Predicting PV Areas in Aerial Images with Deep Learning

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There is a need for distributed PV generation location data

Data on distributed PV installations can be difficult to access for researchers. Aerial or satellite images are a potential source of data, but manual identification is time prohibitive. Computer vision approaches that employ Neural Networks and Deep Learning may automate the identification of PV from images.

U-Net Neural Network architecture with pre-trained weights

Classifying pixels within the image is called “semantic segmentation.” U-Net is a well-established Fully Convolutional Neural Network architecture for this task. Starting from a network that previously worked for another computer vision task can speed up training. We implemented in python using segmentation_models. Four different backbones were considered (ResNet-18, -34, -50, -101).

Training process optimizes the network for the task at hand

Data was split into training, validation and testing sets with a 81%/9%/10% ratio. While maintaining frozen weights for the encoder, the model was trained for 350 epochs keeping only the case with the best validation loss. The loss function used was a combination of Binary Cross Entropy and Jaccard losses.

Methodology exists to compute pixelwise uncertainty

Monte Carlo dropout allows quantification of uncertainty in output of deep neural network. Works by considering the weights of the neural network to be random variables. We evaluate the network using N=100 different dropout configurations and estimate uncertainty of the predictions using the pixelwise standard deviation.

Identification of PV was validated against test set

Best performance was observed for ResNet-50. Metrics indicating that ~80% of predicted pixels are correct and ~80% of labels are identified. Model showed good performance overall based on qualitative review of results. Several aspects of performance can guide future development and improvement.

Error Analysis reveals a few particularly difficult cases

Considering some common failures may guide improvement.

Conclusions and Future Work

Highly accurate PV panel areas were be predicted on aerial images through the proposed method. With a large-scale aerial image database, highly resolved PV areas could be generated for a large geographic region. Uncertainty estimates mostly relate to the labeling uncertainty of the user. Potential future work is possible concerning evaluation and usage of this uncertainty to improve labeling and model training.

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