

Validating the Global Power Plant Database with Automatized Recognition of Wind Turbines on Google Maps

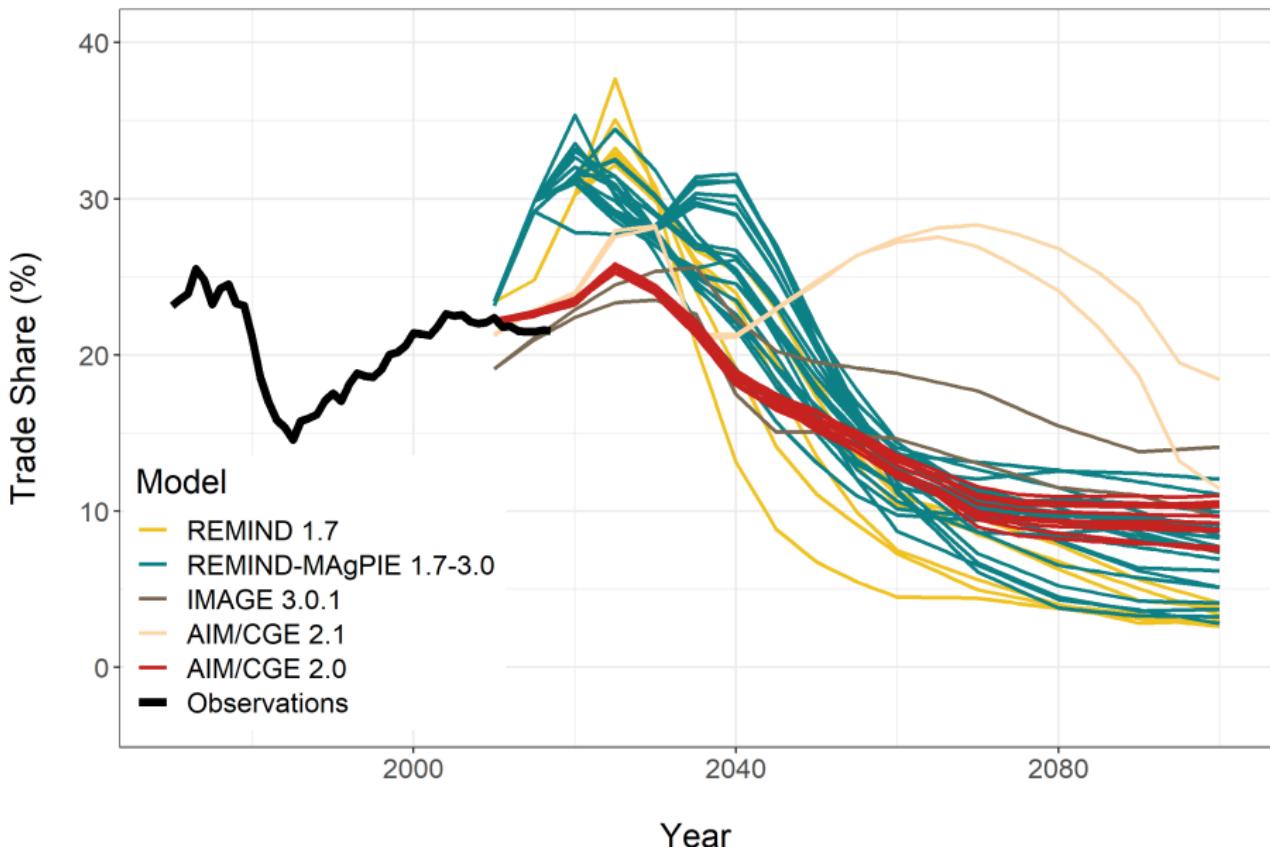
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Introduction to reFUEL (I)



Introduction to reFUEL (II)

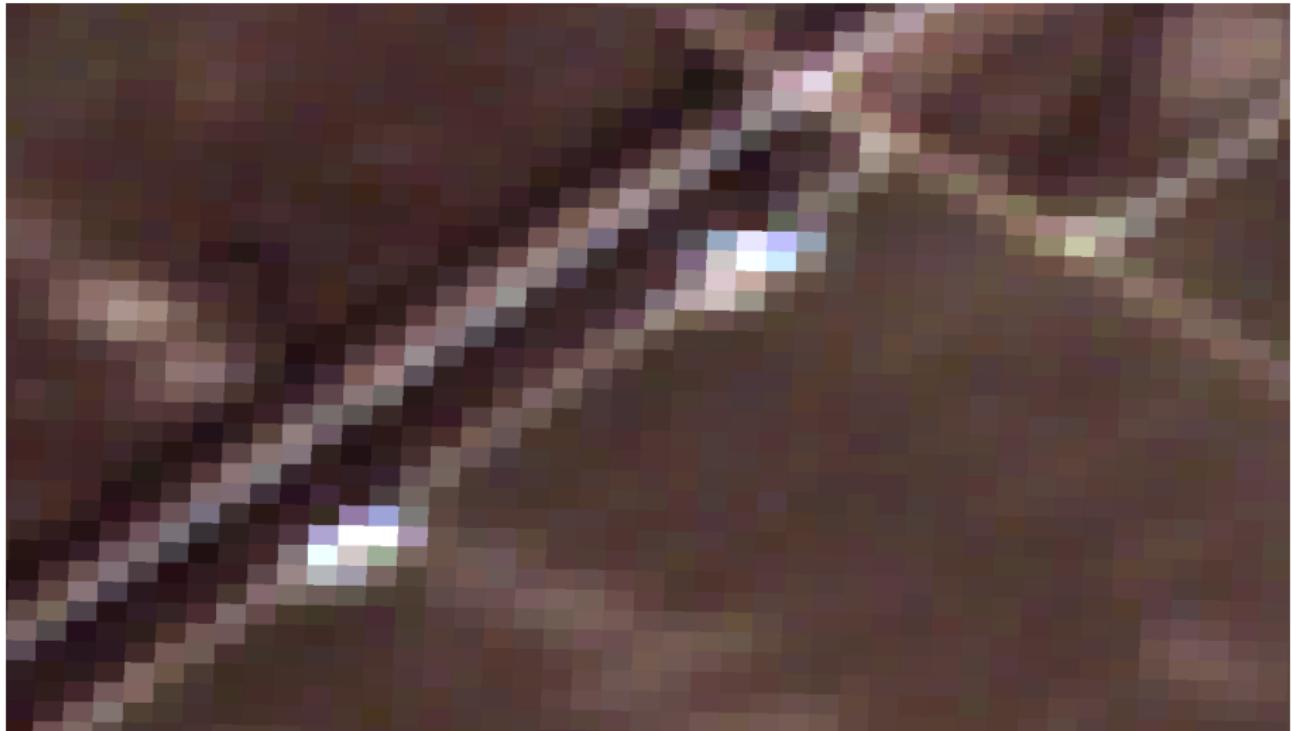
1. Assess global bio-physical potentials of renewable energies (wind and PV) and associated synthetic fuel production
2. Assess options for spatial arbitrage by trade
3. Understand associated *land-use issues*
4. Look into *past* land-use change caused by renewable energy development

Global Power Plant Database: Need for Validation



Satellite data for validation

Sentinel-2 (10 meter resolution), free

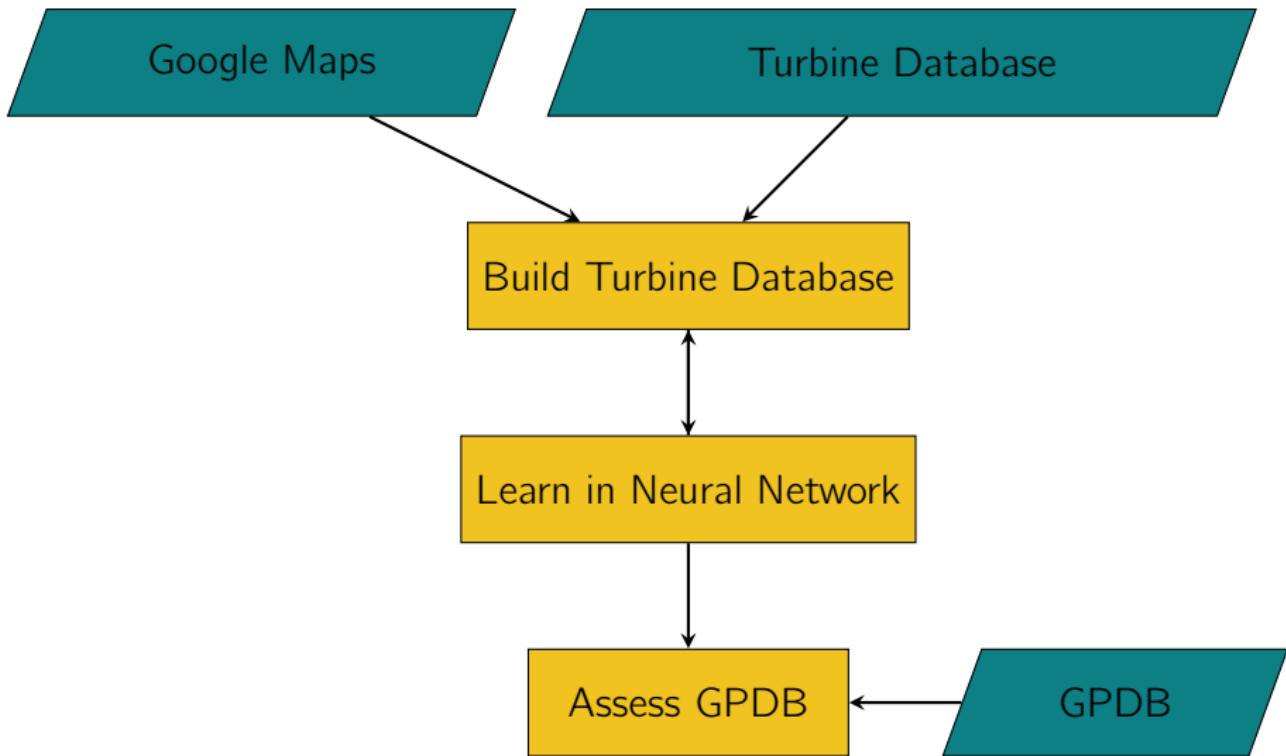


Satellite data for validation

WorldView-4, Quickbird (0.31-0.65 meter resolution) used by e.g. Google Maps



Approach



Software

- ▶ Downloading of data from google maps: R (RGdal, tidyverse, raster)
- ▶ Machine Learning: Python (keras, scikit-image, gdal)
- ▶ Mixing R and Python: not a brilliant idea. Just lazy.

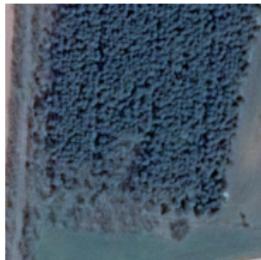
Create Sample Database

Manual quality control

Positives

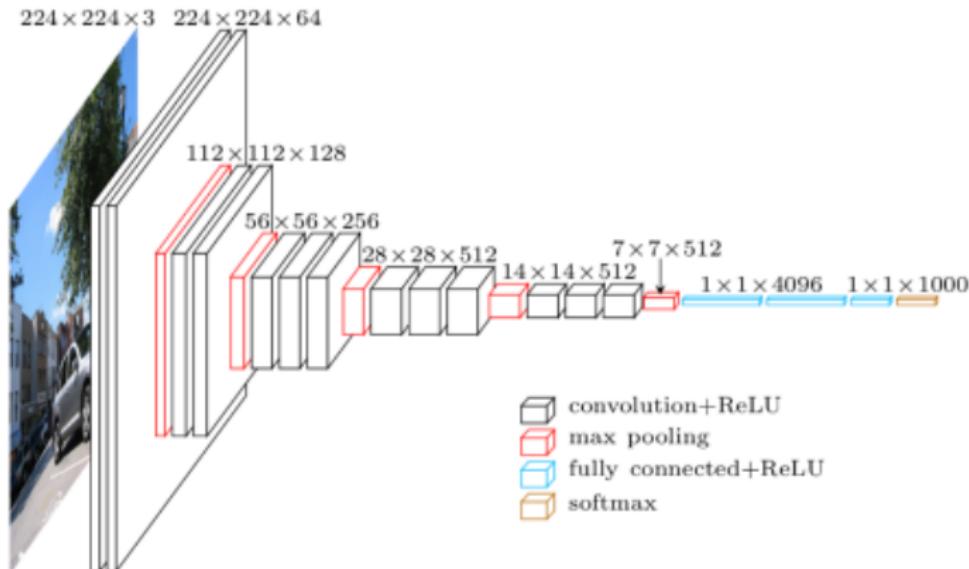


Negatives



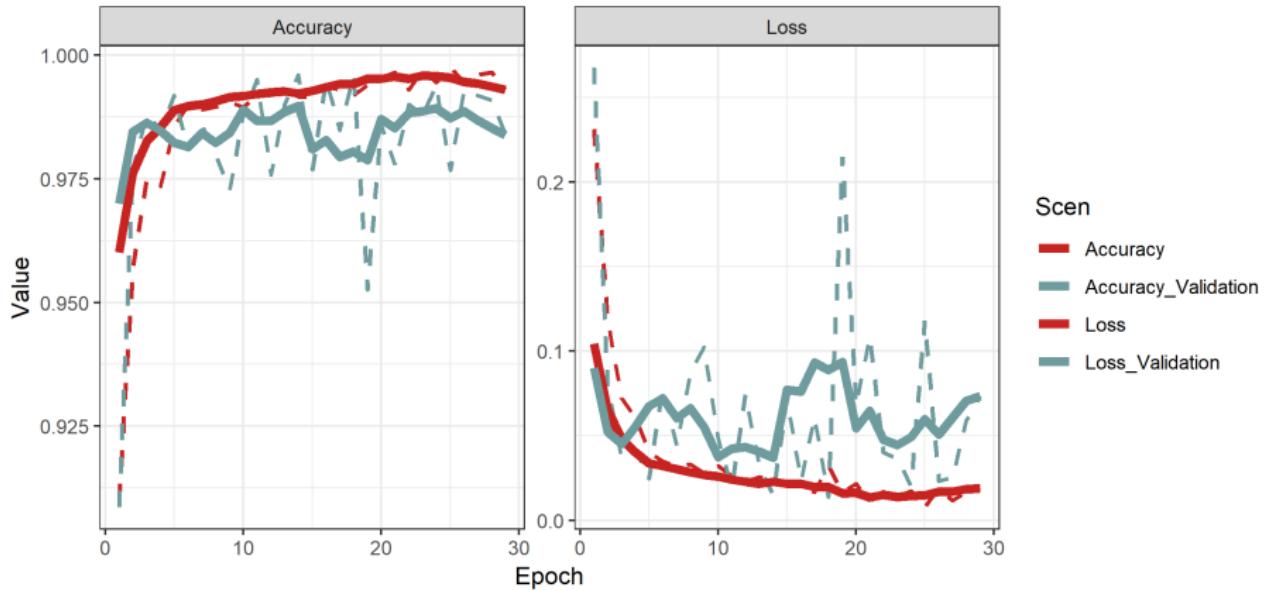
Learn

Unfreezing prelearned Neural Network with Convolutional Layers



Results Learning

Quality Measures

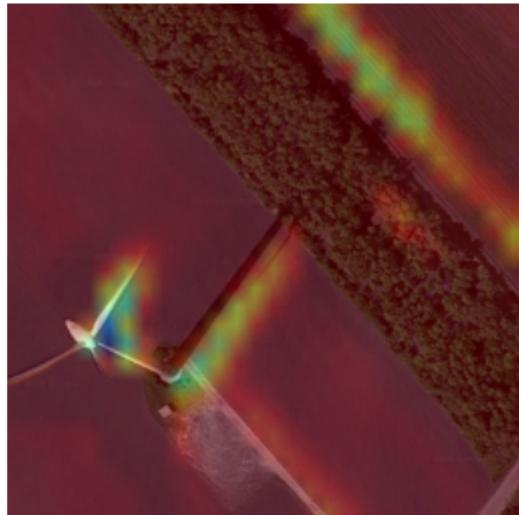


$$\text{Accuracy} = \frac{\text{Number of Correct Predictions}}{\text{Number of Total Predictions}}$$

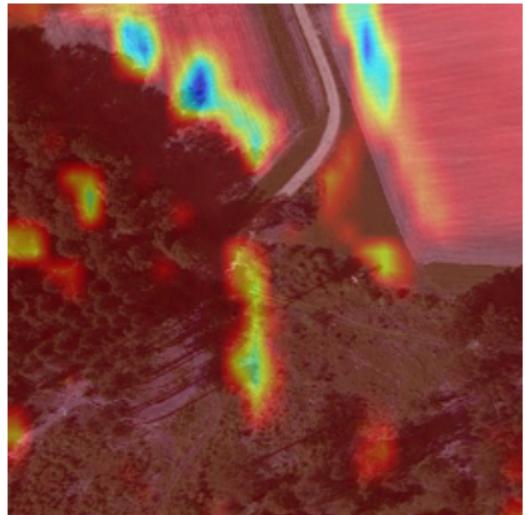
$$\text{Loss} = -1 \frac{1}{N} \sum_{i=1}^N y_i \log(p(y_i)) + (1 - y_i) \log(1 - p(y_i))$$

Results Learning

Class Activation Map



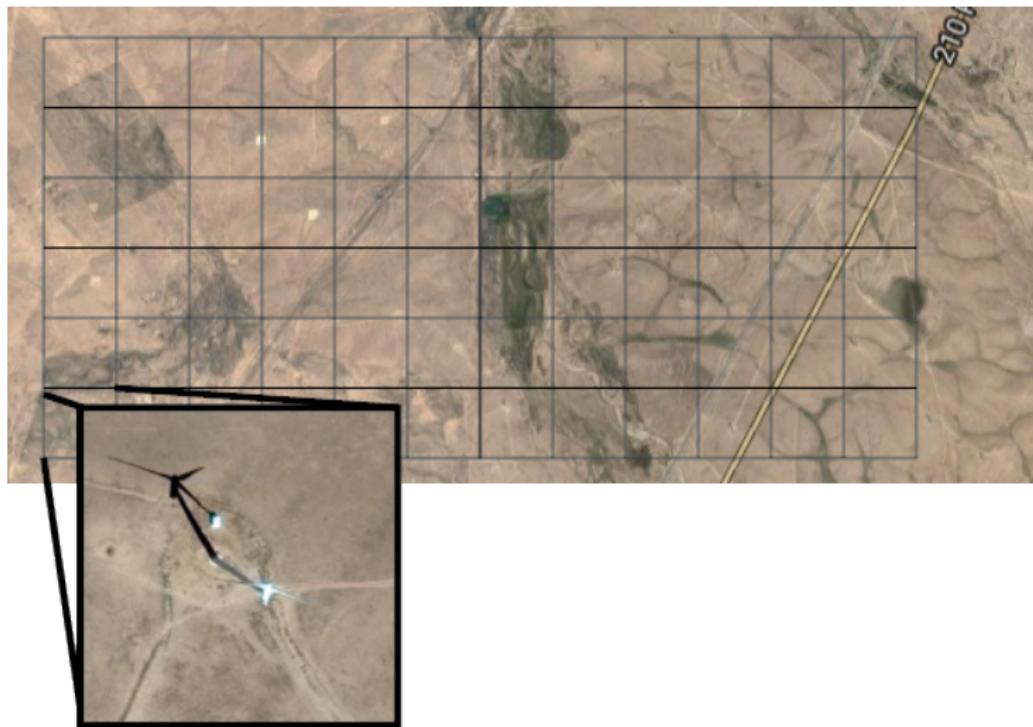
Probability of being wind turbine 0.999



Probability of being wind turbine 0.001

Searching wind turbines

Create grid and check image by image



Application

Chinese and French Wind Parks

China: 28 parks assessed. Found 266 turbines. 83 wrongly classified (manual control). At 7 out of 28 park locations no turbine was found.

France: 10 parks assessed. Found 27 turbines. 15 wrongly classified (manual control). At 5 out of 10 park locations no turbine was found.

Discussion

- ▶ Dates of satellite photos and dates of turbine installations unknown
- ▶ Shaky legal conditions
- ▶ Runtime prohibitive on desktop computers. For a full global check would need cluster computing with high bandwidth (but see shaky legal conditions...)
- ▶ Classification has to be extended to be applicable to different world regions. Applying Austrian/Brazilian conditions to China/France does not work very well (i.e. classification errors).

Conclusions

- ▶ Full validation of GPDB due to missing temporal information not fully possible. However, first assessments of accuracy possible.
- ▶ Current best commercial satellite data allows identification of single turbines with good accuracy by using machine learning approaches
- ▶ Research limited by Data availability. Public domain data is low resolution (i.e. Sentinel-2) or small spatial domain (free ortho-photos, like basemmap.at).

Thank you!

For updates on the project, check **refuel.world**

For source-code, check

github.com/joph/MachineLearningCourse

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