CS 230
DEEP LEARNING

Final Project

"Solar Digital: Mapping Solar Panels using Satellite Imagery"

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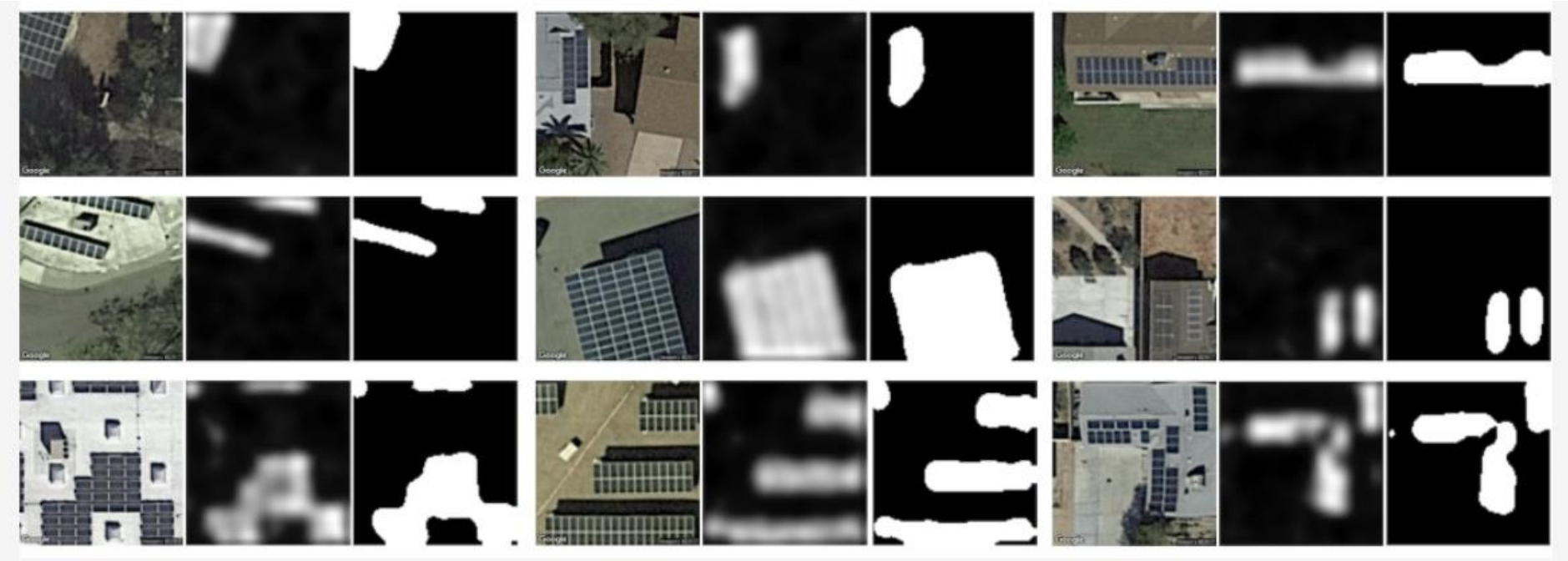
INTRODUCTION

- Climate change is the hot (no pun intended) topic right now!!
  - Reducing current and future greenhouse gas emission (*1.5°C Paris Agreement*)
  - Moving from fossil fuel energy sources to clean energy sources
  - One major renewable sources of energy is **SOLAR** Energy
- A comprehensive database of solar panels is currently not available
  - Collection through voluntary surveys is often incomplete and outdated
  - High-resolution satellite imagery offers a rich data source
  - Profiting from Deep Learning advancements in recent years?
- Building a large-scale solar project database can be highly beneficial
  - Assisting analysts and policymakers in defining strategies for further expansion
  - Accurate information of location and size can improve predictions of solar energy output

RELEVANT WORK

- DeepSolar (2018): Baseline Model?
  - Built a large-scale solar photovoltaics map of the United States
  - “Google Inception V3” for classification of solar panel images (Accuracy 0.93)
  - Computed area using Class Activation Maps (No supervised learning)

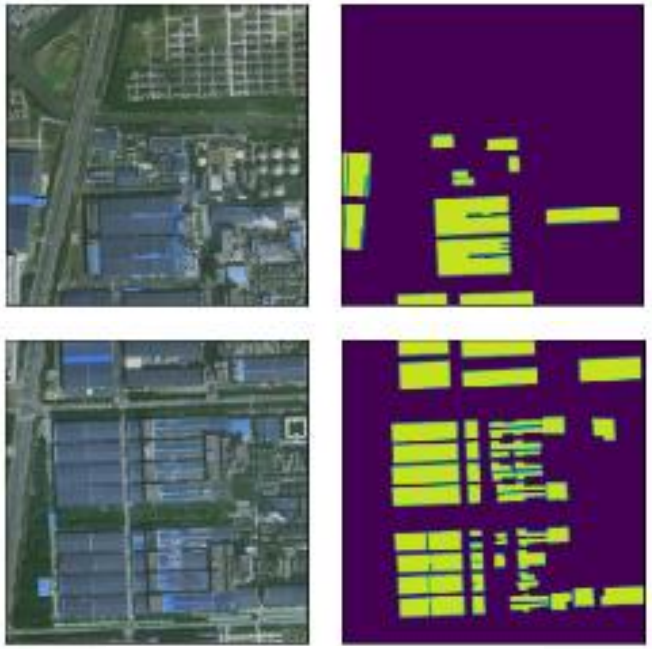


DATASET

- Classification Dataset:
  - 21, 520 total images; 5,380 positive (1) and 16,140 negative (0)
- Segmentation Dataset:
  - 3,716 images with corresponding mask layers (1: solar & 0:non-solar)

Positive examples

Negative examples



Segmentation Training Dataset

CLASSIFICATION MODEL

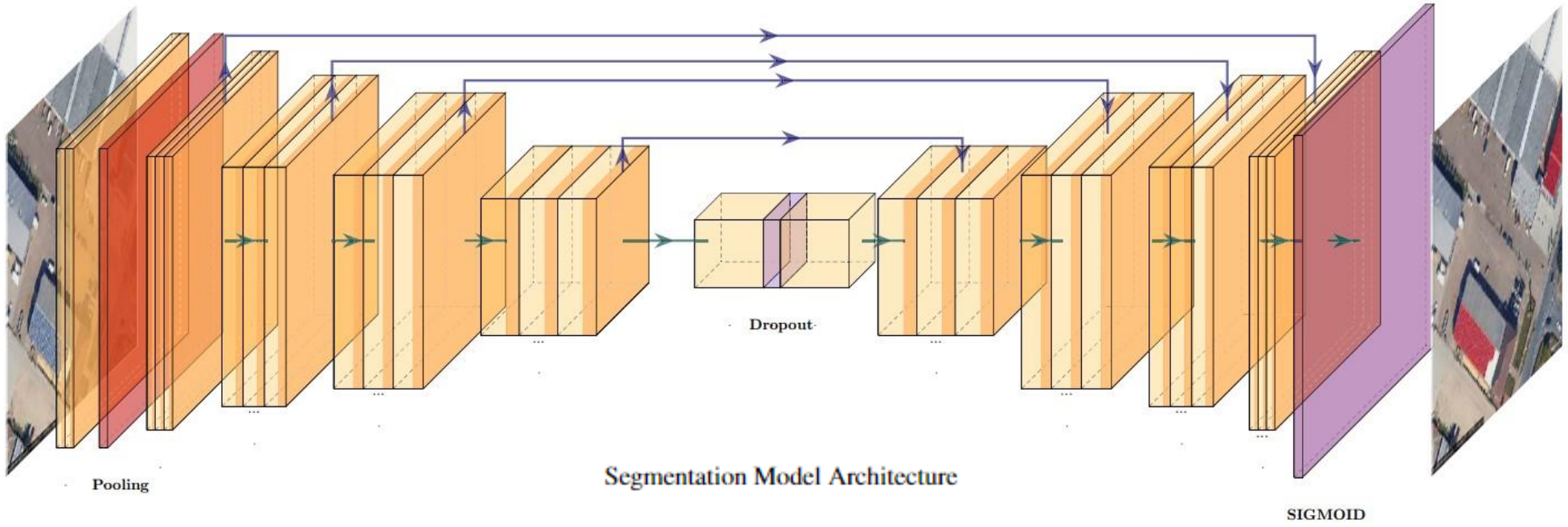
- ResNet-34 CNN architecture pretrained on ImageNet:
  - Loss Function: "Binary cross-entropy loss"
  - Performance evaluation metric: Accuracy (priority), Precision and Recall
- Training experiments and hyperparameters:
  - Train/validation/test split of 90%/5%/5% (batch size = 32)
  - Optimizer: Adam; learning rate: 1e-04; Epochs: 2
  - Final Model performance in **Table 1**

Table 1: Classification Model Performance

	Loss	Accuracy	Precision	Recall
Training	0.02	0.99	0.99	0.98
Validation	0.06	0.99	0.98	0.96
Test	0.05	0.99	0.98	0.96

SEGMENTATION MODEL

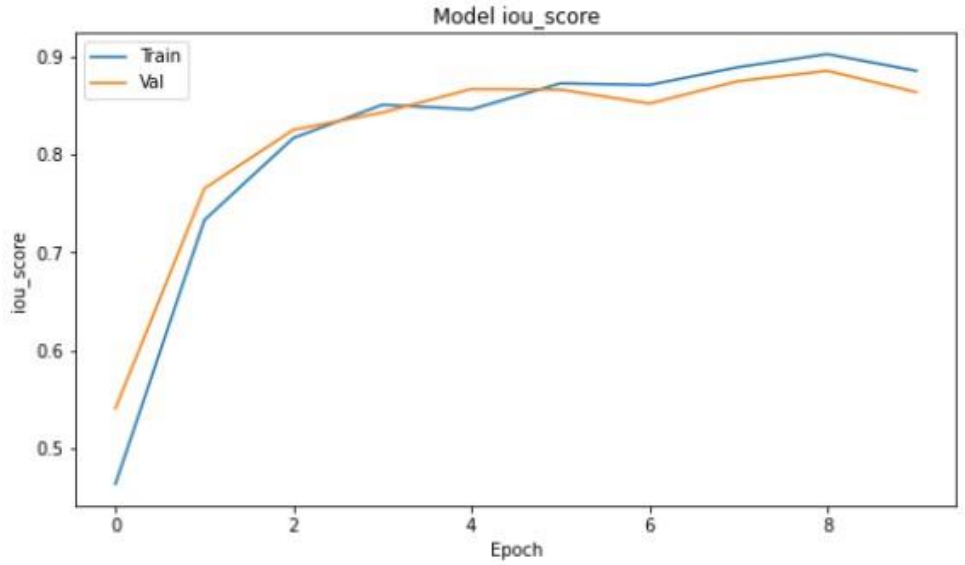
- U-Net architecture:
  - ResNet-34 encoder backbone pretrained on ImageNet
  - Combined "Binary cross-entropy loss" and "Jaccard loss“
  - Performance evaluation metric: IoU (priority) and FScore

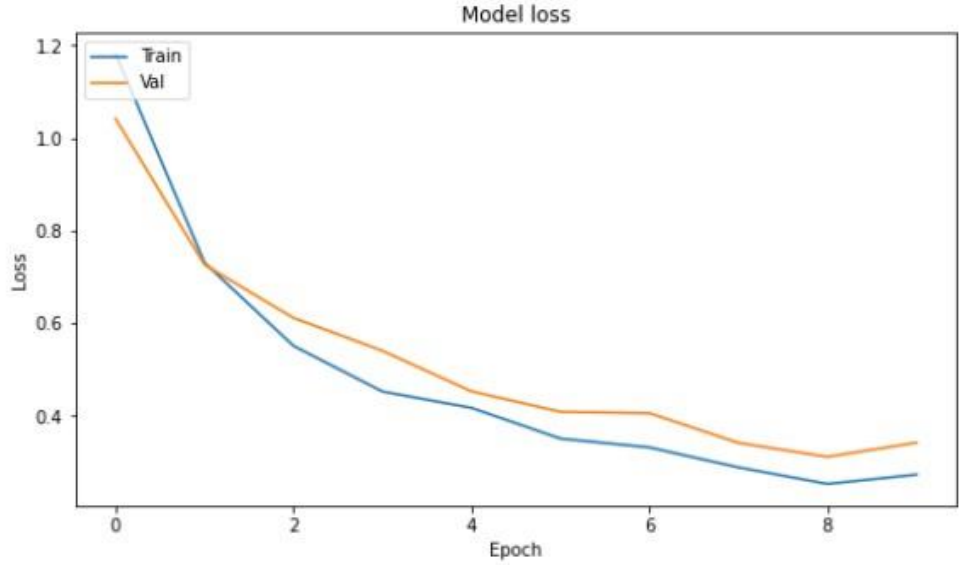


Segmentation Model Architecture

SEGMENTATION MODEL

- Training experiments and hyperparameters:
  - Train/validation/test split of 90%/5%/5%
  - Keras DataLoader function to load each batch (batch size = 16)
  - Optimizer: Adam; learning rate: 1e-04; Epochs: 2 + 10 (fine-tuning)





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  - Final Model performance in **Table 2**

Table 2: Segmentation Model Performance

	Loss	IoU Score	F1 Score
Training	0.27	0.88	0.94
Validation	0.34	0.86	0.92
Test	0.40	0.81	0.85

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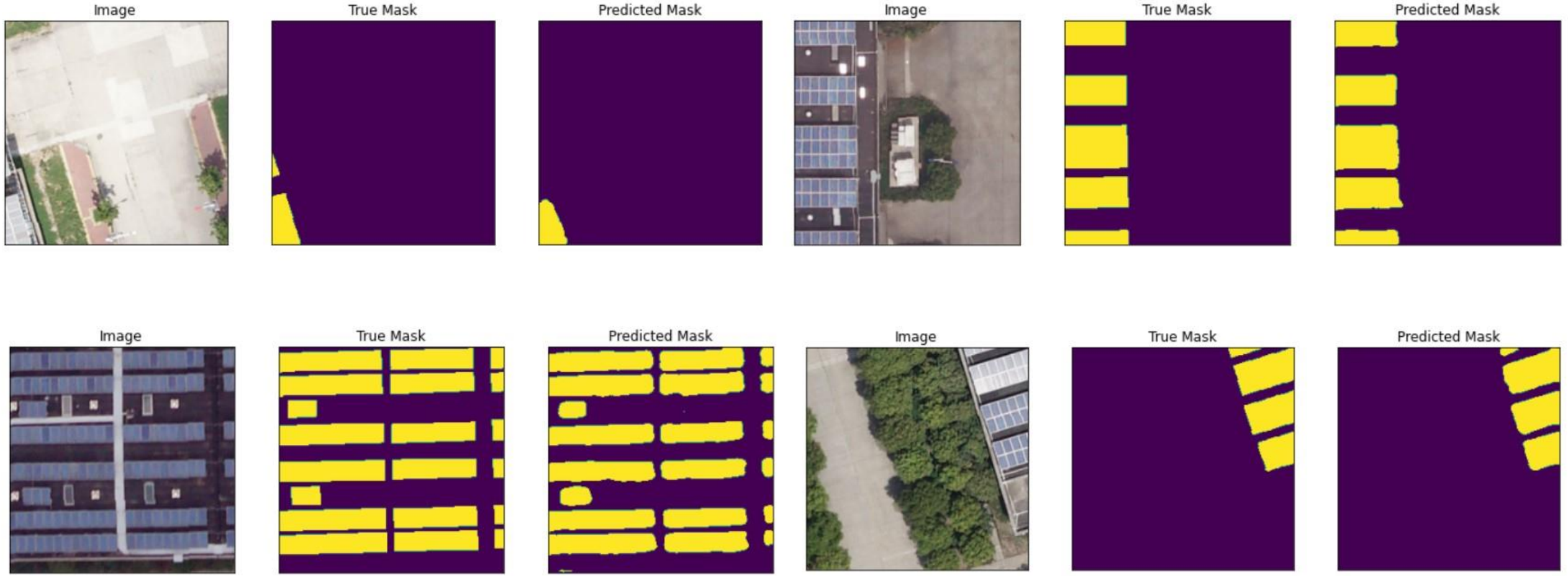
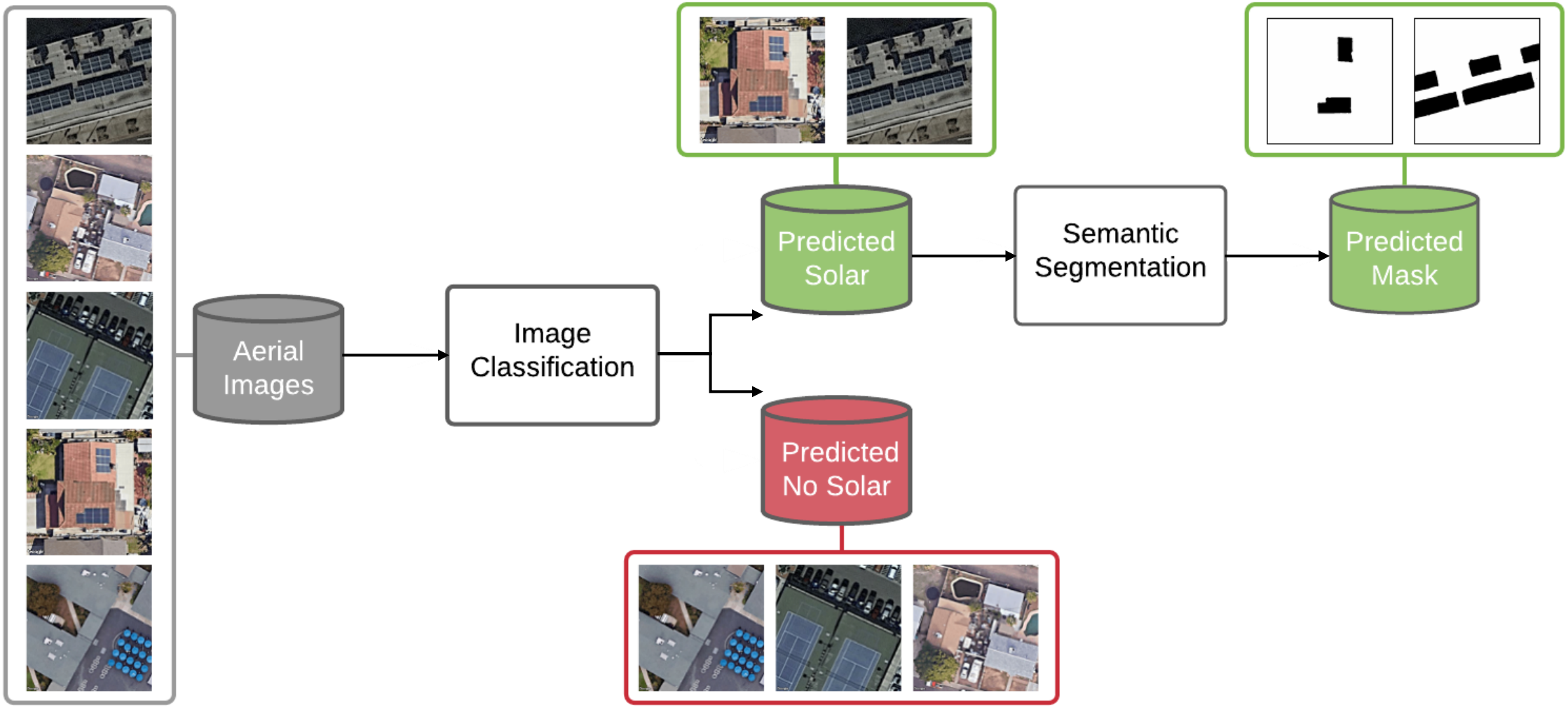
- Solar panel area using Mercator Projection: $\textbf{meters per pixels} = \frac{156543.03392 * cos(latitude * \frac{\pi}{180})}{2^{zoom}}$

FEW TEST SAMPLES



MODEL DEPLOYMENT



CONCLUSIONS

- An urgency to solve climate change crisis by expanding solar energy!
- Our work leverages state-of-the-art deep learning methods
- A two-branch model with a ResNet-34 classifier and a U-Net segmentation model
- Achieved a high accuracy of **0.99** and an IoU score of **0.81**
- However, we also must be aware of some potential negative impacts :
  - surveillance & investigation of compliance with solar energy mandates (*low-income countries*)
- Future work:
  - Improving the IoU with even better segmentation model (maybe under progress right now?)
  - Availability of larger dataset with segmentation masks!


THANK YOU
EVERYONE!!!