# Development of Highway Mowing Operations, Monitoring, and Verification using UAVs

Yosuke Yajima[1], Jingdao Chen[1], Jisoo Park[1], Steven Kangisser[1], Javier Irizarry[1], Yong K. Cho[1]

[1]Georgia Institute of Technology, United States

Contact info: Yosuke Yajima Email: yyajima@gatech.edu

## Research Objective & Overall Framework

- Highway Infrastructure monitoring requires labor intensive inspection[1] and needs to improve inspection process for maintain highway safety.
- Unmanned Aerial Vehicle (UAV) equipped with a camera is used to collect images of highway environments.
- In phase 1, UAV obtains point clouds by photogrammetry (Structure from Motion) and grass area prediction algorithm predicts grass regions.
- In phase 2, the height of vegetations are automatically measured using a base model and grass height estimation algorithm.

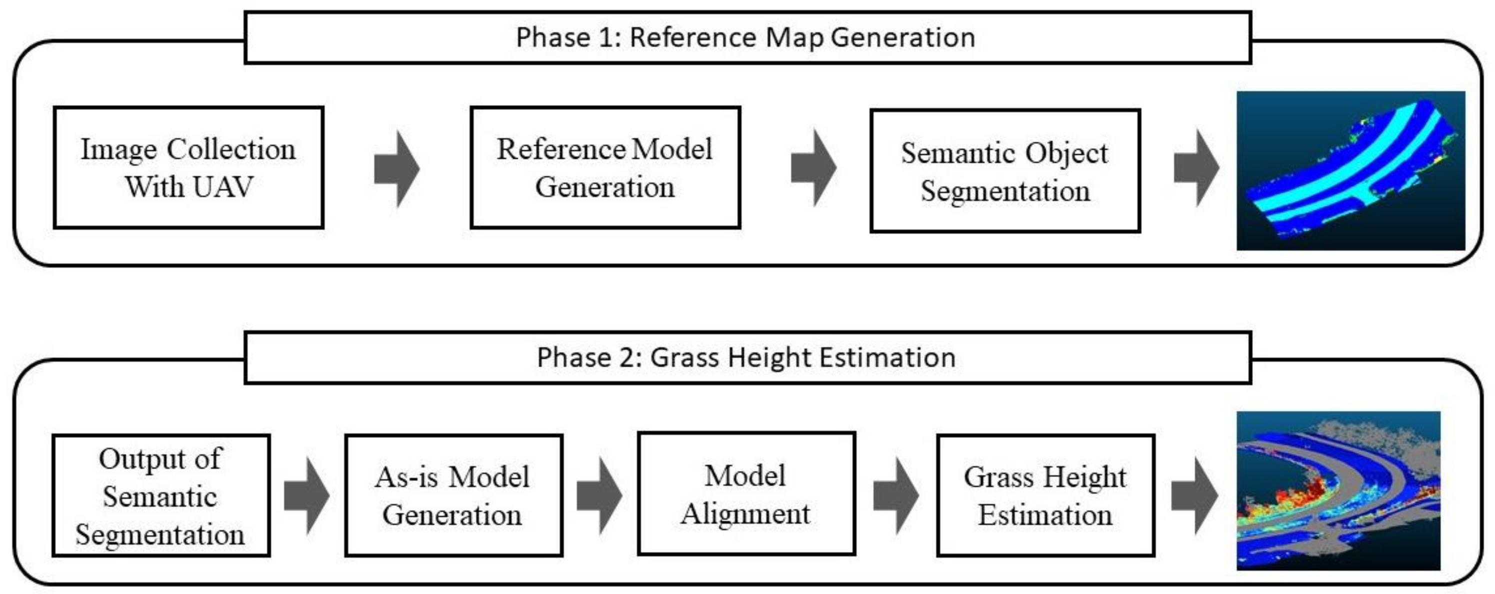


Figure1: Overall Framework

## Conclusion and Future Work

- This project highlights importance of 3D data segmentation using real highway dataset and challenges associated to object recognition, semantic segmentation, and grass height estimation from SfM generated models.
- In the future, SfM generated models needs to automate its manual registration process to align two-point cloud dataset, needs to resolve warping issues, and applying more sophisticated deep learning models that can identify small objects on the highway environments.

## Phase 1: Point Cloud Generation

- Using Structure from motion, the images are converted to point cloud data shown in Figure 2.
- Using the point cloud data, base models are created to compare multiple highway data with different date This models are used in the Phase 2 for estimating grass heights.
- PointNet++ [2] is a deep learning mode used to segment highway objects in point cloud to identify key objects (road, trees, grass, etc.).
- Figure 3 shows that the models identify objects with 75 % or more accuracy, while there are some issues with identifying small objects due to imbalanced dataset.
- Important findings include a higher accuracies on large objects (grass, road, etc.), while the accuracy is lower for the small objects (trees, etc.).

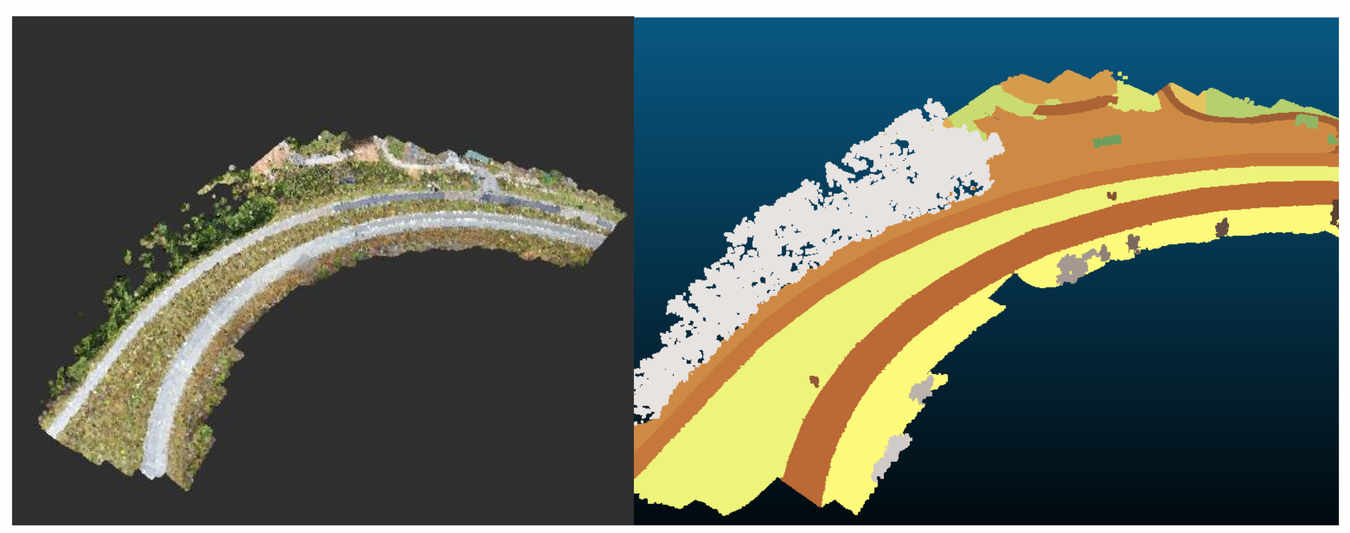

Figure 2: Dataset of Highway Environment Point Clouds

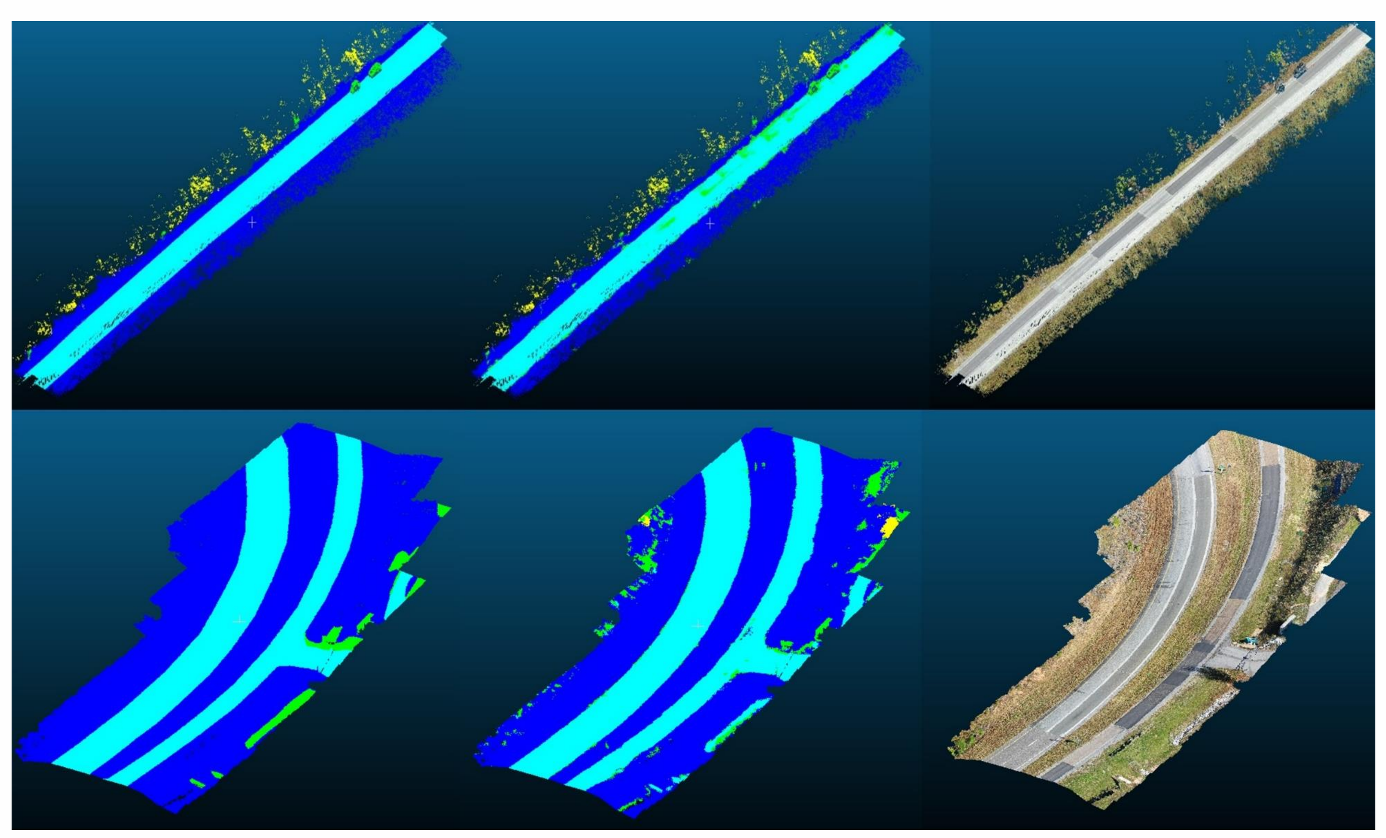

Figure 3: Point Cloud Segmentation Results (left: ground truth, center: predicted results, right: original data)

## Phase 2: Grass Height Estimation

- A base model is obtained by manually measuring the grass height at each calibration marker
- Height estimation is performed by calculating the elevation difference between the current point cloud and the base model

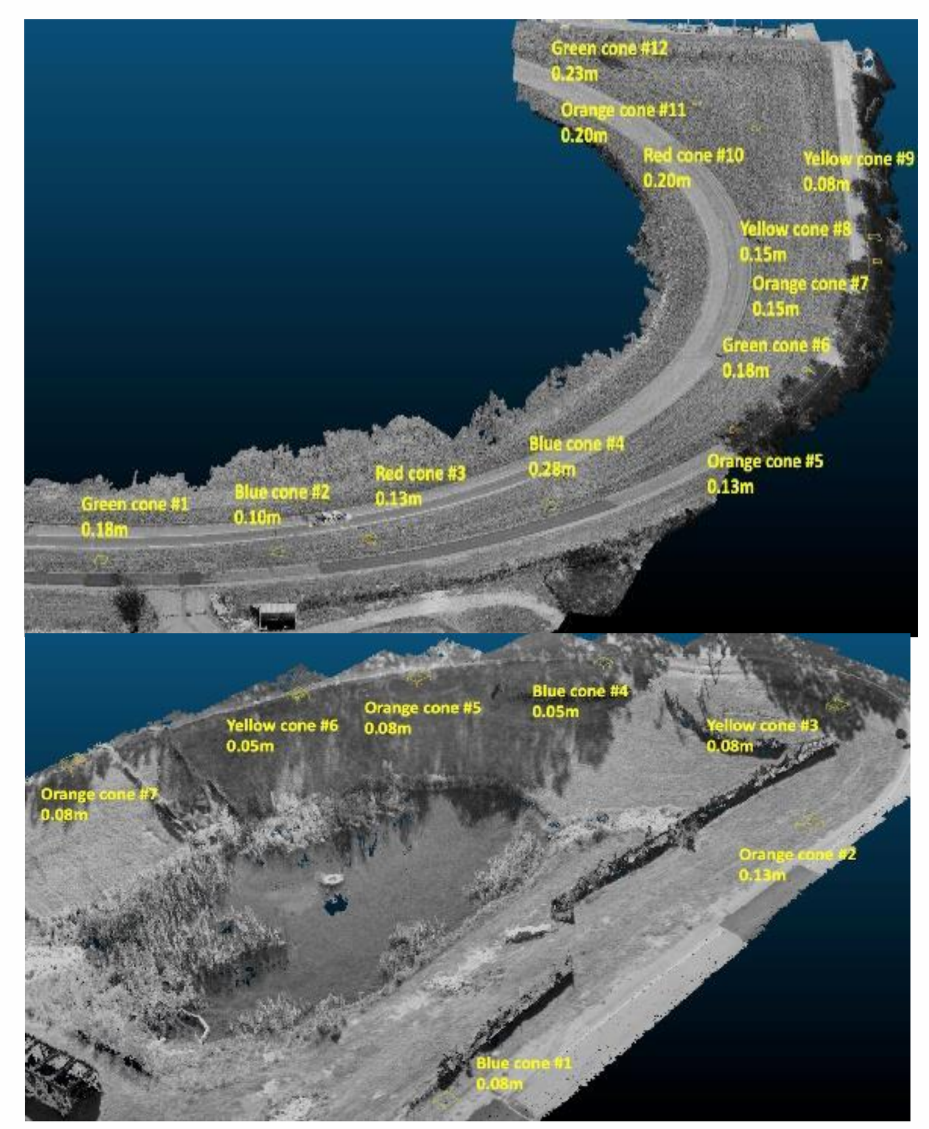

Figure 4: Cone placement for height calibration

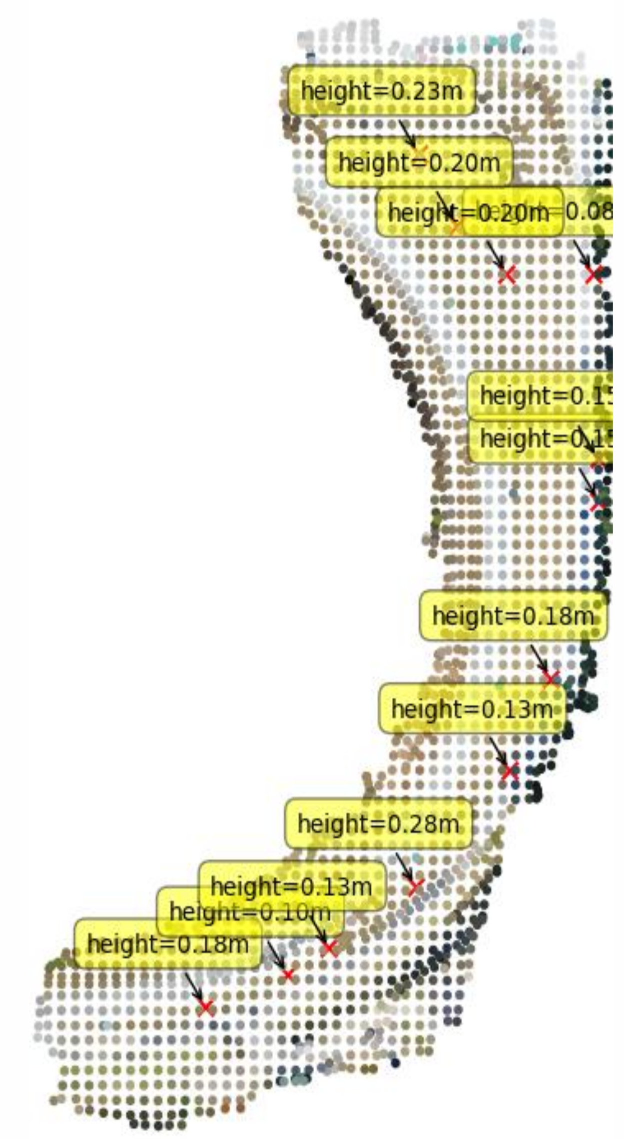


Figure 5: Base model for grass height

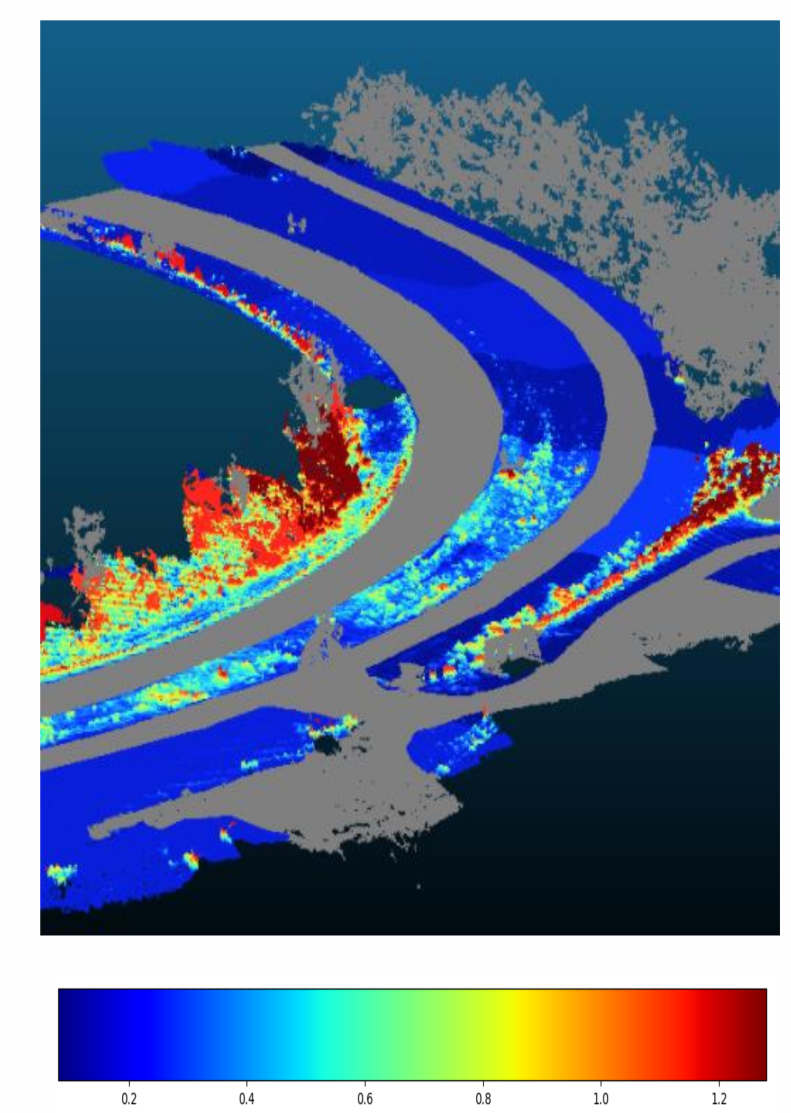

Figure 6: Grass height estimation results

## REFERENCES

1) Adams, T. M., and Sokolowski, D. (2007). "Routine Highway Maintenance: Relationship between Cost and Condition." (August), 0–13.
2) Ruizhongtai Qi, Charles & Yi, Li & Su, Hao & Guibas, Leonidas. (2017). PointNet++: Deep Hierarchical Feature Learning on Point Sets in a Metric Space.

ASC 2021 International Conference

**Note: Please hover your mouse around Figure 1 to listen our embedded voice**