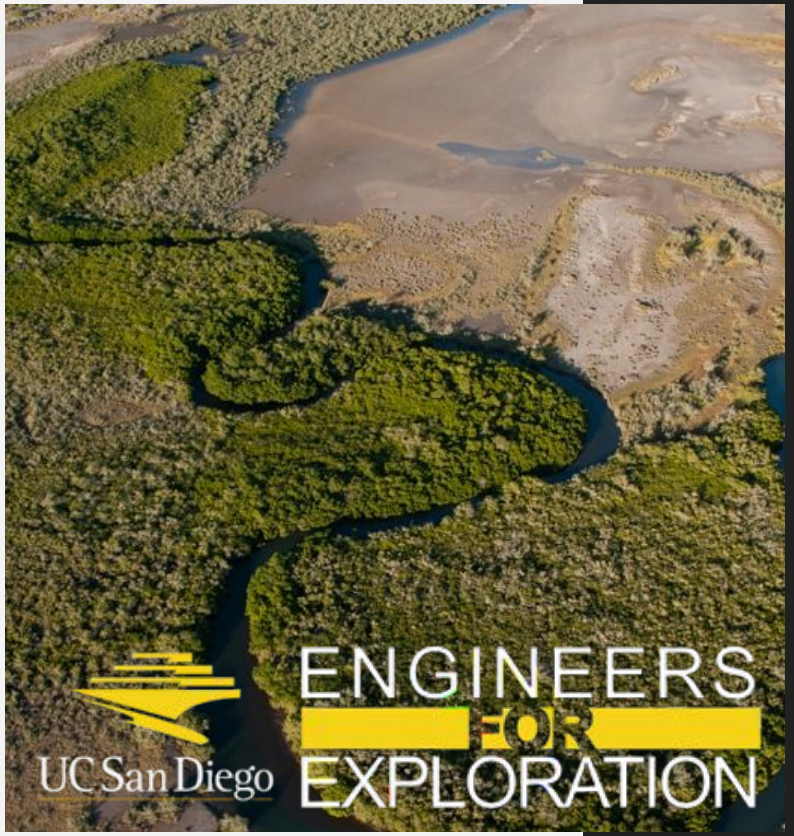
Mangrove Ecosystem Detection using Mixed-Resolution Imagery with a Hybrid-Convolutional Neural Network



What are Mangroves?

Mangroves are a type of tree species that live in the intertidal zones of the coasts of tropical areas in over 118 countries.

Why mangroves?

Carbon Sequestration

Mangroves can absorb almost twice as much CO2 in their roots compared to tropical rainforests

Protection from Tropical Storms

Mangroves act as natural storm breaks, preventing damage to communities

Fisheries

Mangroves offer critical nursing habitats for thousands of fish species

High Value

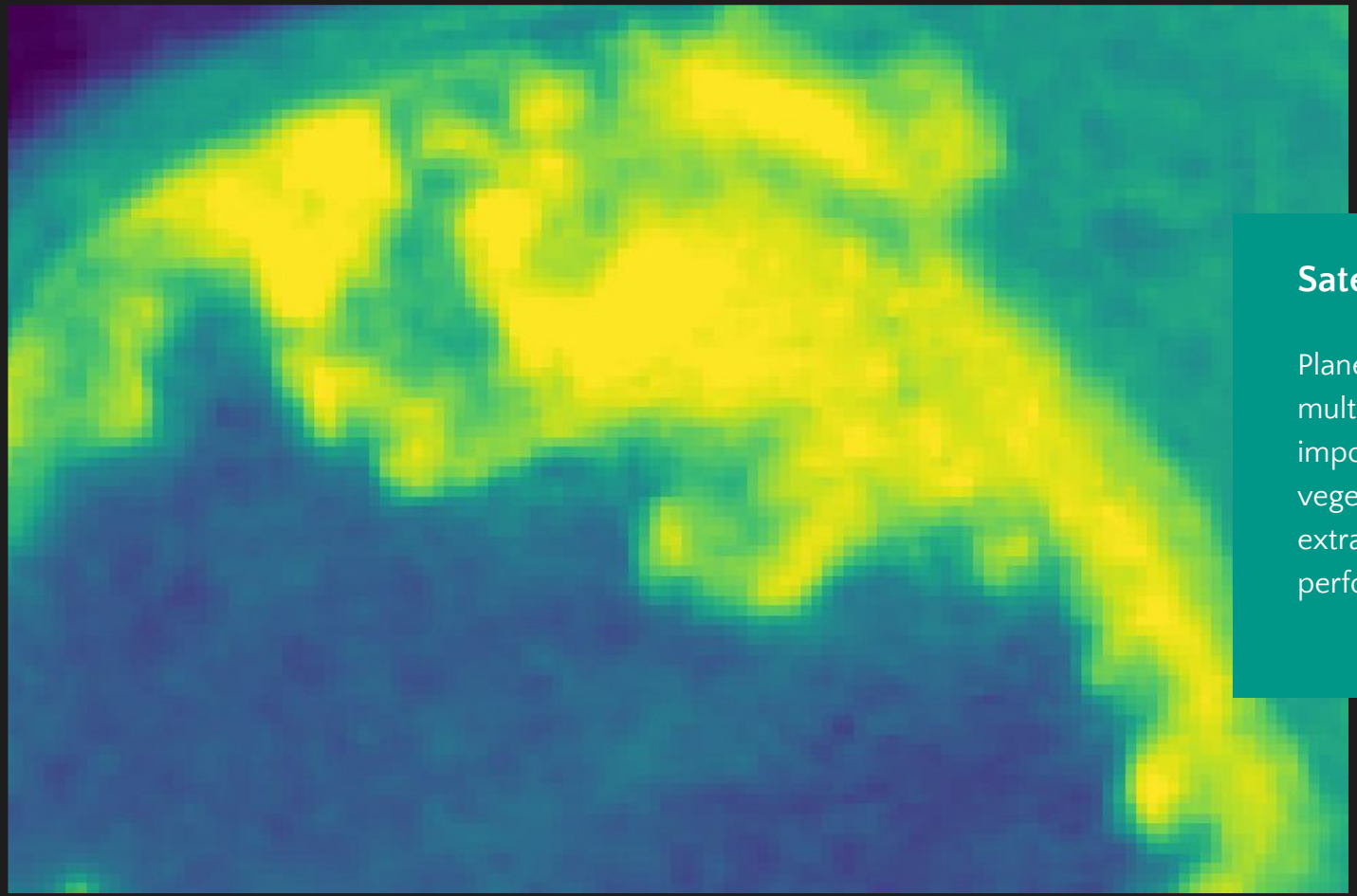
Because of these services, mangroves are worth up to $57,000 per hectare

Mangrove Extent

Mangrove Extent can be used as a direct measurement for their productivity - including their economic value - how can we measure it?

Satellite Imagery

We acquired lower resolution Skywatch PlanetScope imagery (3m/pixel) to offer multispectral bands for our ML algorithms



Satellite Imagery

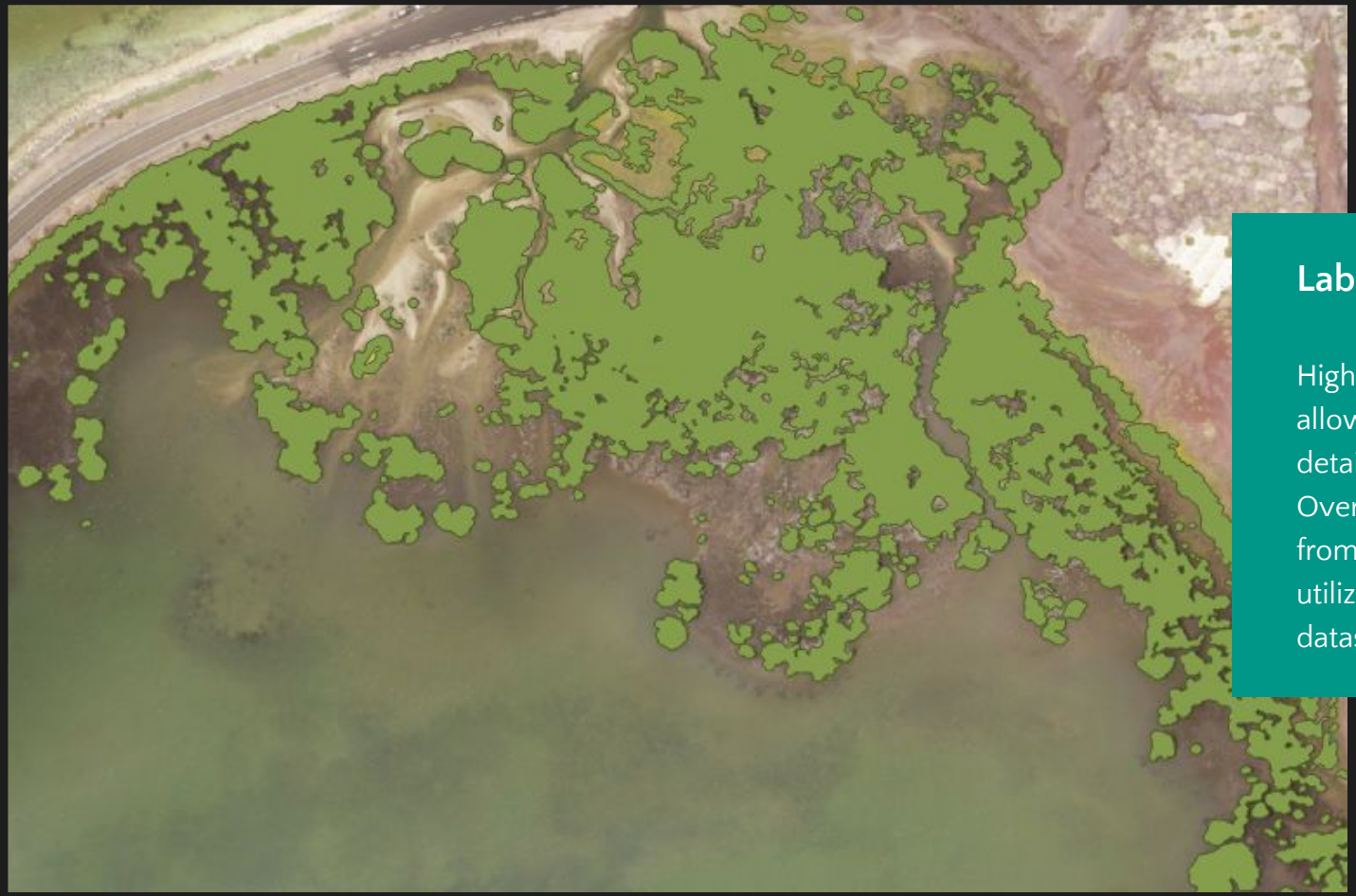
Planetscope Imagery is multispectral, and thus important features such as vegetation indices can be extracted for better ML performance

Drone Imagery

We fly surveys with our collaborators in Mexico to acquire recent, high resolution Drone imagery of mangroves

Drone Imagery

We have over 10TB of imagery with a resolution of 3cm/pixel, much higher than that of our satellite imagery (3m/pixel)
Made using Agisoft Metashape



Labels

High resolution imagery allows us to make highly detailed labels using QGIS. Over 1500 person hours from volunteers was utilized to make our label dataset.

Use already existing labels
Global Mangrove Watch

No Development Needed

Global Mangrove Labels can be downloaded - with a catch

No Flexibility

Pixel Classifier using SAR satellite data at a resolution of ~15m^2/pix with the Extremely Randomized Trees Algorithm

Use already existing labels

Global Mangrove Watch

0.662

(IOU)

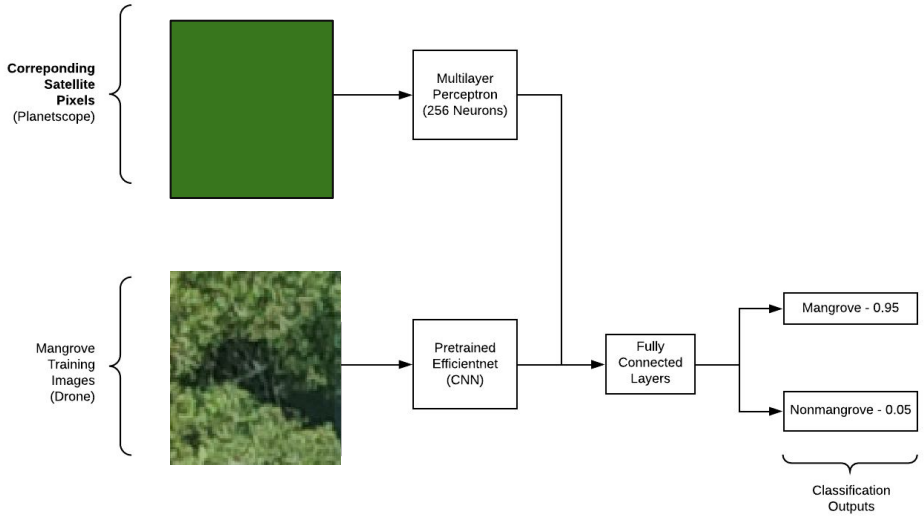
Improving Accuracy

We created a novel Hybrid-CNN that uses both satellite pixels and drone tiles to generate mangrove classification maps of higher accuracy.

Such a network can use both the high resolution image features of our drone imagery and multispectral bands of satellite images for better extent estimations.

IOU: 0.949

Hybrid CNN Architecture

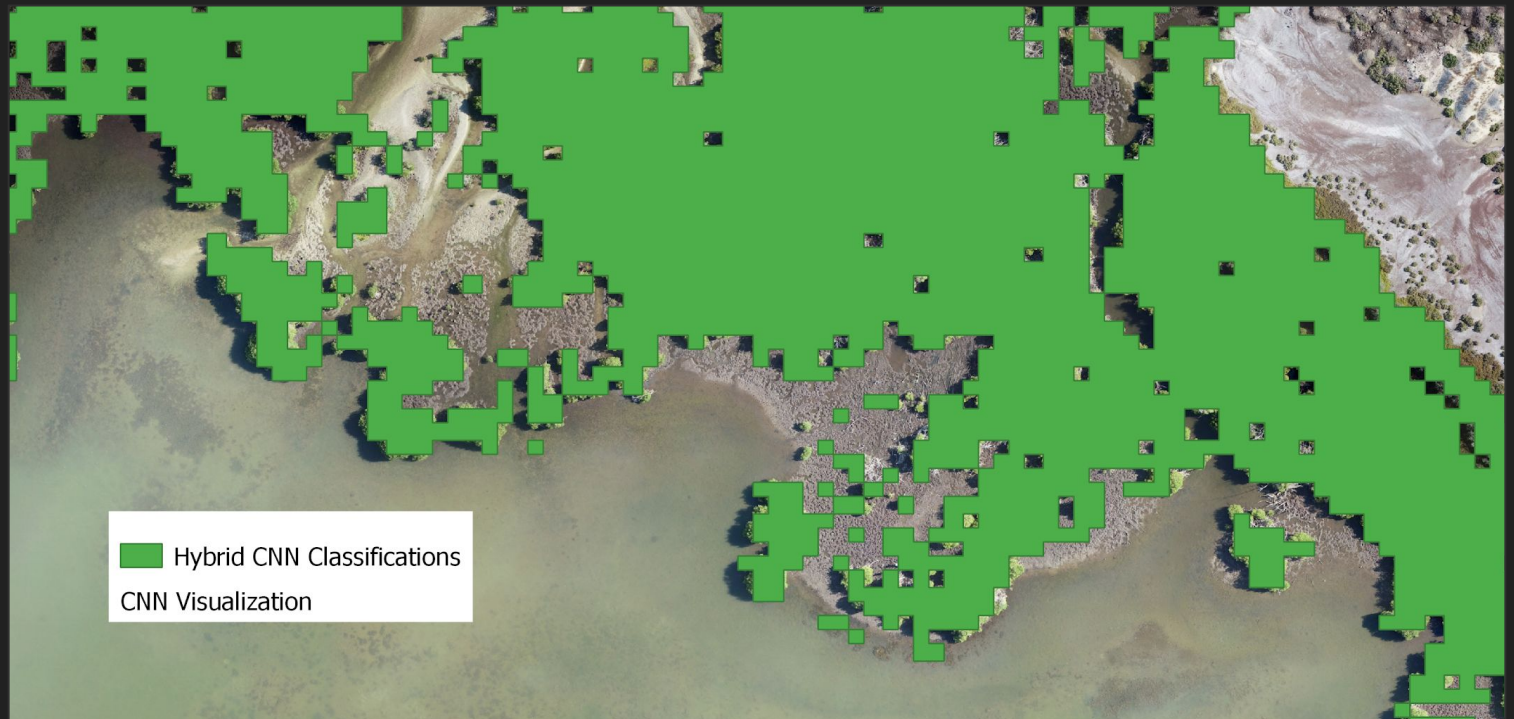


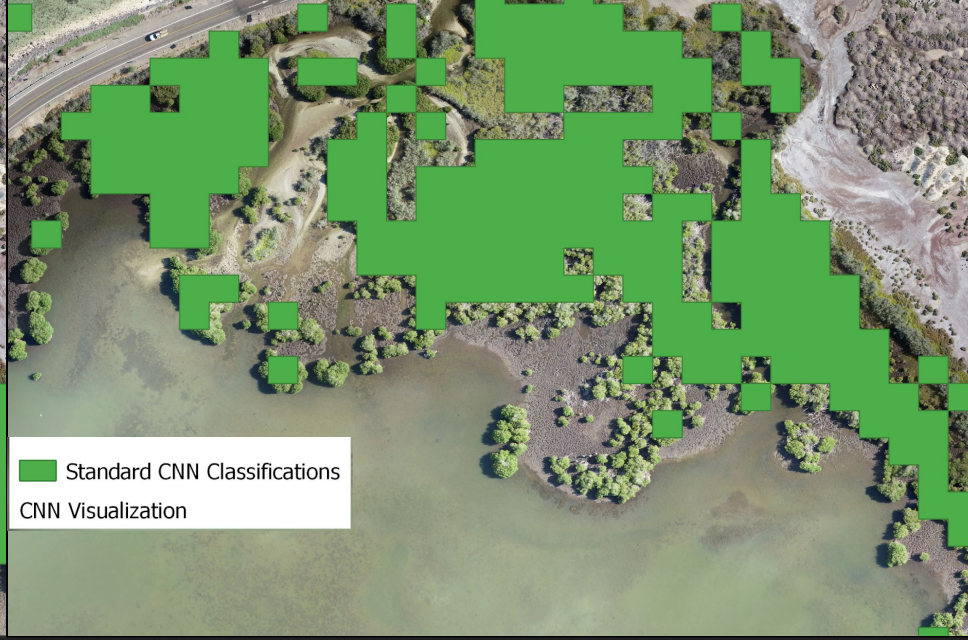
Hybrid CNN

Satellite + Drone Features

Better (and more) features lead to much better performance!

0.949
(IOU)





Hybrid CNN

Local 3m resolution labels from high resolution drone imagery and medium resolution satellite imagery

0.949 (IOU)

0.898 (IOU)

Standard CNN

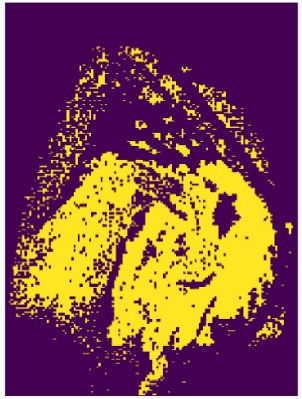
Local 8m resolution labels from high resolution drone imagery

a. Ground Truth

b. Hybrid CNN

0.949

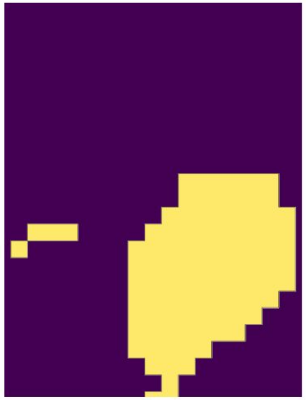
(IOU)



c. Baseline CNN (Efficientnet-b0)

0.898

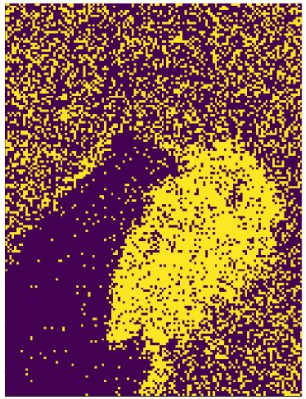
(IOU)



d. GMW Labels - 2016

0.662

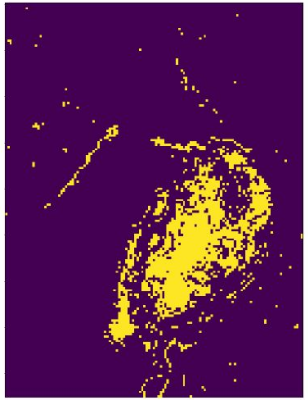
(IOU)



e. Random Forest (NDVI)

0.730

(IOU)

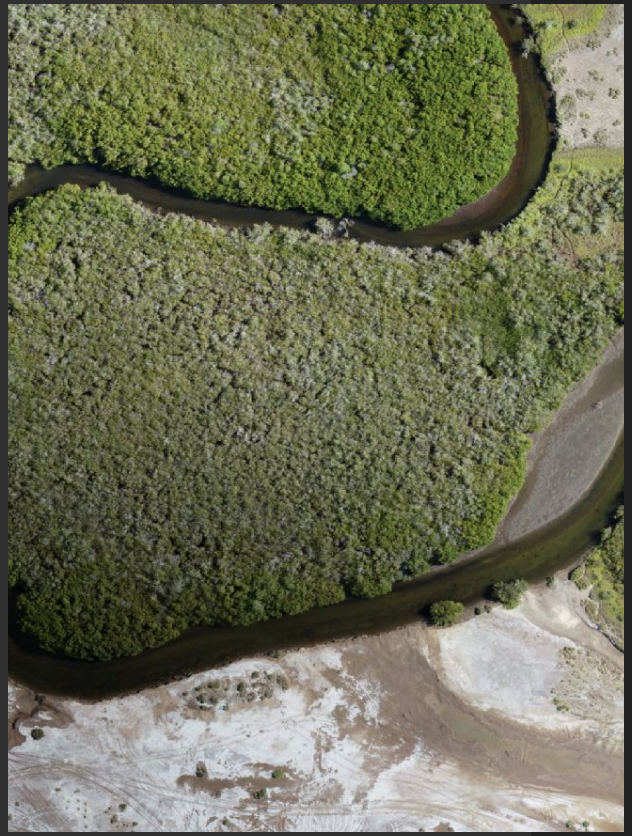


f. Random Forest (RGB/NIR + NDVI)

0.824

(IOU)

Our Hybrid CNN beats all of our baselines at a resolution of our planetscope imagery



Conclusion

Future Steps

- Release our dataset of Mangrove Labels
- Implement Hybrid UNet for higher resolution classifications

More info:

Engineers for Exploration:
http://e4e.ucsd.edu

Mangrove Monitoring:
https://ucsd-e4e.github.io/mangrove/

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