HyperionSolarNet

Solar Panel Detection from Aerial Images

Nathan Nusaputra | Poonam Parhar | Ryan Sawasaki | Felipe Vergara

UC Berkeley

Capstone Showcase

Motivation

- Fight climate change by integrating solar energy

- Idea originated from Professor Paolo D'Odorico, Chair of the Department of Environmental Science at UC Berkeley

- Solar energy output determined by:
  - Solar irradiance
  - Solar panel location and size (HyperionSolarNet)

- HyperionSolarNet uses deep learning methods and satellite imagery to identify solar panel locations and estimate their total surface area

- Target users include energy companies, policy makers, environmental agencies, market analysts, and solar panel companies.
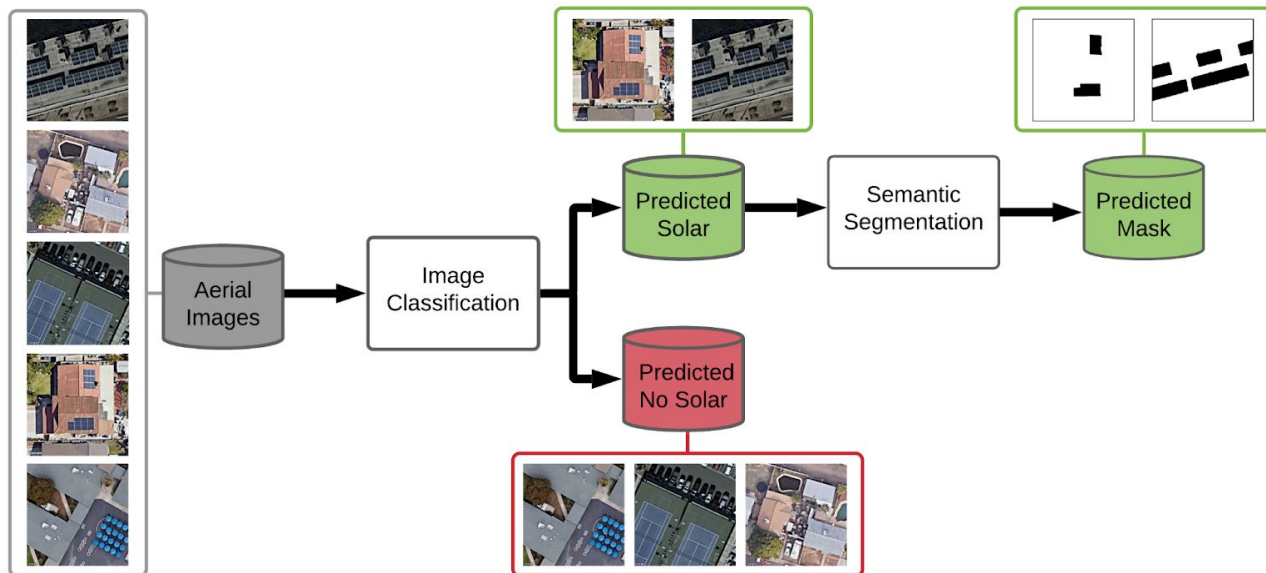
HyperionSolarNet

- Start with input data of satellite images from Google Maps

- Binary image classification model separating into solar and no-solar classes

- Segmentation model performs the task of classifying each pixel to its specific class

- Predicted masks are further processed to determine the area and number of solar panels

Data

- Images from Arizona, California, Colorado, Florida, Hawaii, Idaho, Louisiana, Massachusetts, Nevada, New Jersey, New York, Oregon, Texas, Washington

- Zoom 20 and 21

- Sizes 416x416 and 600x600

- Residential and Commercial

- For no-solar images, focus on objects that could be misclassified as solar panels, for example:

Classification Dataset			
	Solar	No-Solar	Total
Training	668	1295	1963
Validation	168	324	492
Berkeley Testset	321	1922	2243

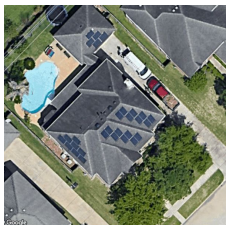| Segmentation Dataset	
Training	668
Validation	168
Berkeley Testset	321

Skylights
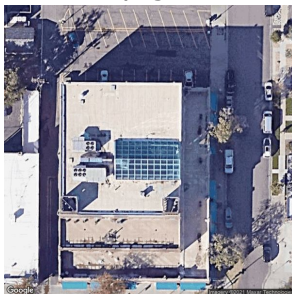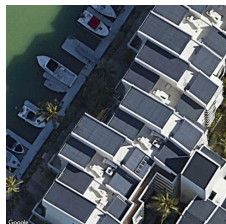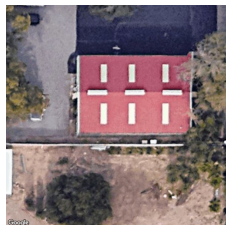

Crosswalks
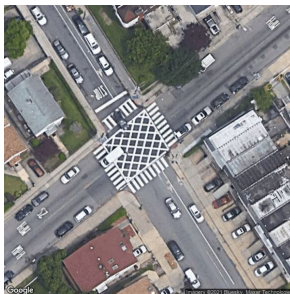
Side of tall buildings
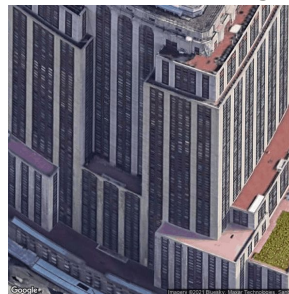
Data Labeling

Classification:

- Manually grouped images into solar and no-solar classes

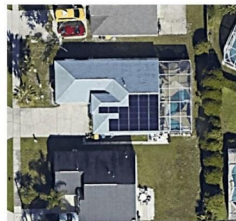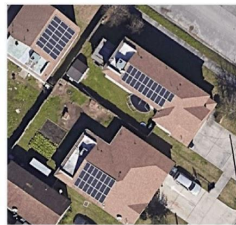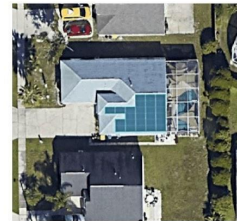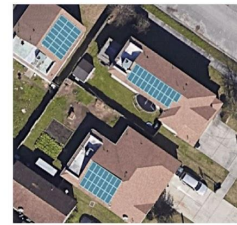- Time spent locating quality and diverse solar panel images
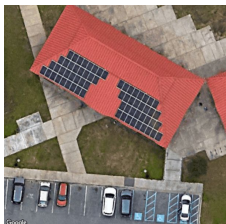
Segmentation:

- Used LabelBox platform to annotate solar panel images and create segmentation masks (labels)

- Labeling of 1,200 images required additional resources

Solar   No-solar

Human annotated images in LabelBox
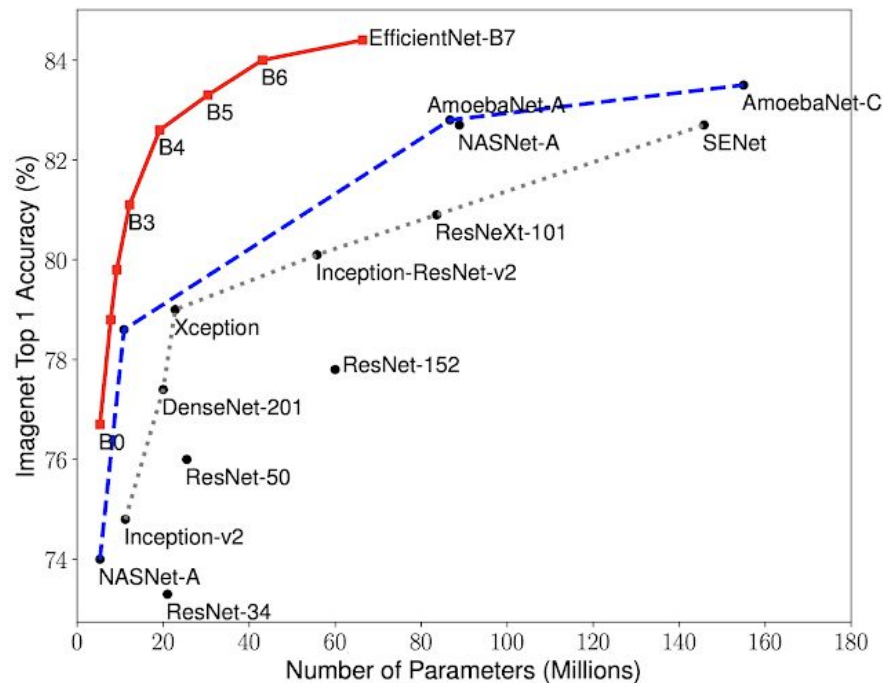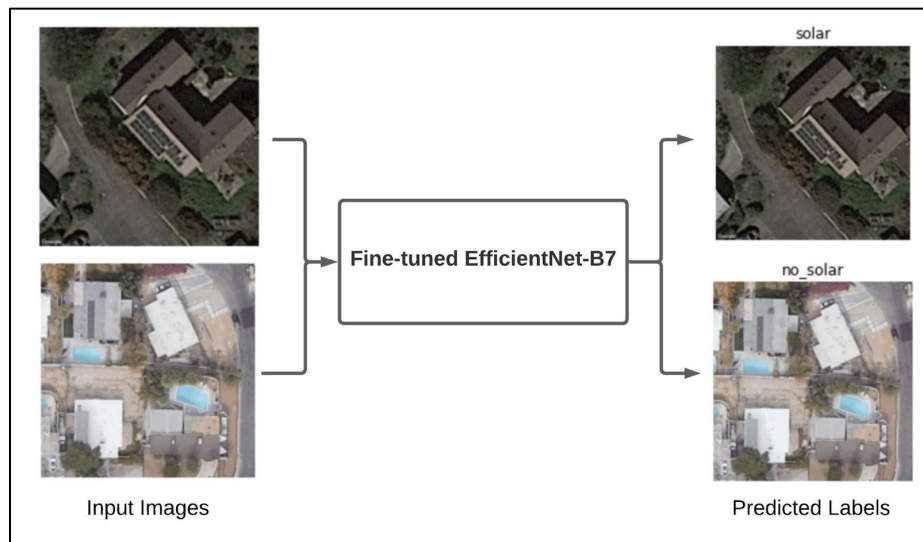
Classification Model

- Transfer Learning

- Fine-tuned EfficientNet-B7 for solar panel images

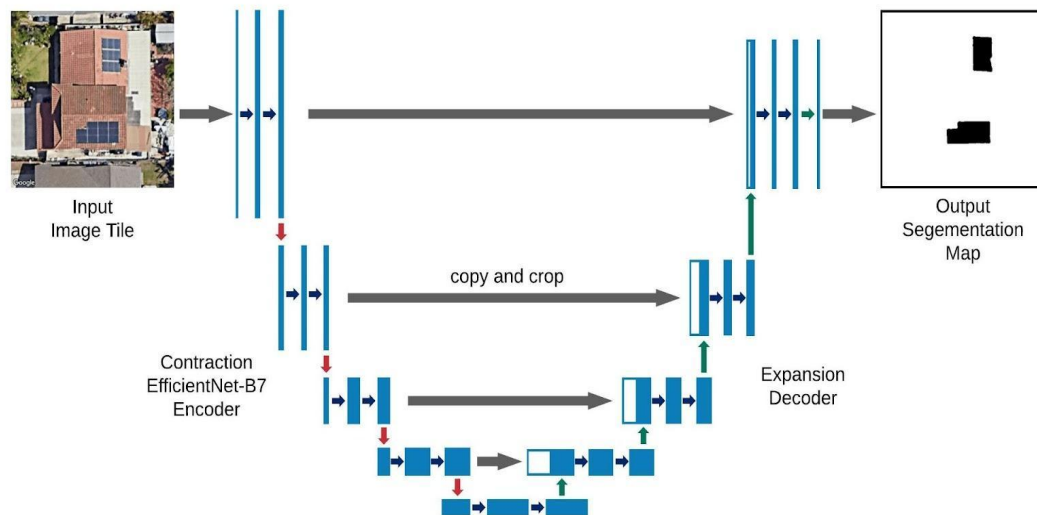# Semantic Segmentation Model

- U-Net is one of the most popular deep learning based semantic segmentation method

- U-Net architecture with EfficientNet-B7 backbone

- Images augmentation using Albumentations library

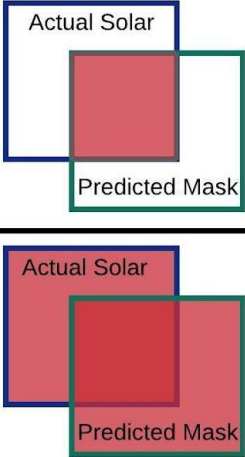- Model training using Segmentation Models library

Input Image Tile

Output Segementation Map

copy and crop

Contraction EfficientNet-B7 Encoder

Expansion Decoder

Performance Metrics

- Accuracy, Precision, Recall and F1-score for the Classification Model

- IoU and F1-score for the Segmentation Model

Intersection over Union (IoU) = $\dfrac{\text{Area of Intersection}}{\text{Area of Union}}$

Classification Model Performance

Model	Accuracy	Precision	Recall	F1 Score
Baseline	0.7240	0.66	0.81	0.73
HyperionSolarNet	0.9764	0.95	0.98	0.97
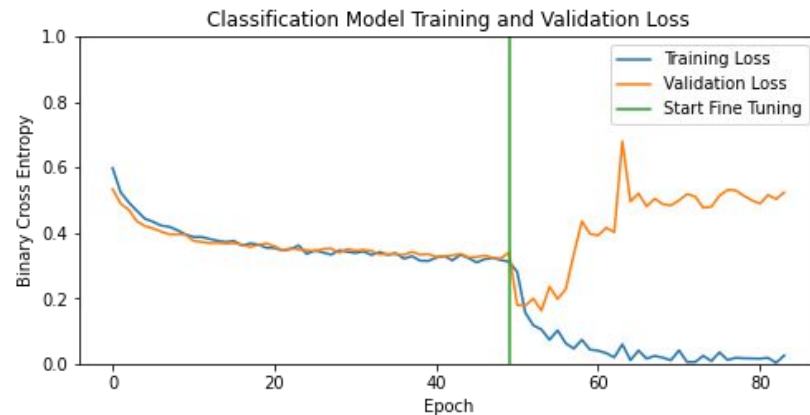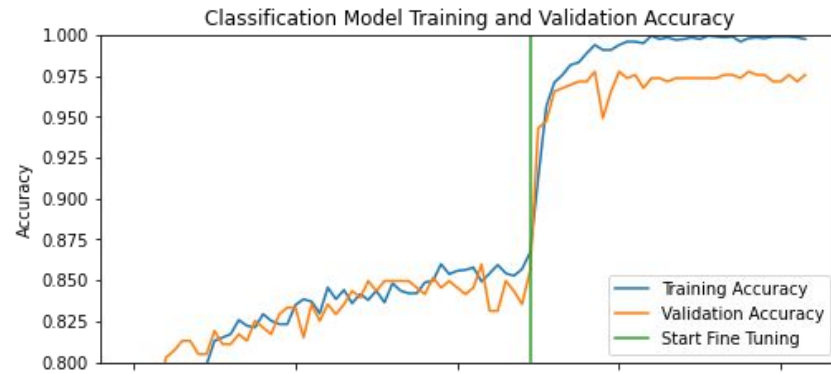
Classification Model Training and Validation Accuracy

Classification Model Training and Validation Loss

Segmentation Model Performance

Segmentation Model Training and Validation IoU

Segmentation Model Training and Validation Loss
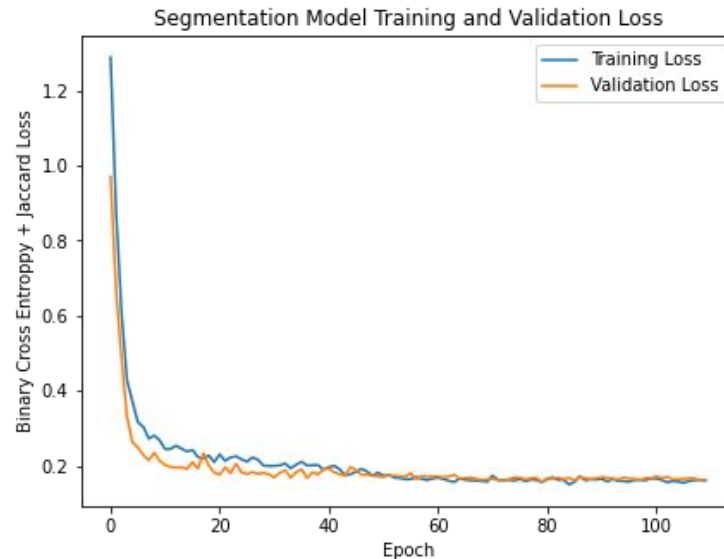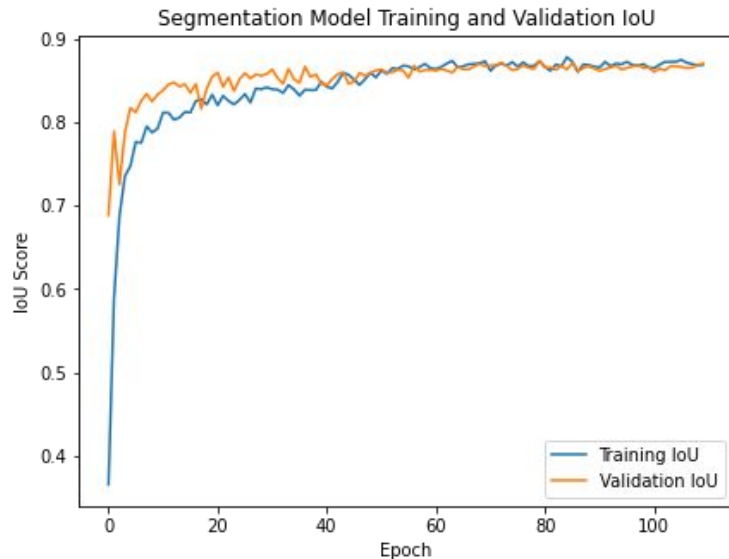
Model	IoU Score	F1 Score
Baseline	0.8107	0.8841
HyperionSolarNet Segmentation Model	0.8591	0.9197

Segmentation Examples
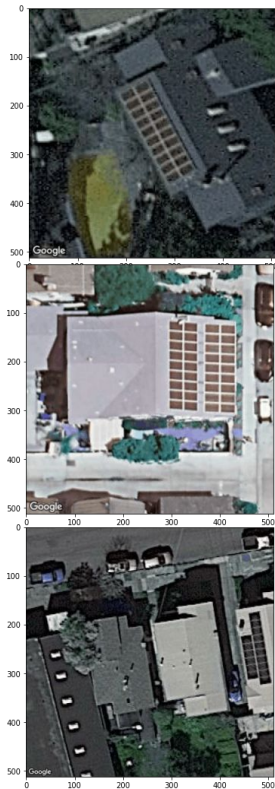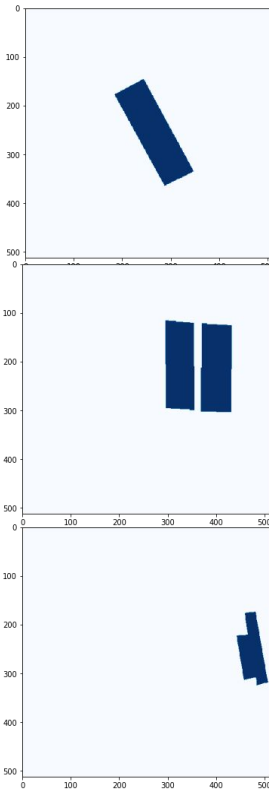
Satellite Image   Label   Prediction
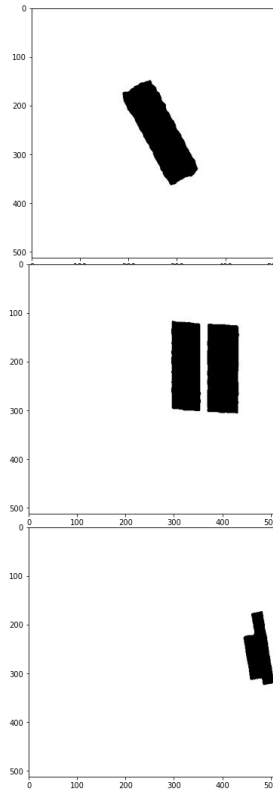
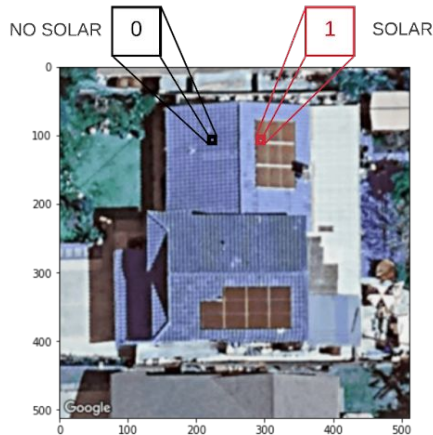# Number and Size Estimation

- Segmentation model produces 600x600 matrix of 1's and 0's

- Function inputs are latitude, zoom and matrix from segmentation model

- Meters per pixel calculation is derived from Mercator Projection

  `meters_per_pixel = 156543.03392 * math.cos(latitude * math.pi / 180) / math.pow(2, zoom)`

- Output is the total area and number of solar panels in the image

Berkeley Testset

Class	Precision	Recall	F1	Support
no-solar	0.98	0.97	0.98	1922
solar	0.82	0.91	0.86	321

Berkeley Testset

Segmentation	IoU	F1
Berkeley Testset Evaluation	0.8243	0.8922
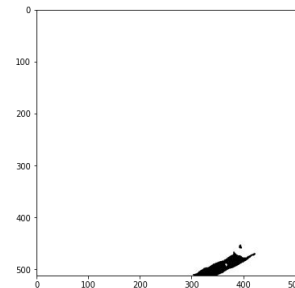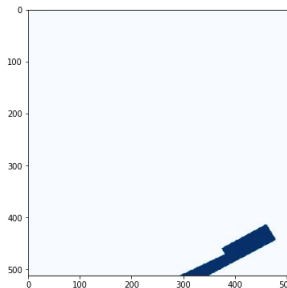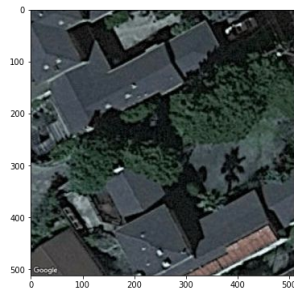
Berkeley Testset	Area (sq. ft.)	Number of Solar Panels
Actual	101,765.48	5,787
Predicted	102,609.72	5,828
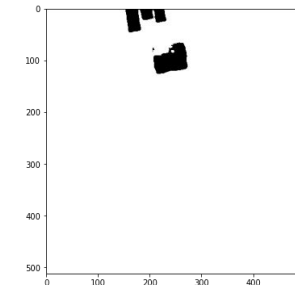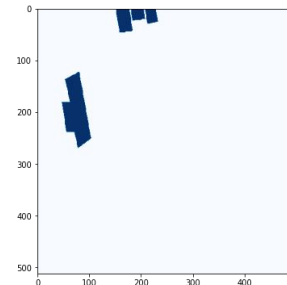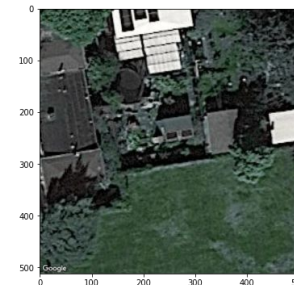
Berkeley Final Results
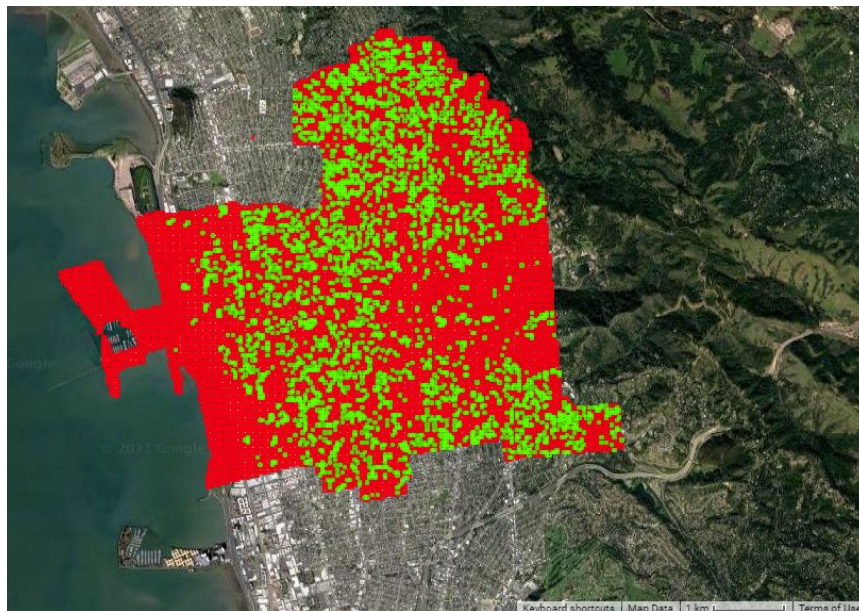
Berkeley City	Area (sq. ft.)	Number of Solar Panels
Estimated Berkeley Solar Panels	1,082,431.98	61,480

System Architecture
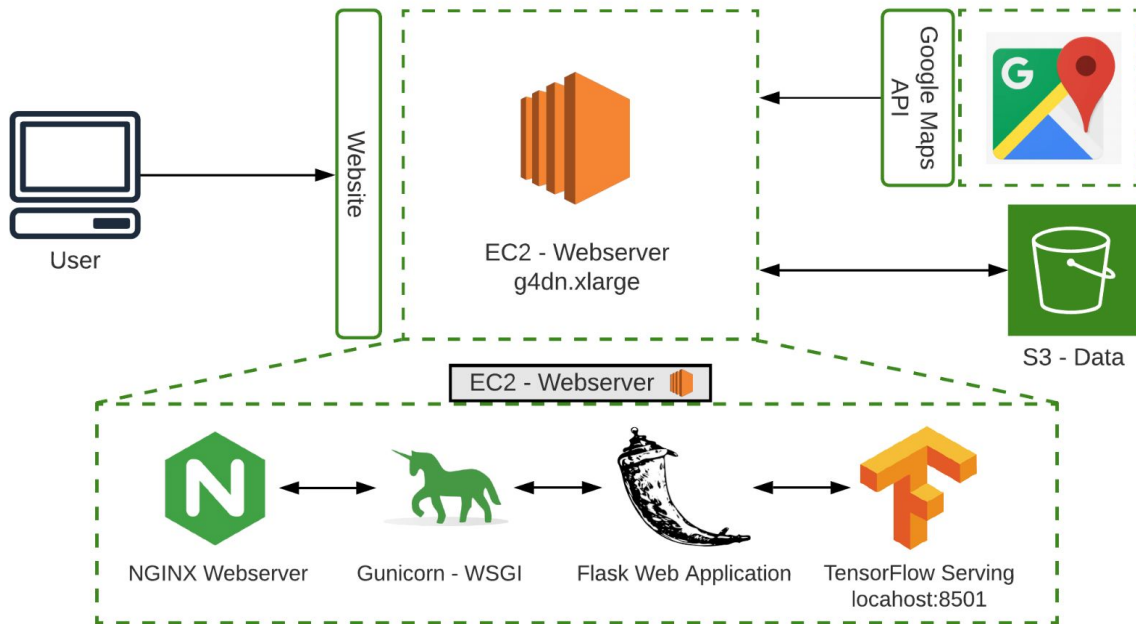
Offline Inference

API
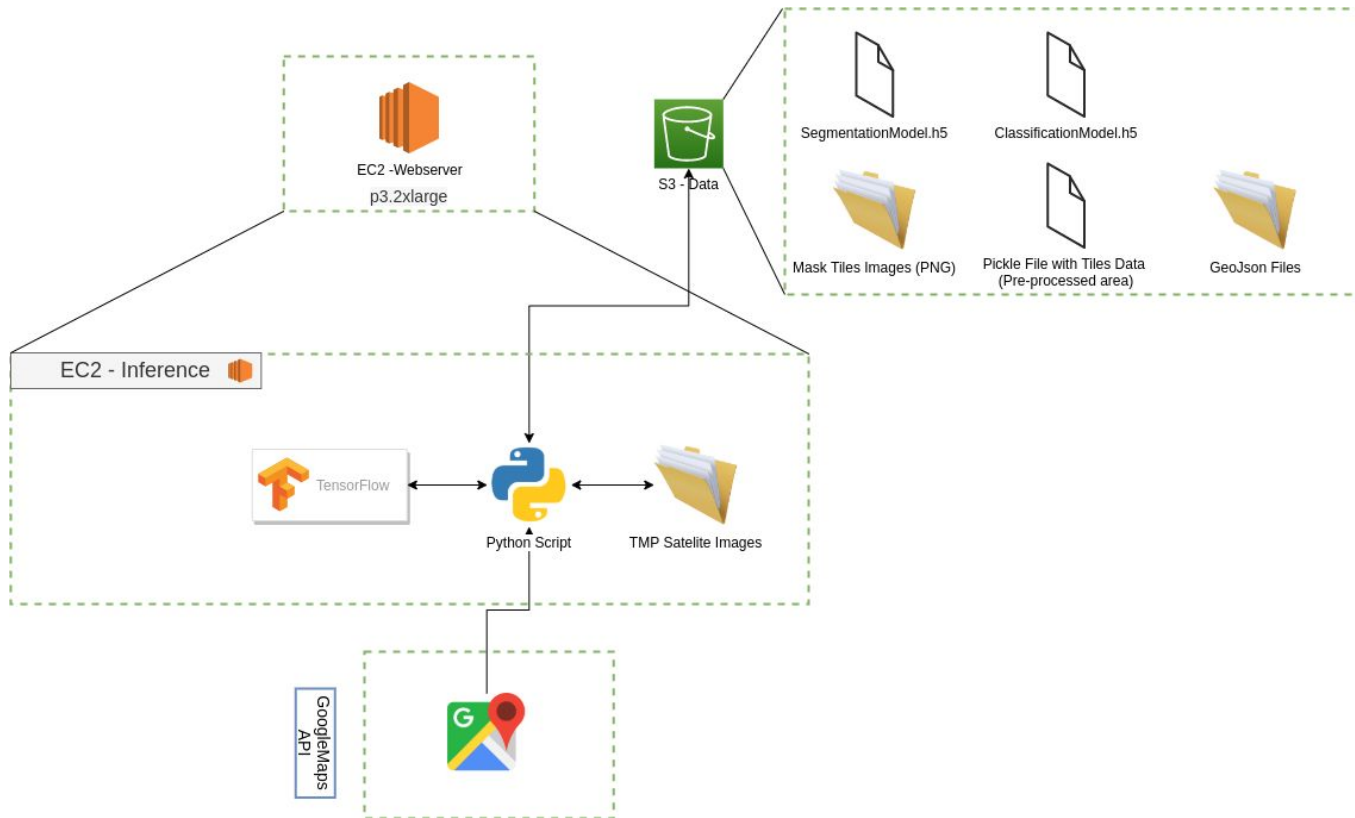
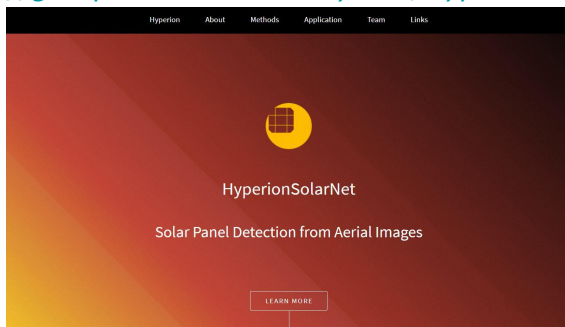| API	Input	Output	Method	Example curl
api/classification	Form-data: bounds	1. JSON with tiles information 2. Prediction whether image tiles contain solar panels	POST	curl --location --request POST 'http://www.hyperionsolarnet.com//api/classification' \ --form 'bounds="21.32556150142789,-157.80387642931356,21.32593628430245,-157.8030717666091"
api/segmentation	Form-data: bounds	1. JSON with tiles information 2. Number of solar panels within bounds 3. Total area of solar panels within bounds	POST	curl --location --request POST 'http://www.hyperionsolarnet.com/api/segmentation' \ --form 'bounds="21.32556150142789,-157.80387642931356,21.32593628430245,-157.8030717666091"'

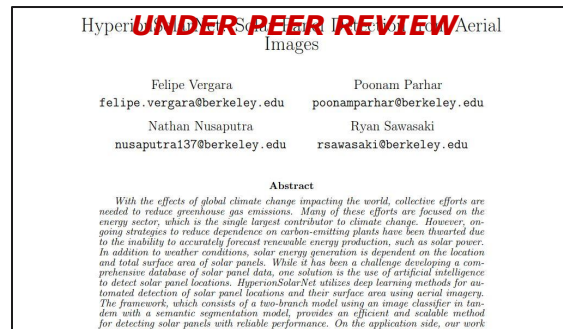# Web Application Demo
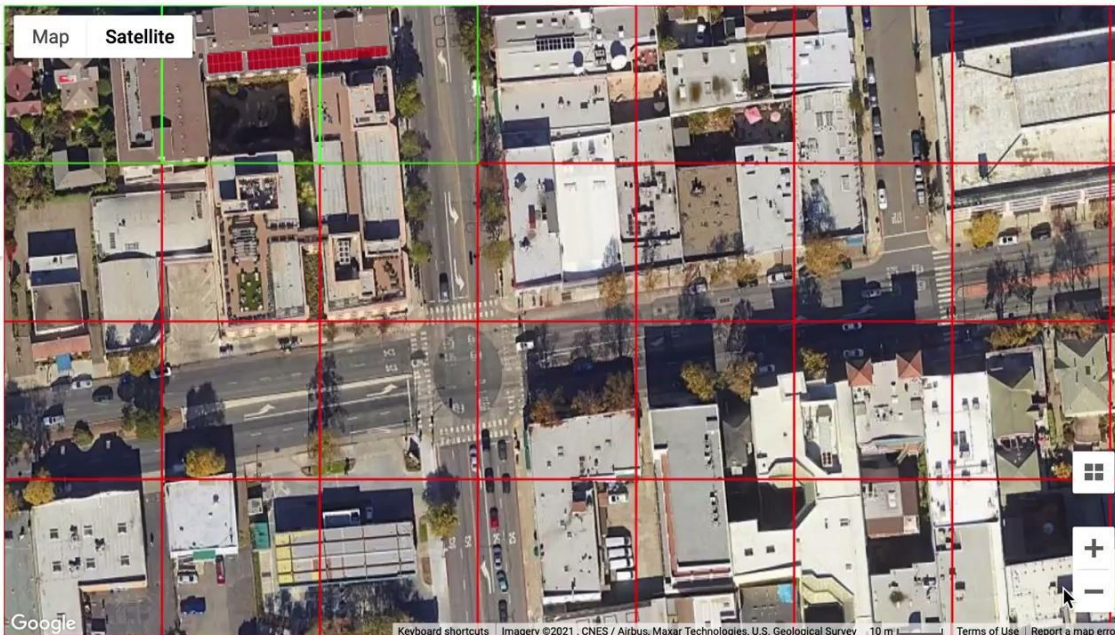
Conclusion

- Future Work includes:

  - Applying HyperionSolarNet to diverse locations around the world

  - Use results for further improvement of model

  - Integrate solar irradiance models to predict total solar energy output
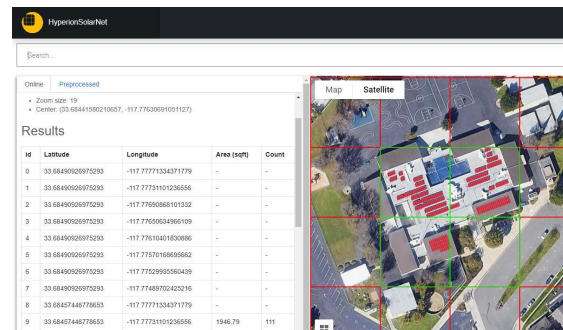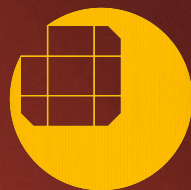
- For additional information, please see:

WEBSITE
https://groups.ischool.berkeley.edu/HyperionSolarNet

RESEARCH PAPER

WEB APPLICATION
http://hyperionsolarnet.com

Thank you! Any Questions?