# Fall 2022 Research Progress Summary

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# Summary of what we will go over

- **Project 1: Simulation Framework for Development of Robotics and IoT for Precision Agriculture**
- **Project 2: Realtime Deformable Linear Object Detection through Minimal Bending Energy Superpixel Traversals**

# Simulation Framework for Development of Robots and IoT for Precision Agriculture

Andrew Choi, Shivam Kumar Panda, Seonggeun Park, and Khalid M. Jawed

# Introduction + Motivation

- In agricultural robotics, there is no complete testing framework for robots and sensors used in precision agriculture
- It is expensive to test our physical robot in the outside world, especially in its earlier stages of development
- Therefore, we require a virtual reality environment that includes a 3D, high-resolution rendering of crops, weeds, and soil in order to simulate our robot’s sensors and analyze its behavior

# Methodology

- Our goal is to develop a testing framework, in which our autonomous robot can traverse through an agricultural field and construct a 3D virtual environment in real time
- We achieve this objective by taking sets of 50-150 images of a plant and feeding it into the NVIDIA Instant-NGP framework

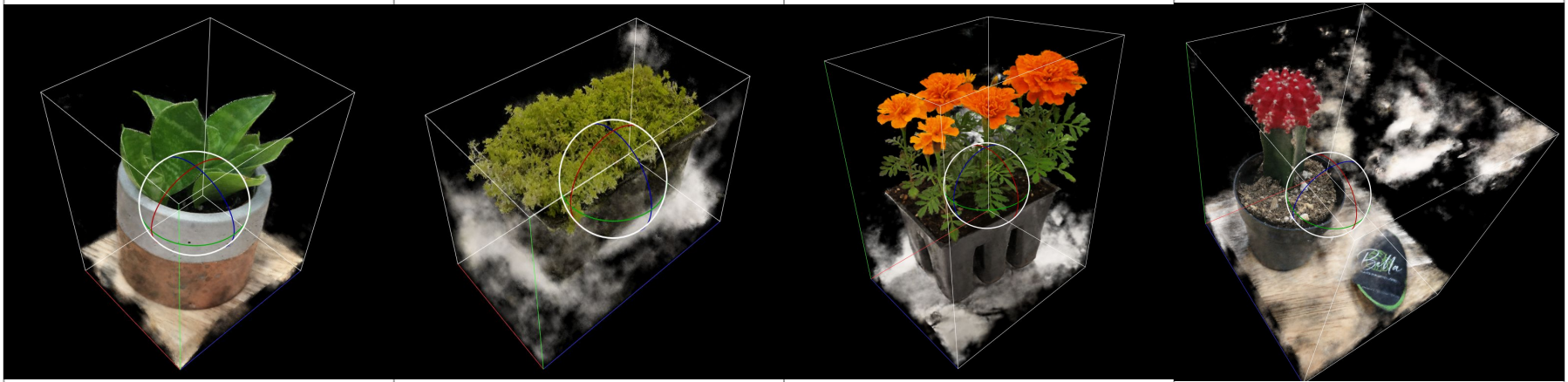
# Preliminary Results

To better understand the functionality and limitations of Instant-NGP and its GUI, we created a reconstruction of a single plant object using 50, 100, and 150 images. From the preliminary results, it is clear that the accuracy and quality of the NeRF increases with the number of images used in the dataset.

| 50 Image NeRF | 100 Image NeRF | 150 Image NeRF |
| --- | --- | --- |
|  |  |  |

# Results

We now create NeRFs for several types of plant species, with a variety of different textures, shapes, and colors using datasets of 150 images for each object.

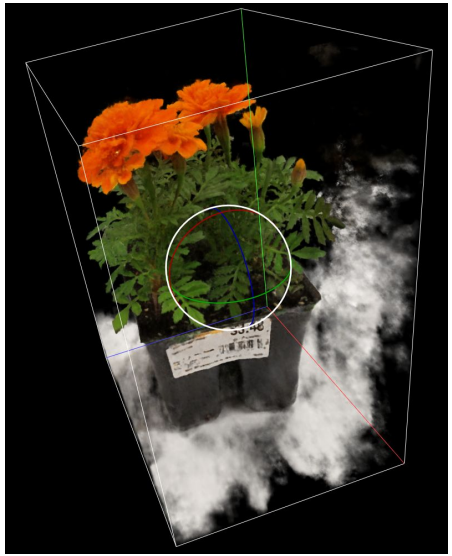
| Snake Plant | Golden Moss | French Marigold | Cactus |
| --- | --- | --- | --- |
|  | | | |

# Results cont.

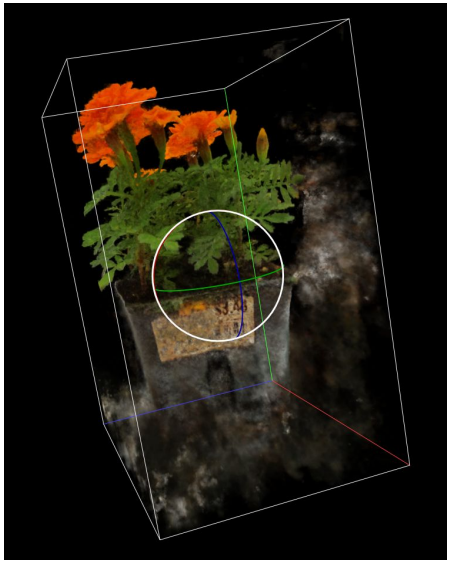
Here, we examine a case where we don't provide Instant-NGP enough data for a particular view angle.

These are two images of the same object, but with at a different view angle. In View 1, the white tag on the side of the pot is clear and legible. However, View 2's white tag is noisy and blurry. This is caused because we gave Instant-NGP a significantly greater amount of images from View 1, compared to View 2.

**View 1**



**View 2**



# Realtime Deformable Linear Object Detection through Minimal Bending Energy Superpixel Traversals

Andrew Choi, Dezhong Tong, Seonggeun Park, and Khalid M. Jawed

# Introduction + Motivation

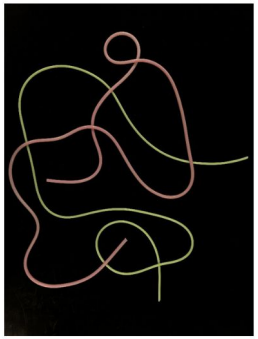
- Deformable Linear Objects are an important part in many activities, such as cable assembly and knot tying
- However, the structure and flexibility of DLOs raise difficulty for robotic manipulation of these tasks
- Therefore, we present an algorithm to produce an accurate segmentation of any number of DLO objects

# Methodology

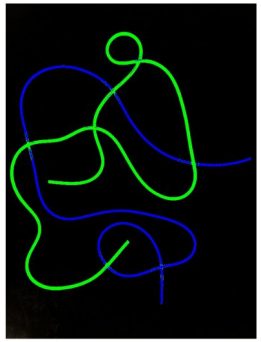
- Our objective is to implement an algorithm mBEST that takes in an image of a Deformable Linear Object and outputs an accurate segmentation of the object without prior knowledge about the geometry and number of objects
- We first produce a binary mask of the object using two methods: Color Filtering and a Deep Convolutional Neural Network
- Then, feed this mask into a skeletonization algorithm to produce the segmentation of the DLO

# Results with Our Dataset

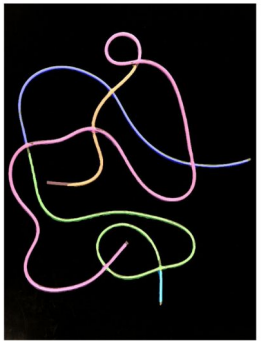
- It is clear that mBEST is able to accurately segment the two different DLOs
- The FASTDLO algorithm incorrectly segments the same rod into two different colors
- The Ariadne+ algorithm is unable to capture the full object



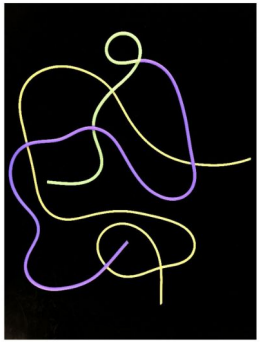
Ground Truth



mBEST (Color Seg)



FASTDLO (DCNN)

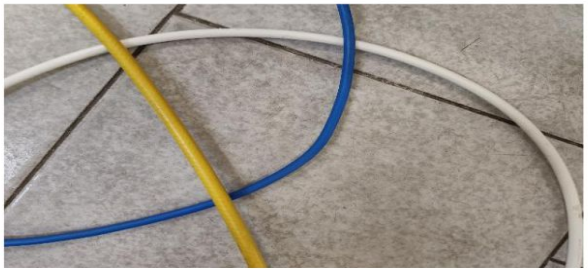


FASTDLO (Color Seg)

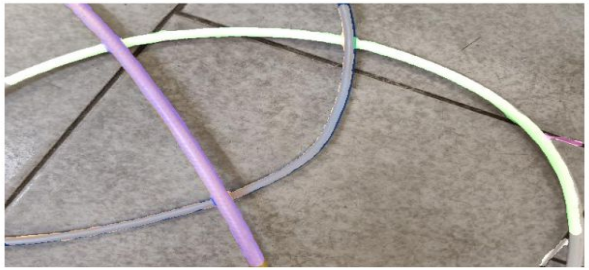
Ariadne+

# Results with FASTDLO dataset

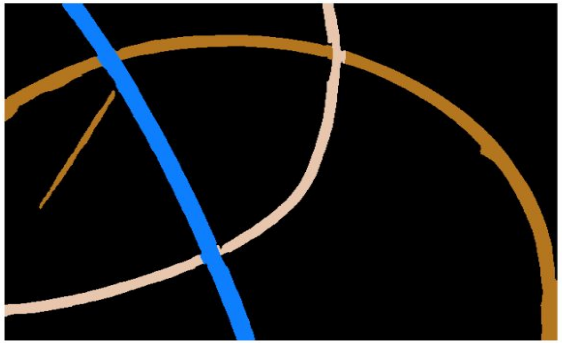
- The Ariande+ and FASTDLO algorithm incorrectly detects the pattern of the background as a DLO



Ground Truth



FASTDLO (DCNN)



Ariadne+

# Future Plans/Improvements

- **Project 1 Plans**
  - In slide 7, we saw the importance of having sufficient data for every view angle, in order to create a more complete, accurate reconstruction of the object
  - In the coming future, our plan is to devise and implement an active learning algorithm that trains the robot to calculate the best view angle that will cause the most improvement in the current NeRF
- **Project 2 Plans**
  - In the following quarter, our plan is to
    - Obtain results from the mBEST algorithm using the FASTDLO dataset
    - Add functionality that allows us to view the average time taken to create all 50 segmentations from our dataset
  - With these results, we will show that using color filtering is a more optimal way to obtain binary masks, and that mBEST has improved performance compared to the previous algorithms for extracting DLO configurations