Pricing Disaster Recovery Using Aerial Segmentation: Semantic Segmentation on RescueNet Dataset with Fine-Tuned Model

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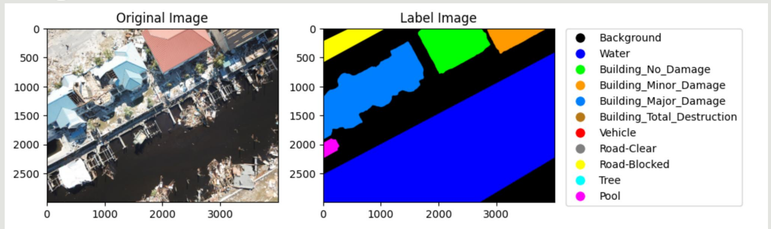
Motivation

Problem: Accurate and rapid assessment of damage following natural disasters is vital for effective disaster response

Goal: Implement and fine-tune a semantic segmentation model to identify and quantify damage using UAV imagery from the RescueNet dataset.

Objective: Achieve a segmentation accuracy of greater than 90% and provide rough cost estimates for the damage incurred.



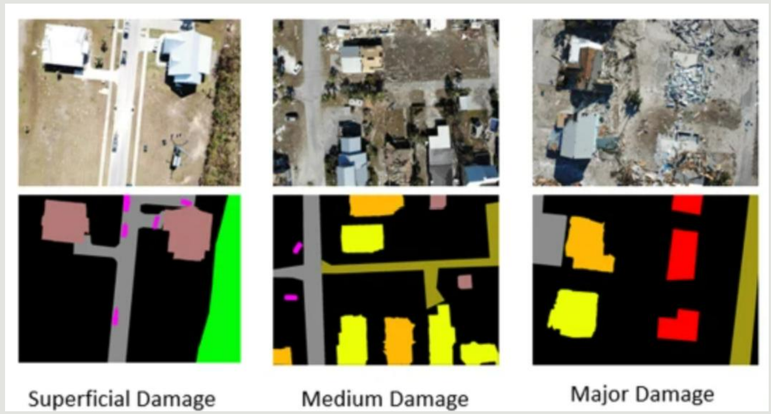
Dataset

The RescueNet dataset comprises high-resolution Unmanned Aerial Vehicles (UAV) images from the aftermath of Hurricane Michael.

- 4,494 annotated images

Preprocessed steps:

- Resizing and scaling
- Data augmentation (rotation, brightness, noise)
- Dataset split: training 70%, validation 15%, testing 15%



Methodology

Segmentation models:

- DeepLabV3 (ResNet50 backbone): Pretrained fine-tuned model.
- Metrics: Dice coefficient, Intersection over Union (IoU).
- Cost Damage Esimtation:

$$\text{Total Cost} = \sum_{class}(Pixels_{class} \times \text{Area per Pixel} \times \text{Cost Factor}_{\text{class}})$$

Experiments & Design

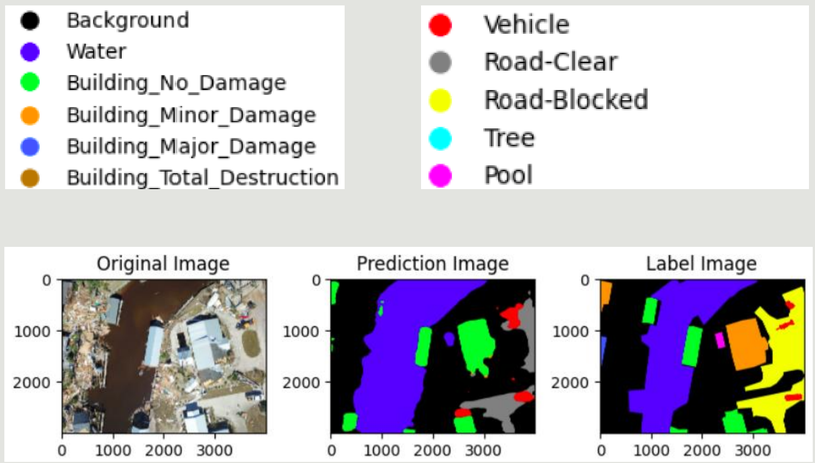
Baseline: Established the initial damage cost estimate using the ground truth labels at 1.25B for the test set.

Model Training: initialized the DeepLabV3+ model with pretrained weights and fine-tuning. The initial training performed included tuning the learning rate, batch size, optimizer, and number of epochs.

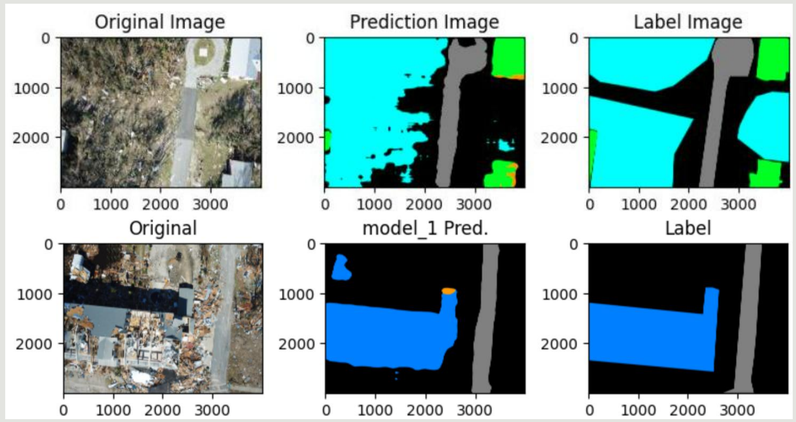
Evaluation Setup: IoU calculation was used to validate the segmentation performance during the training and testing.

Results

Segmentation Performance with 7 Epochs, 8 hrs. of training and a batch size of 25 images.



Initial Segmentation Performance



Quantitative Metrics:

- IoU score: 0.506
- Avg. Training Loss: 0.541

Damage Cost Calculation (5 test images):

- Average pixel-wise accuracy: 81.65%
- Average percent cost error: 178.24%

Future Work

- This project focused on creating a model that had good accuracy, with a secondary objective of quick response. Developing a quick response system could be an area of further development.
- Further work can develop the cost-estimating figures. These figures will change according to various factors such as country, demographics, etc.
- Additionally, another point of interest is that the current model only focuses on 2D images, while a skyscraper would have a much larger cost ratio than a house.

References

[1] T. Chowdhury, R. Murphy, and M. Rahnemoonfar, "RescueNet: A High Resolution UAV Semantic Segmentation Benchmark Dataset for Natural Disaster Damage Assessment," arXiv.org, Feb. 24, 2022. https://arxiv.org/abs/2202.12361