted first round of field trials at Texas A&M Soltis Center in Costa Rica

- Extensive preliminary data collection:
  - Water vapor and carbon dioxide concentrations, air temperature
  - Imagery over multiple land uses near center:
    - Rainforest
    - Agricultural field (cassava/yuca farm)
    - Carbon farm (a “payment for ecosystem services” tree plantation)
- Testing helped determine:
  - Sensor package needs
  - Payload requirements
  - UAV weather-proofing needs
  - Logistics and sampling patterns for flights

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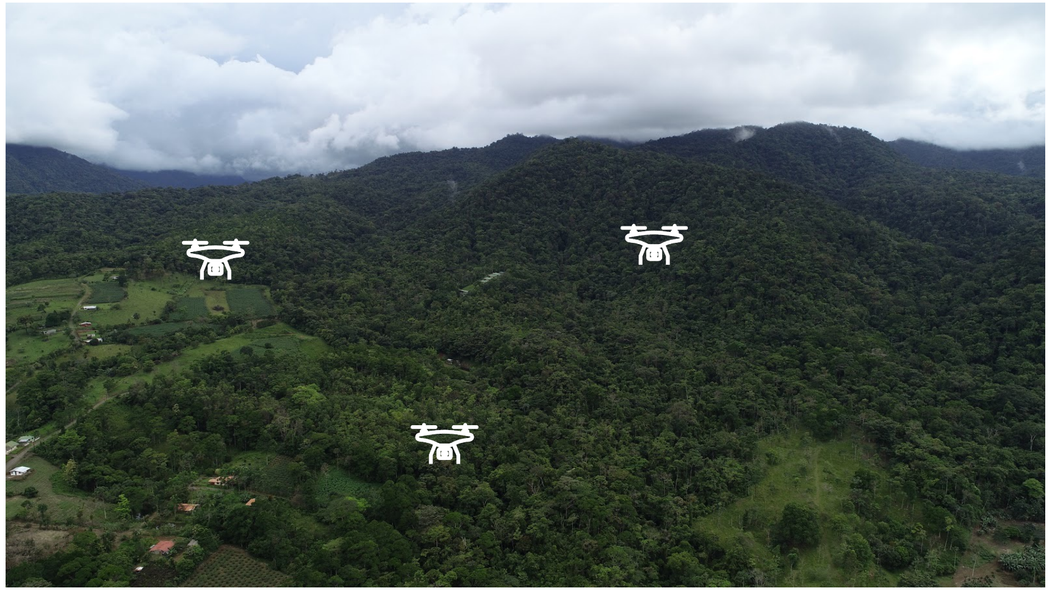
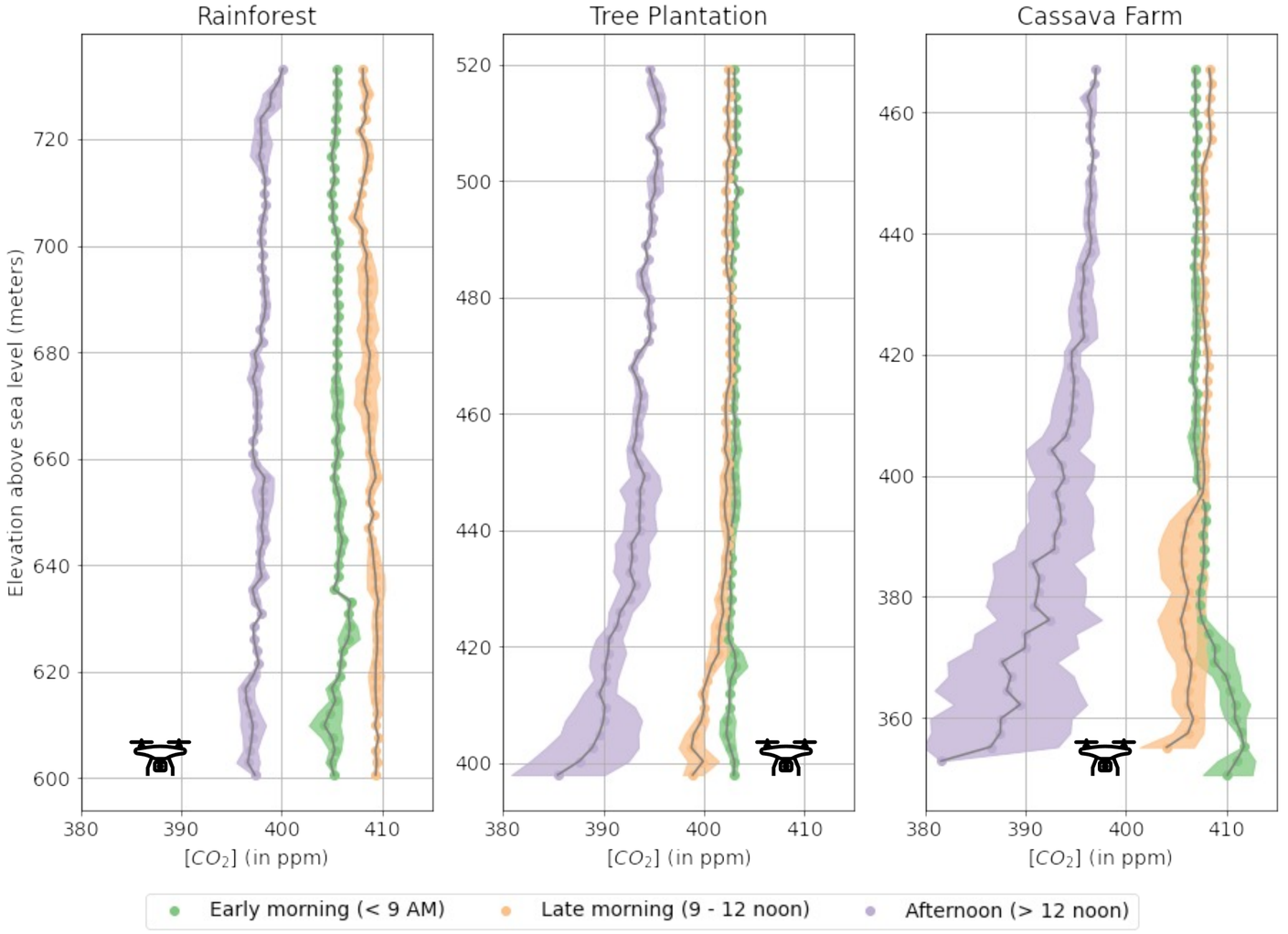
CO_2 profiles collected via UAS reveal contrasting carbon use patterns by vegetation





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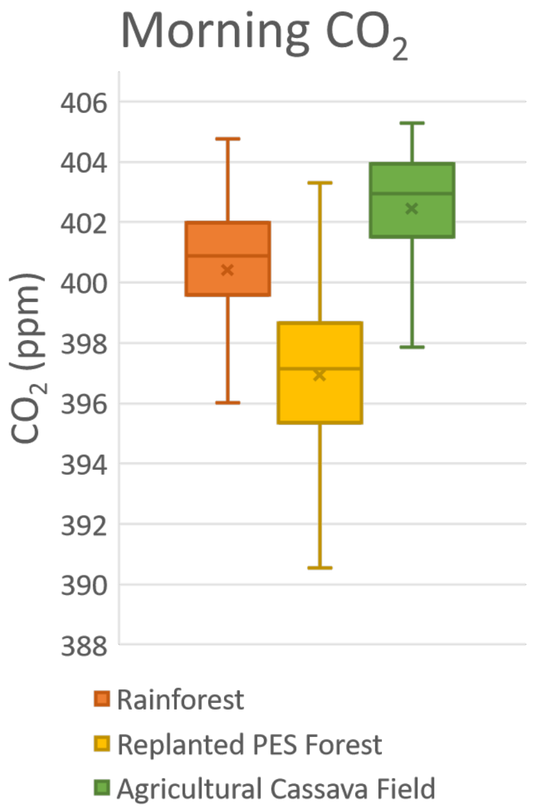
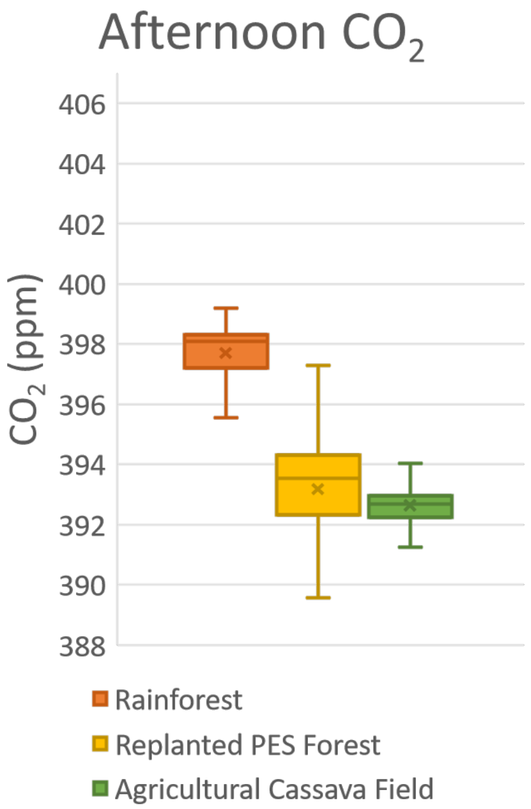
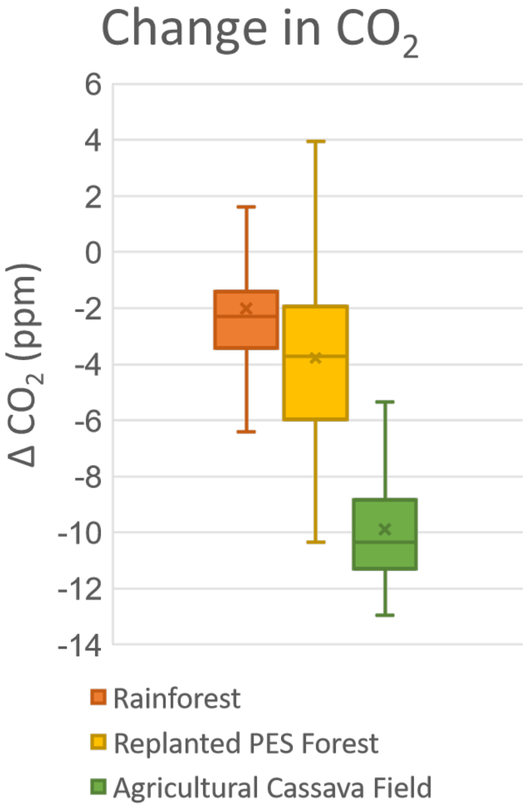
Horizontal canopy flights yield supporting data carbon use patterns by vegetation







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Fundamental Challenges inspired by Real-World Deployment

- Proximity to trees is necessary for various sampling
  - Both leaf and CO_2 profiles require close interaction
  - Identification of areas of interest and visibility of the system can be hard from these perspectives
  - Potential entanglement risk
  - Automated area of interest recognition and recommendations require much more data than can be feasibly collected

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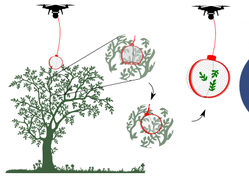

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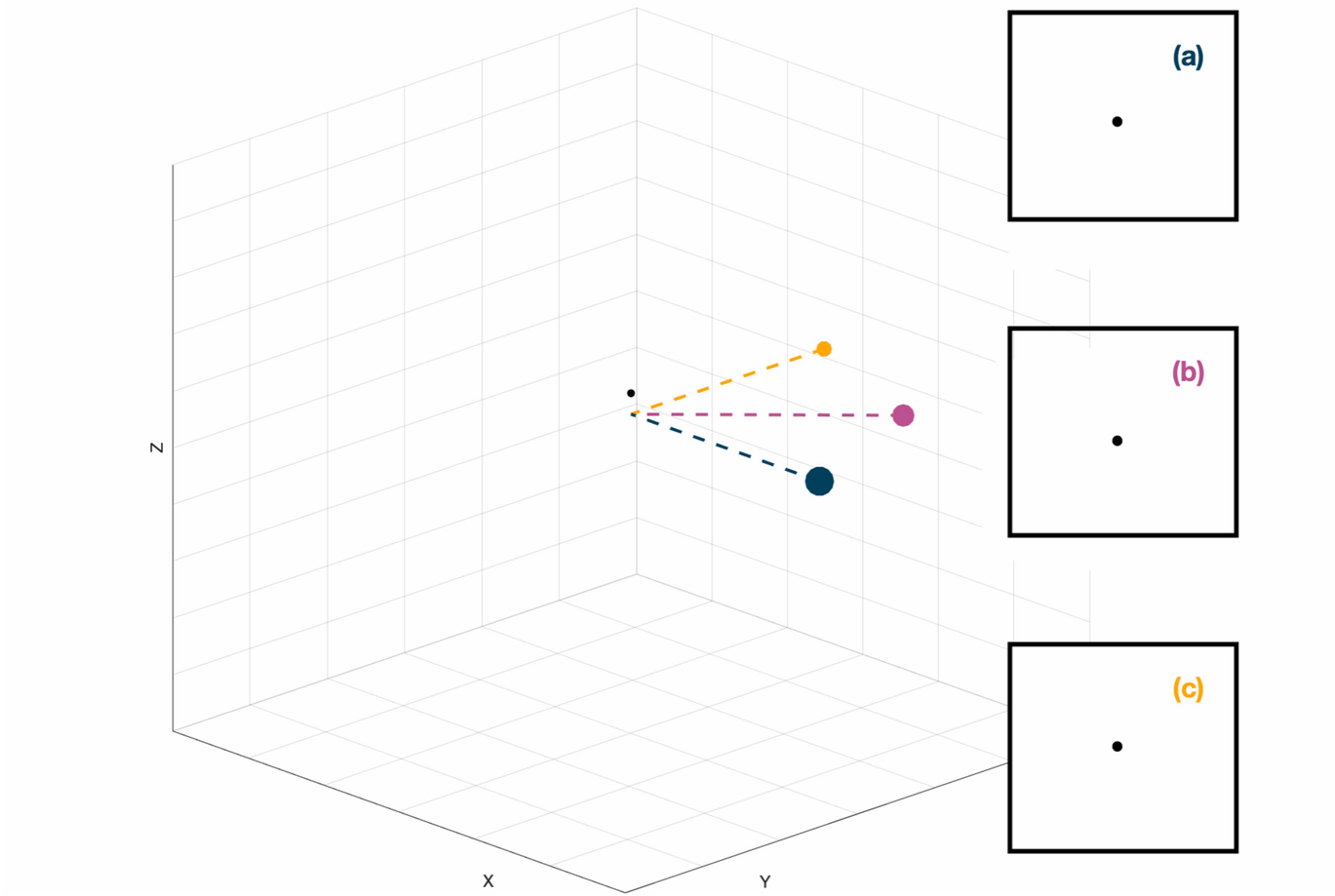
Viewpoint Variance

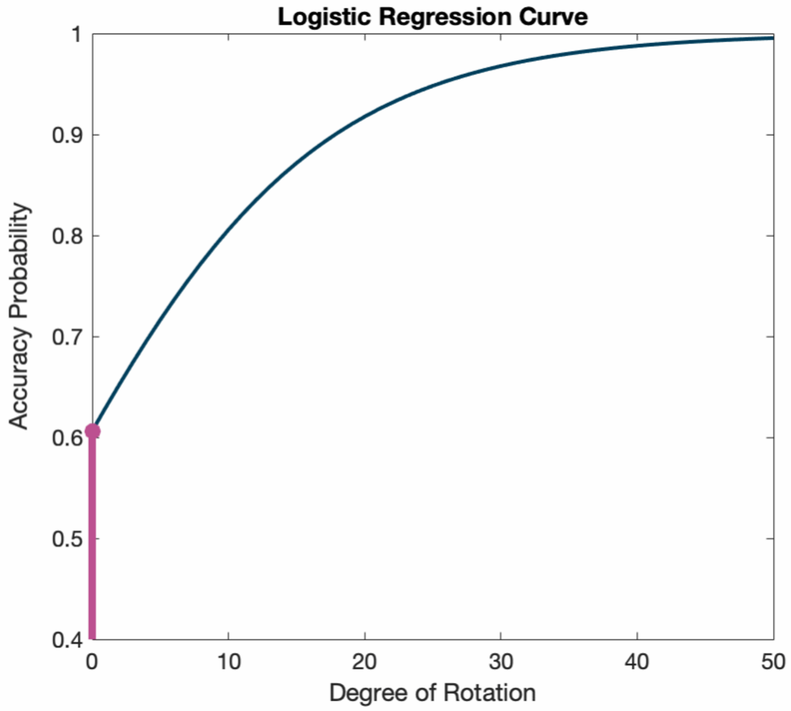
Shapes of motion look different when viewed from varying perspectives.

We explore how observers perceive the shape of a gesture's motion from varying viewpoints.



Viewpoint Threshold

Identified a ninety percent accuracy threshold at twenty degrees away from the most occluded viewpoint.



Accuracy Probability 0.60632

Degree Rotation 0

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Original Gesture

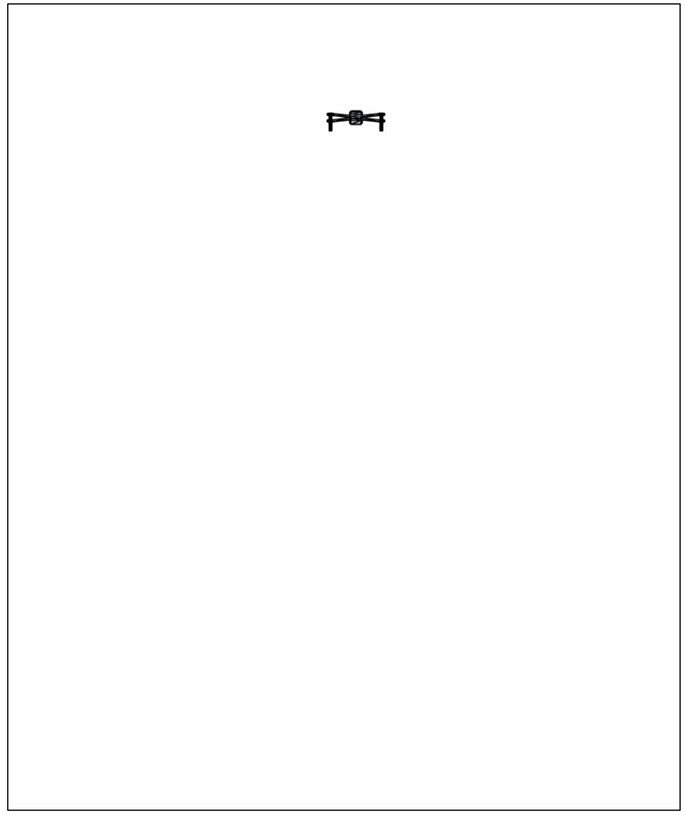

Figure 1

Equal Actual Gesture Size

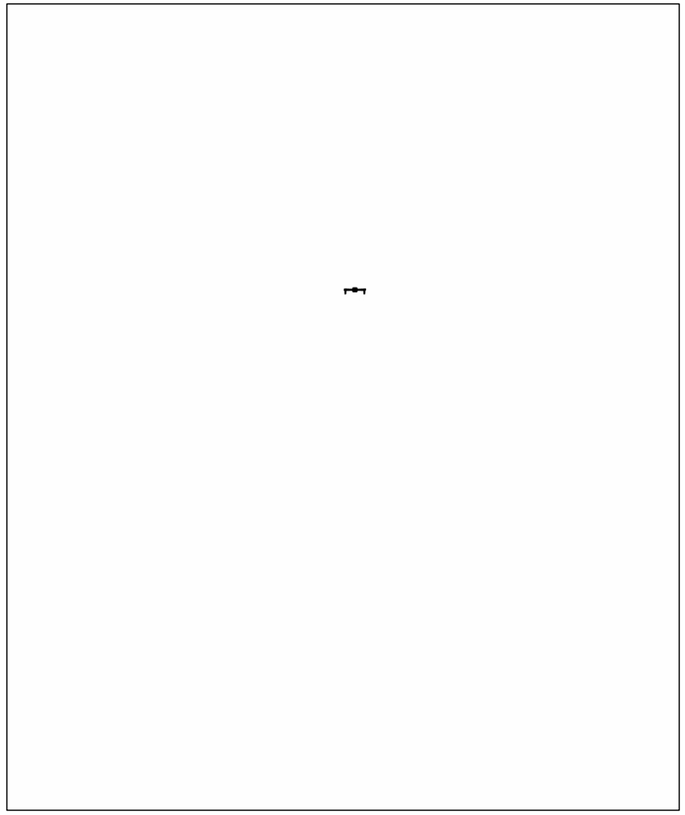

Figure 2

Equal Apparent Gesture Size

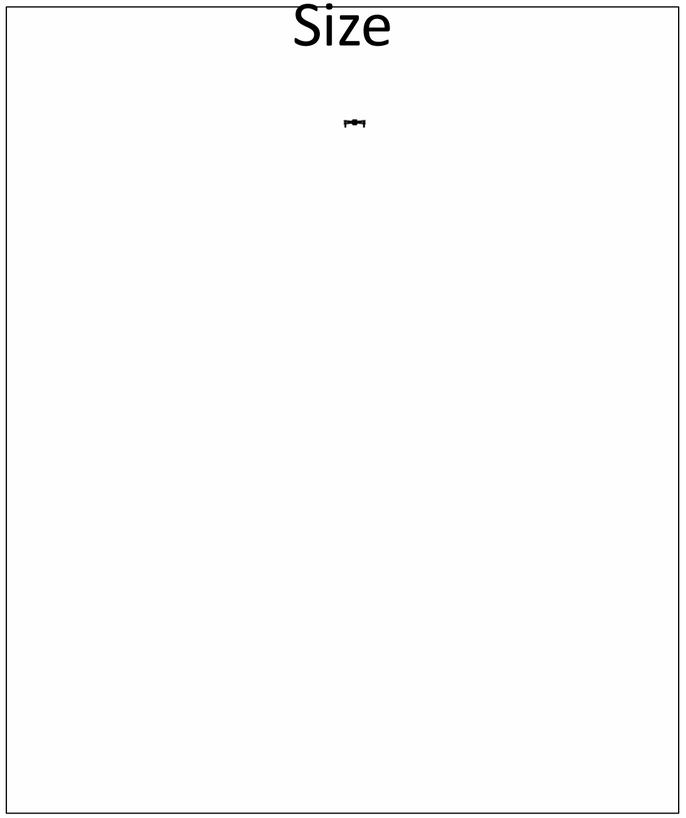

Figure 3

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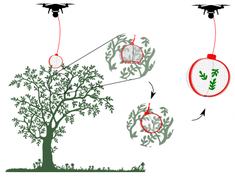
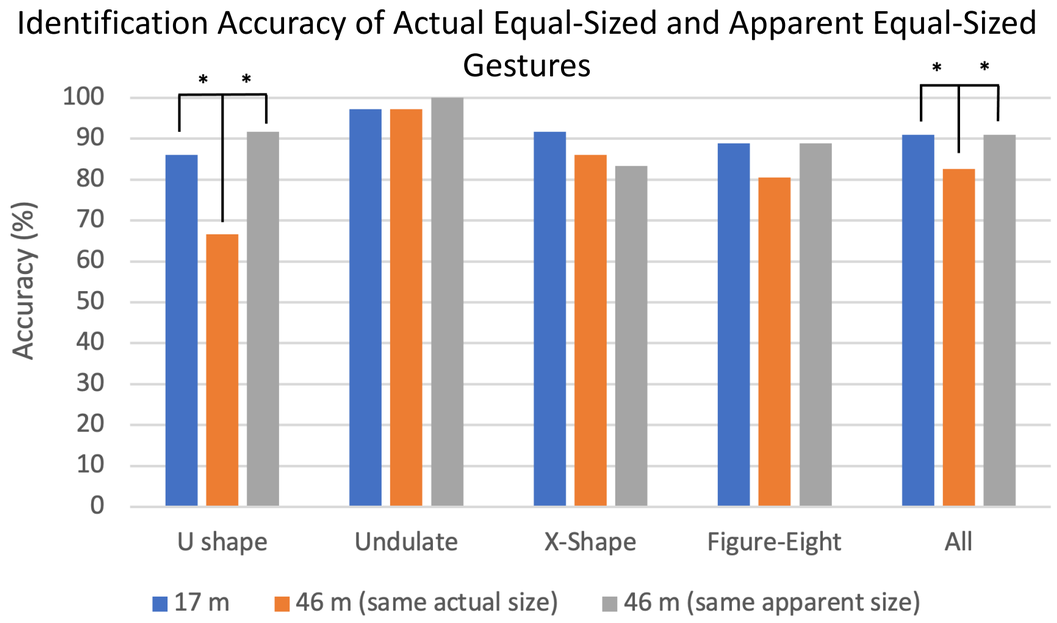


Gesture Size and Recognition

- Accuracy decreased for same-sized gestures at farther distances
- Accuracy was fairly constant for gestures with the same apparent size
- Propose that gestural communication can be maintained over large distances



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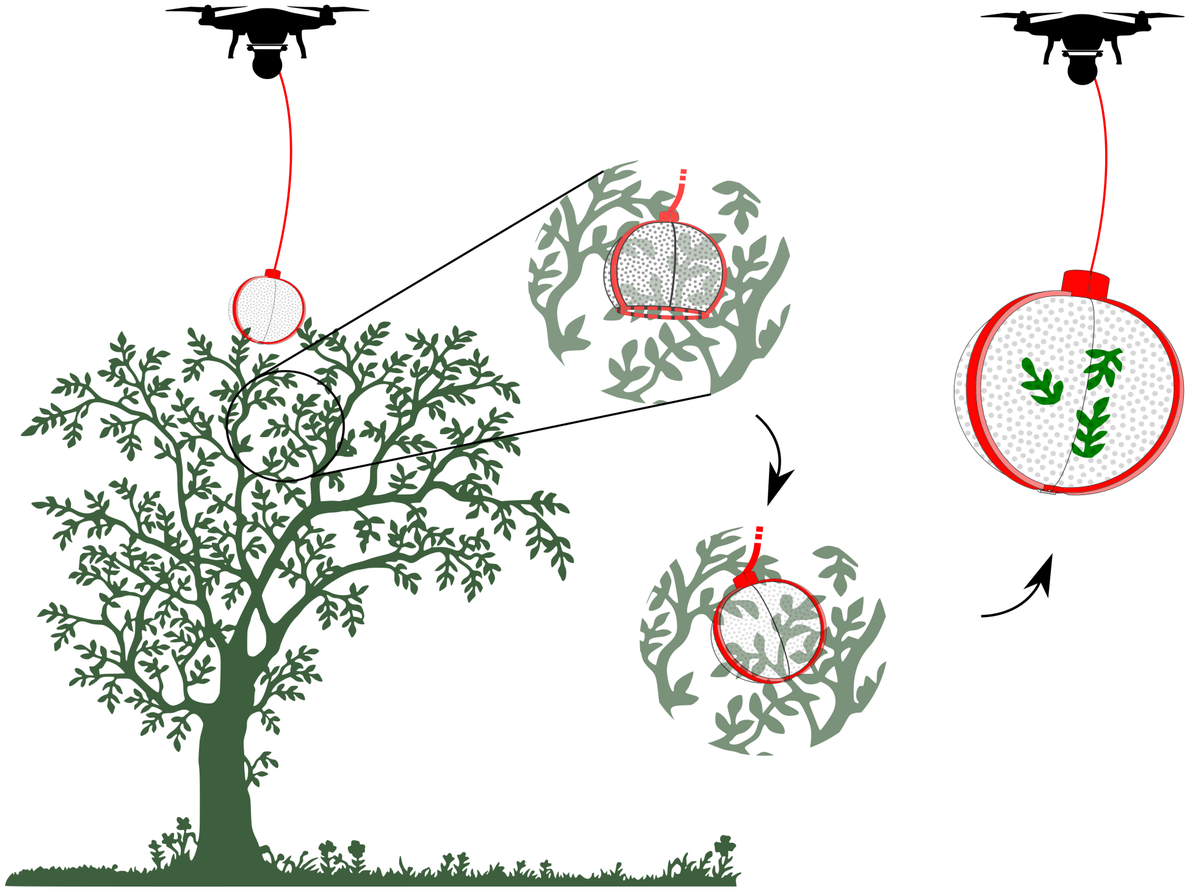
Safe and Autonomous Leaf Sampling

- Collect leaf samples for lab analysis
  - Leaves from top and within canopy
  - Difficult and dangerous to do manually
- Challenge with UAS sampling
  - Sampler tangled in branches
- Approach
  - Reinforcement Learning to generate motions that prevent tangles



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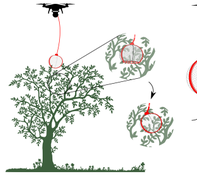
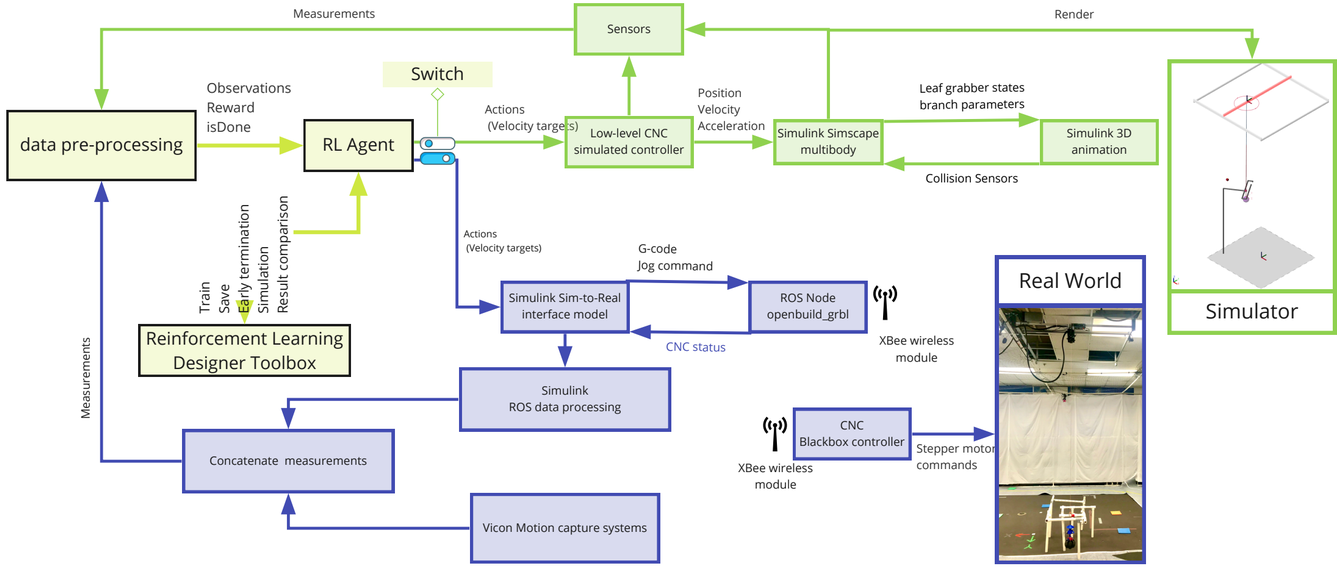
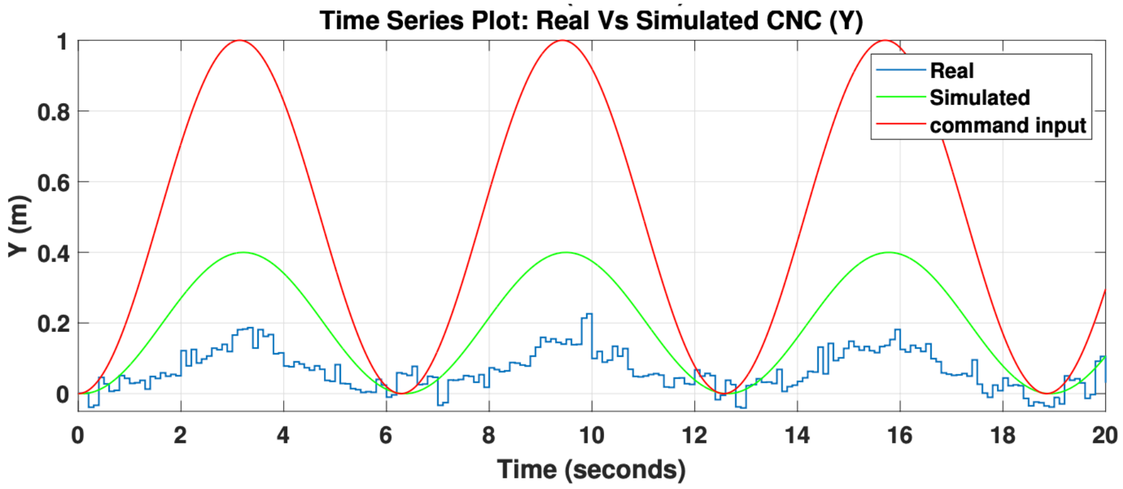
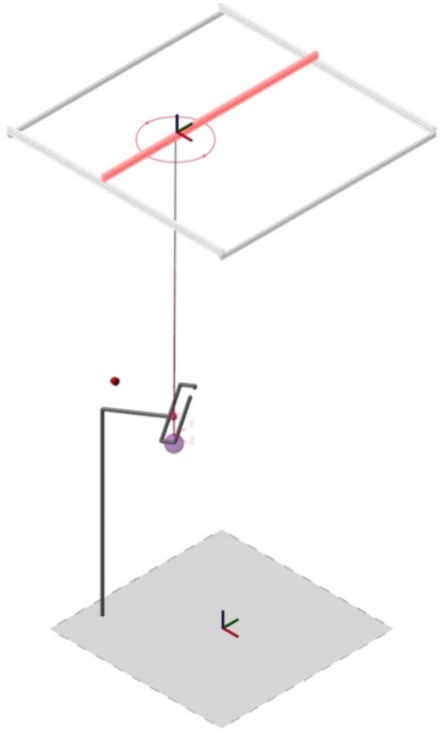


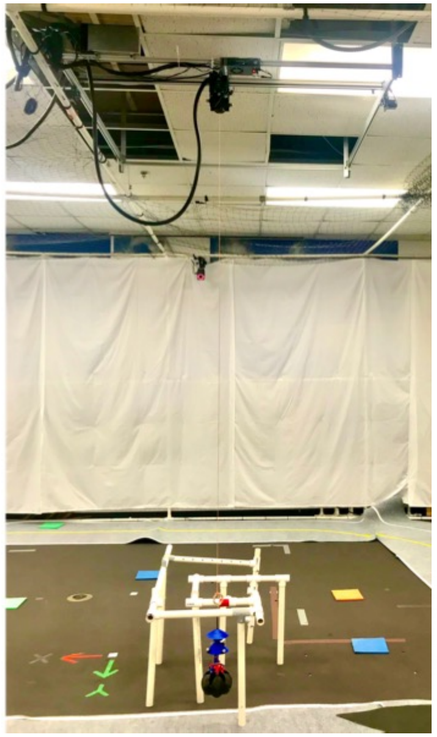
Safe and Autonomous Leaf Sampling

- Currently
  - Training in simulator
  - Followed by training in lab (non-UAS)
- Future Plans
  - Lab UAS evaluation
  - Field evaluation









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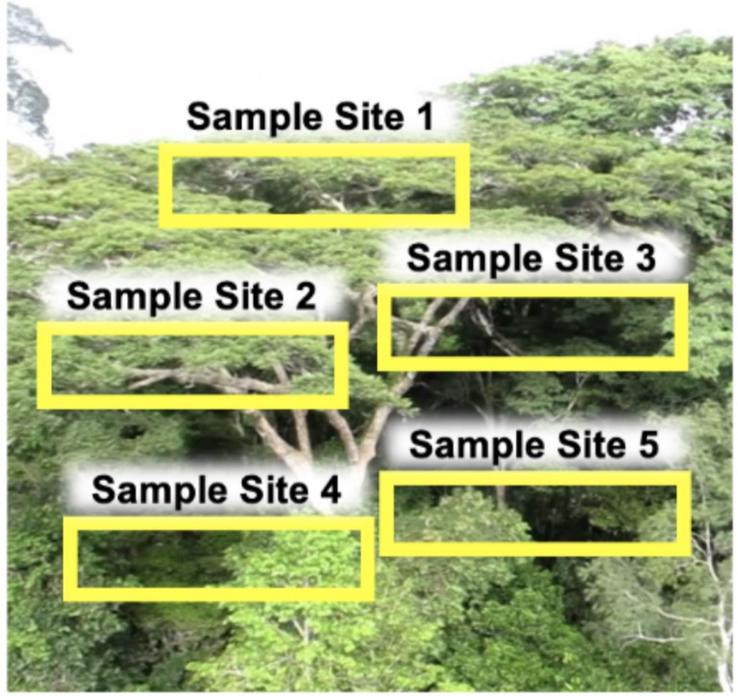
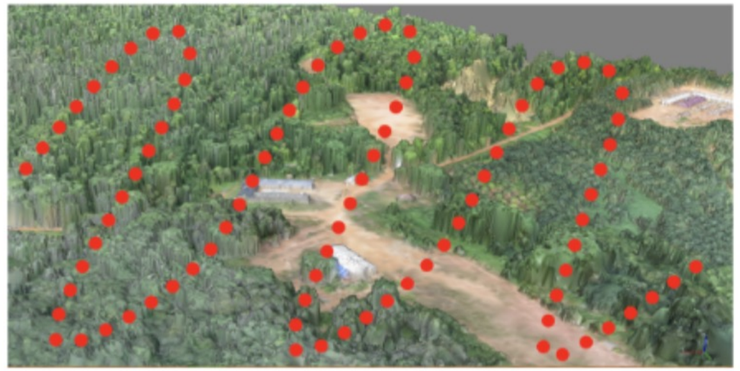
Perception and Assistance Goal

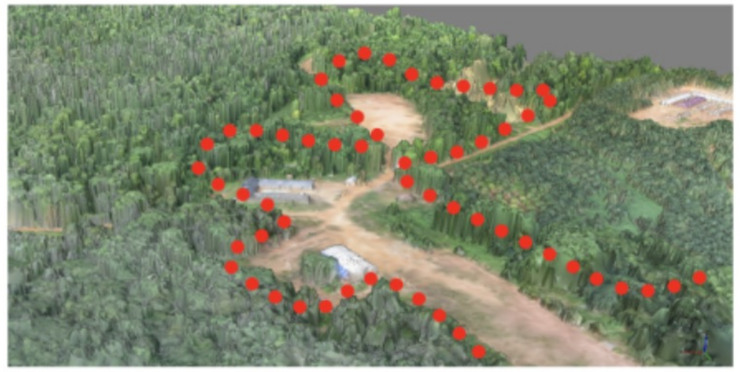
(a) Important Features in an Image



(b) Labels for Important Regions

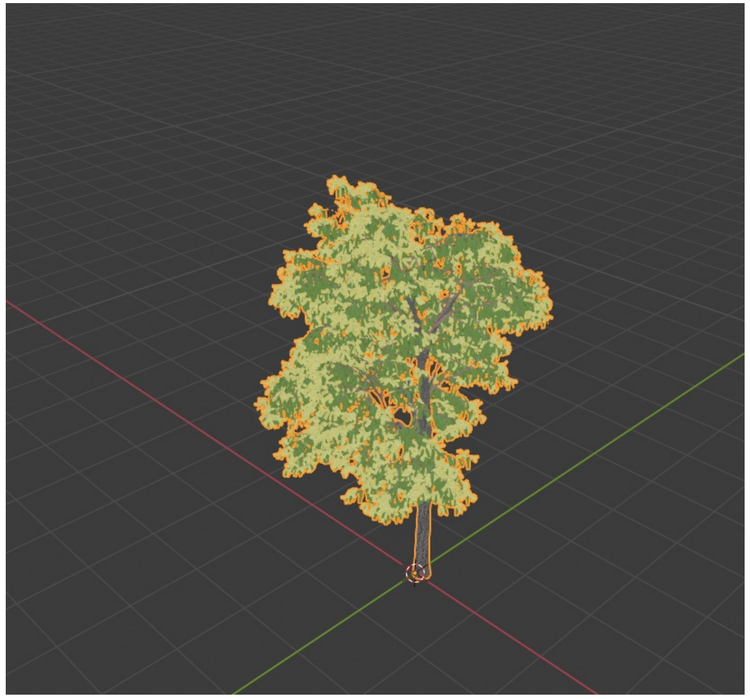


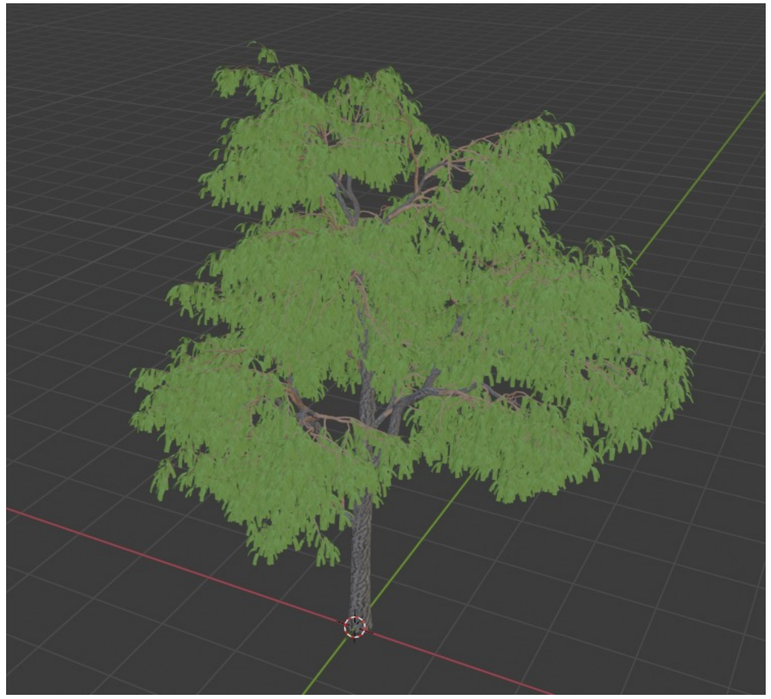
(c) Uninformative Path



(d) Informative Path

Blender Forest Creation





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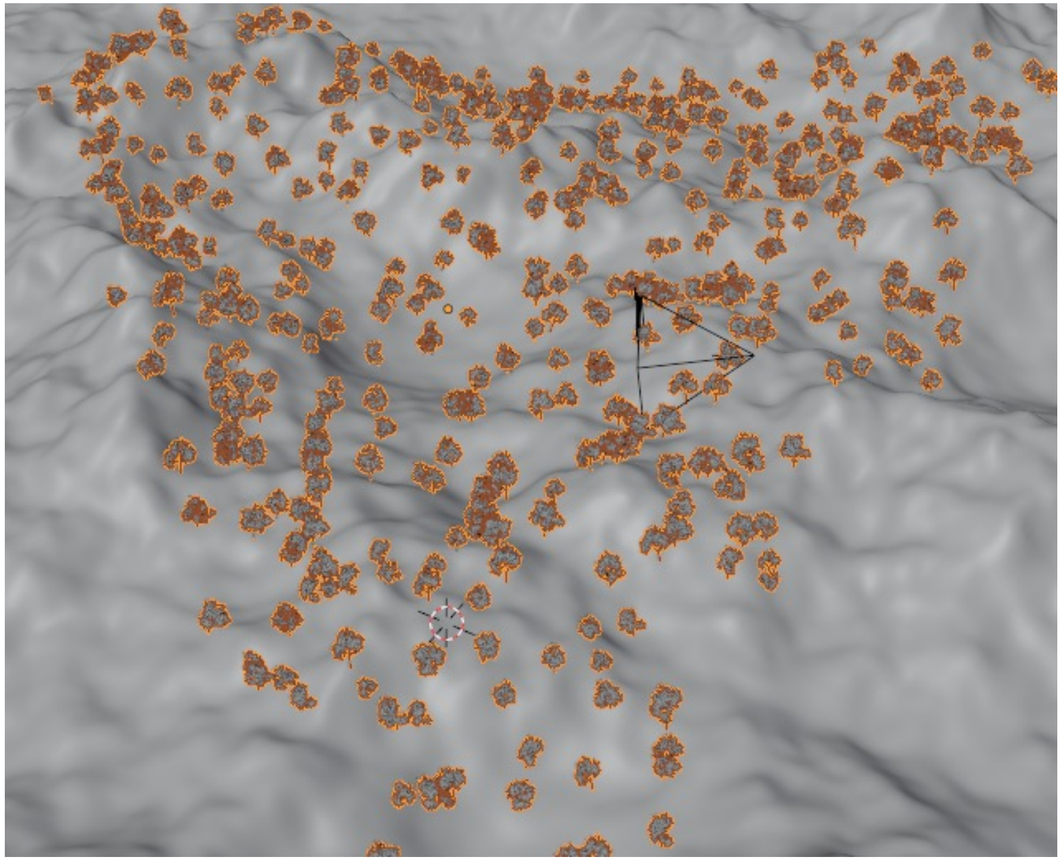

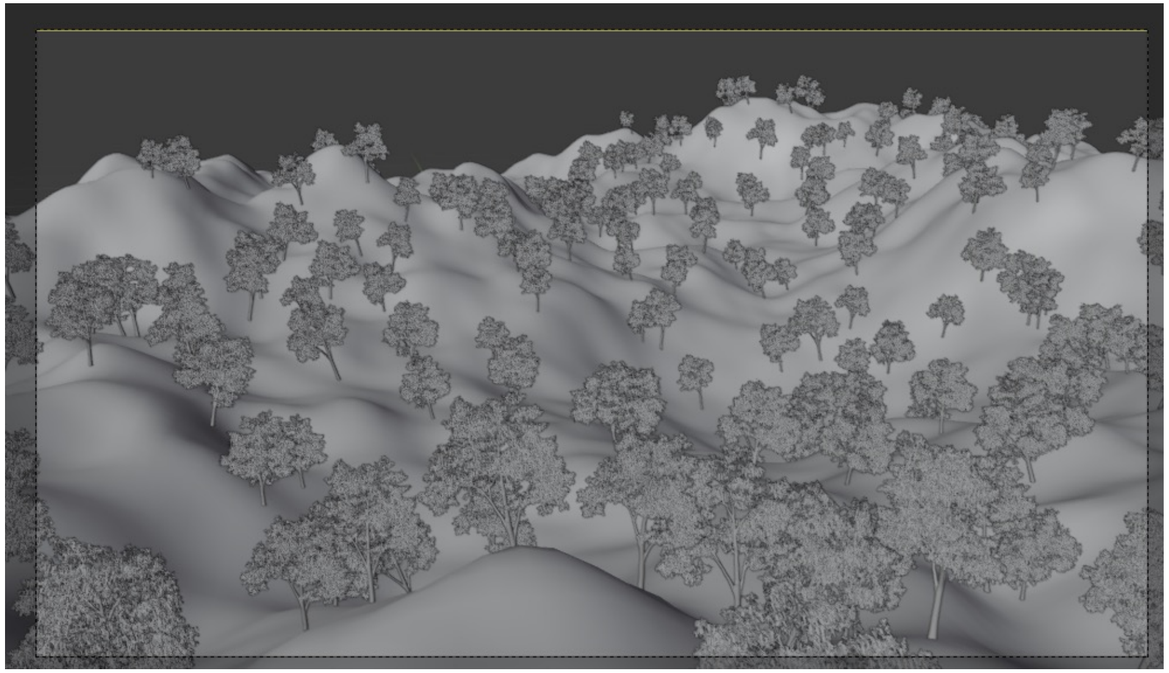

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Blender Forest Creation

Blender Depth Extraction

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New Real Data

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Model Results Overlay to Understand Depth of Canopy

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Next Year

- Integrate depth sensing and sampling research to aid scientists in carbon and leaf sampling
- Deploy gesturing on vehicles to better convey current state to bystanders
- Continue adjusting research objectives based on field-inspired needs and intended use to create a system which can be consistently fielded by scientists

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