Detection of solar panels based on aerial images of the city of Poznań using deep neural networks

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POZNAŃ UNIVERSITY
OF ECONOMICS
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Introduction – motivation

- New data sources for official statistics (e.g. big data).
- Satellite and aerial photographs are used by some statistical offices for agricultural statistics (also by the Central Statistical Office).
- There is no obligation to record the installation of solar panels and collectors. They can be recorded when connected to the network of operators.
- Increased interest in renewable energy (RE) due to, climate change, rising energy prices or subsidies.
- However, there is no complete information on the above mentioned installations.
- One of the possible approaches is to use aerial photographs to identify solar panels and collectors mounted on roofs or plots.

Existing RE information sources

- Operators – micro and consensual installations (prosumers)
- Central Statistics Office - Energy from renewable sources (reports and questionnaire on fuel consumption and energy in households - sample of about 4.5k).
- Other data sources – based on portals for installation users, among others `https://pvmonitor.pl/`

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Aerial photographs – acquisition

- The data were obtained from the GEOPOZ Surveying and Urban Cadastre Management Board on the basis of the "Application for access to district surveying and cartographic resources" for the purpose of scientific research and development pursuant to the Geodetic and Cartographic Law (Article 40a(2) of the PGI Act)
- **Orthophotomap**
  - Date of raid: 2016-04-30 – 2016-05-05,
  - resolution 5cm (=1 pixel),
  - 3 808 of the photo files (roughly 100 GB),
  - TIF format
- **Layer of buildings** – status of 2019.03.06; SHP format.
- Spatial data processing in **R** with the use of packages `sf` and `raster`.

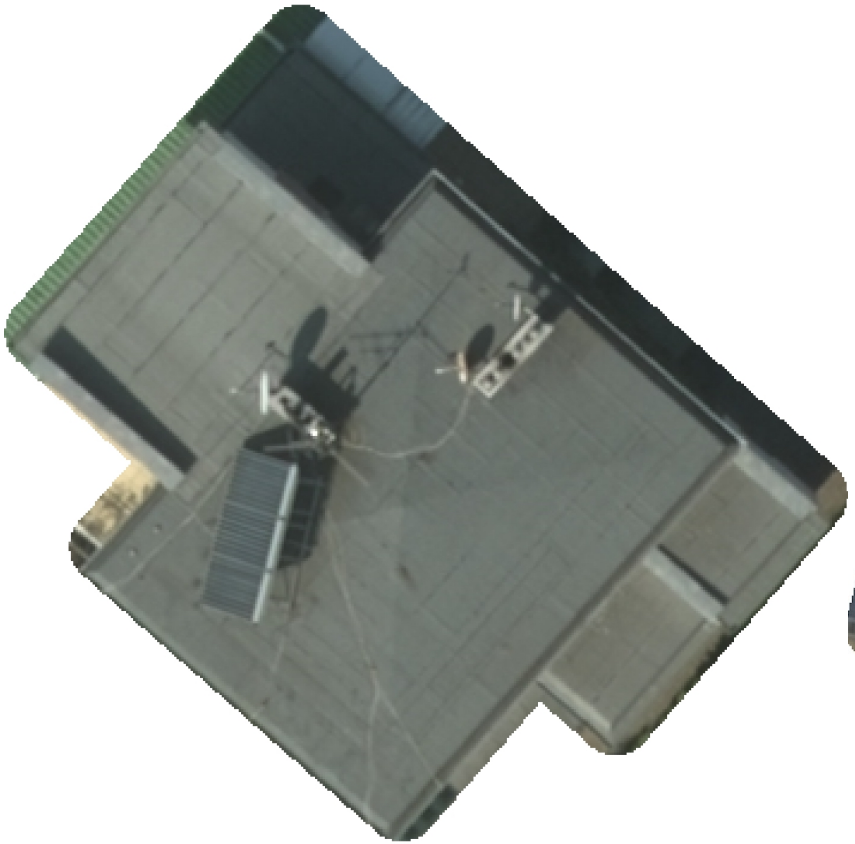
Orthophotomap – images of panels

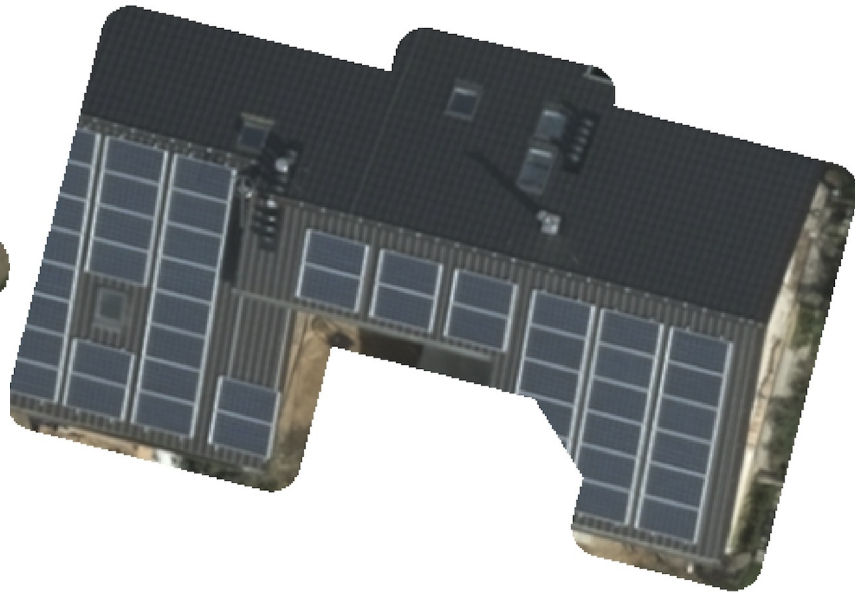
Spatial data processing

- The spatial data processing has been performed using the statistical package R (packages `raster` and `sf`).
- To take into account the different angles of inclination, the following function has been used `st_buffer`, that adds a certain buffer

Number of sections	Number of buildings
1	9309
2	895
3	7
4	15

Orthophotomap after building removal





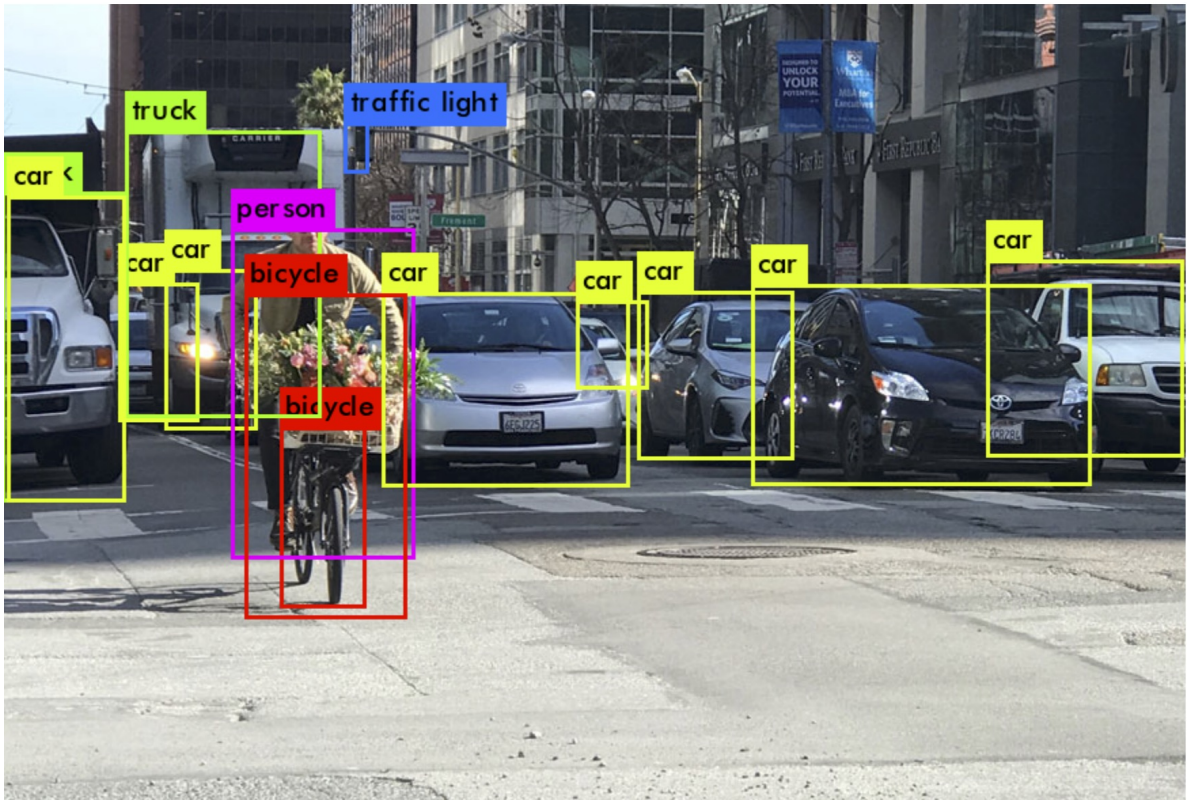
Tools and technologies used

The following technologies and tools have been used to classify and recognise images

- Keras / Tensorflow – in the initial testing phase
- Turi Create (Apple)
- YOLO – You Only Look Once
- The InnoUEP infrastructure was used (CentOS, 30 cores, 120 GB RAM) and AWS (graphic card calculations)

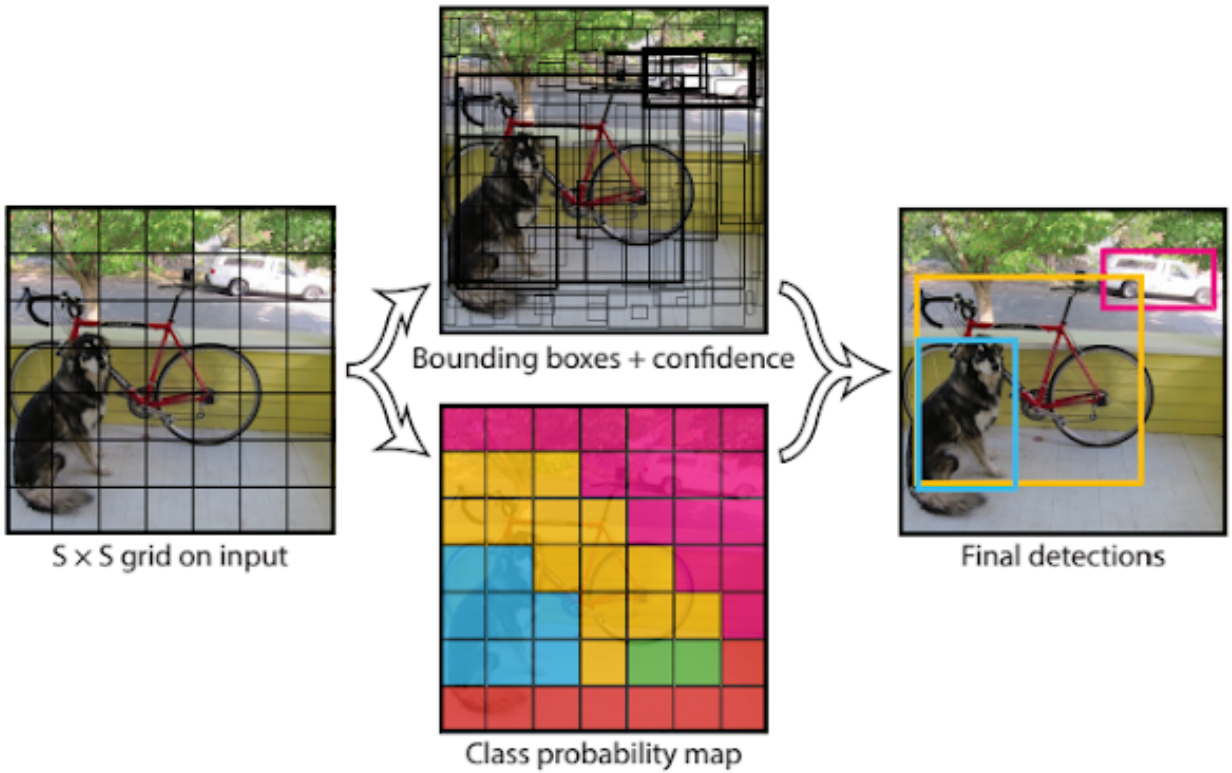
YOLO – idea

YOLOv2 (You only look once) is a object detection system.



YOLO – how it works

- Images are converted to the following resolution: 416x416x3.
- Division of images into a grid of 13 cells into 13 cells.
- Each cell in the grid predicts only one object.
- Each cell is responsible for predicting up to 5 bounding boxes.

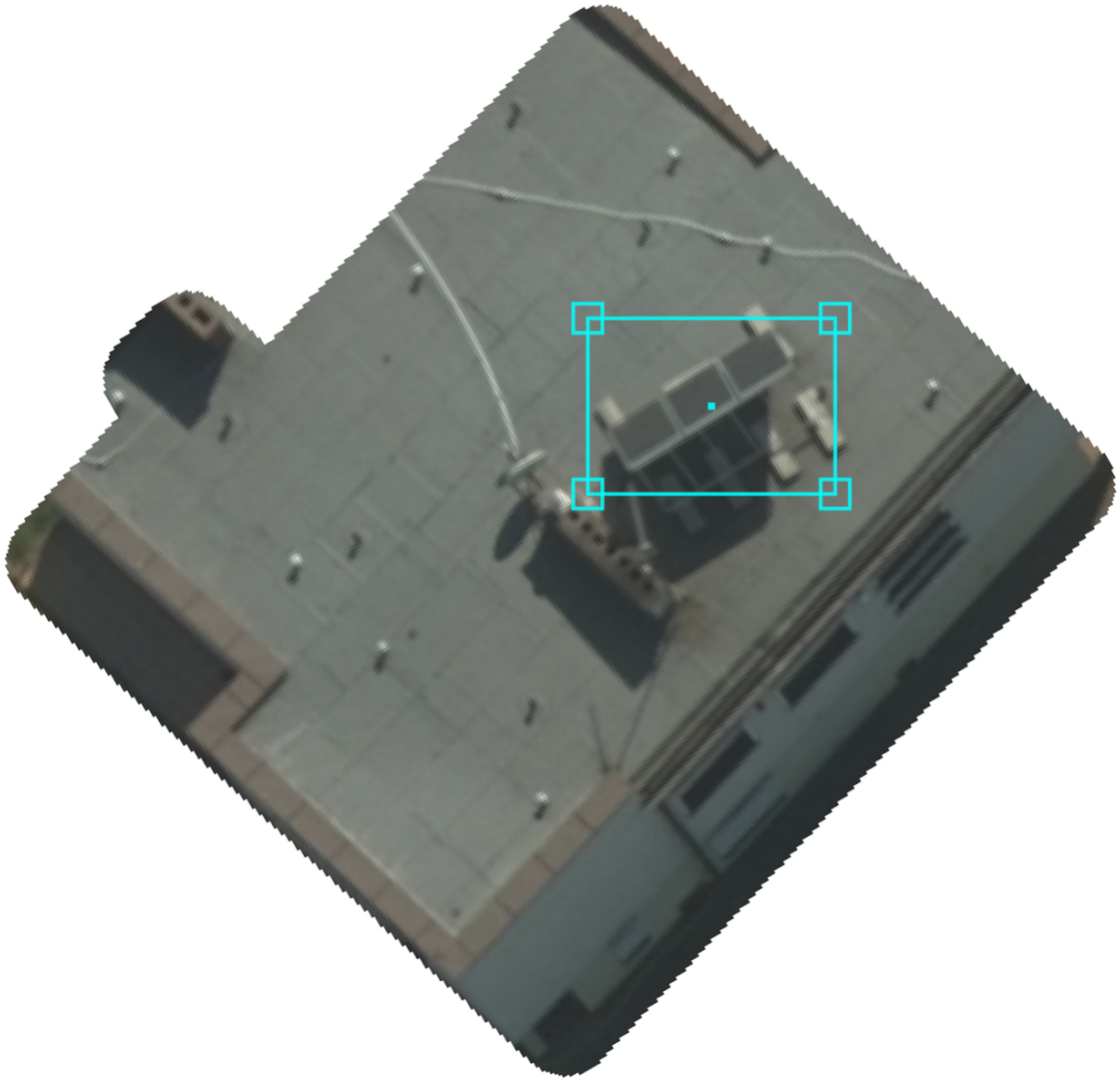


YOLO – loss function

YOLO uses the sum of the squared errors to calculate the loss. The loss function consists of:

- Classification loss
- Localization loss – errors between predicted bounding box and the actual position of the rectangle.
- Confidence loss

Learning with YOLO



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Example results – Model 1

Model: random sampling, loss: 0.551, time: over 10 hours, threshold: 0.5.

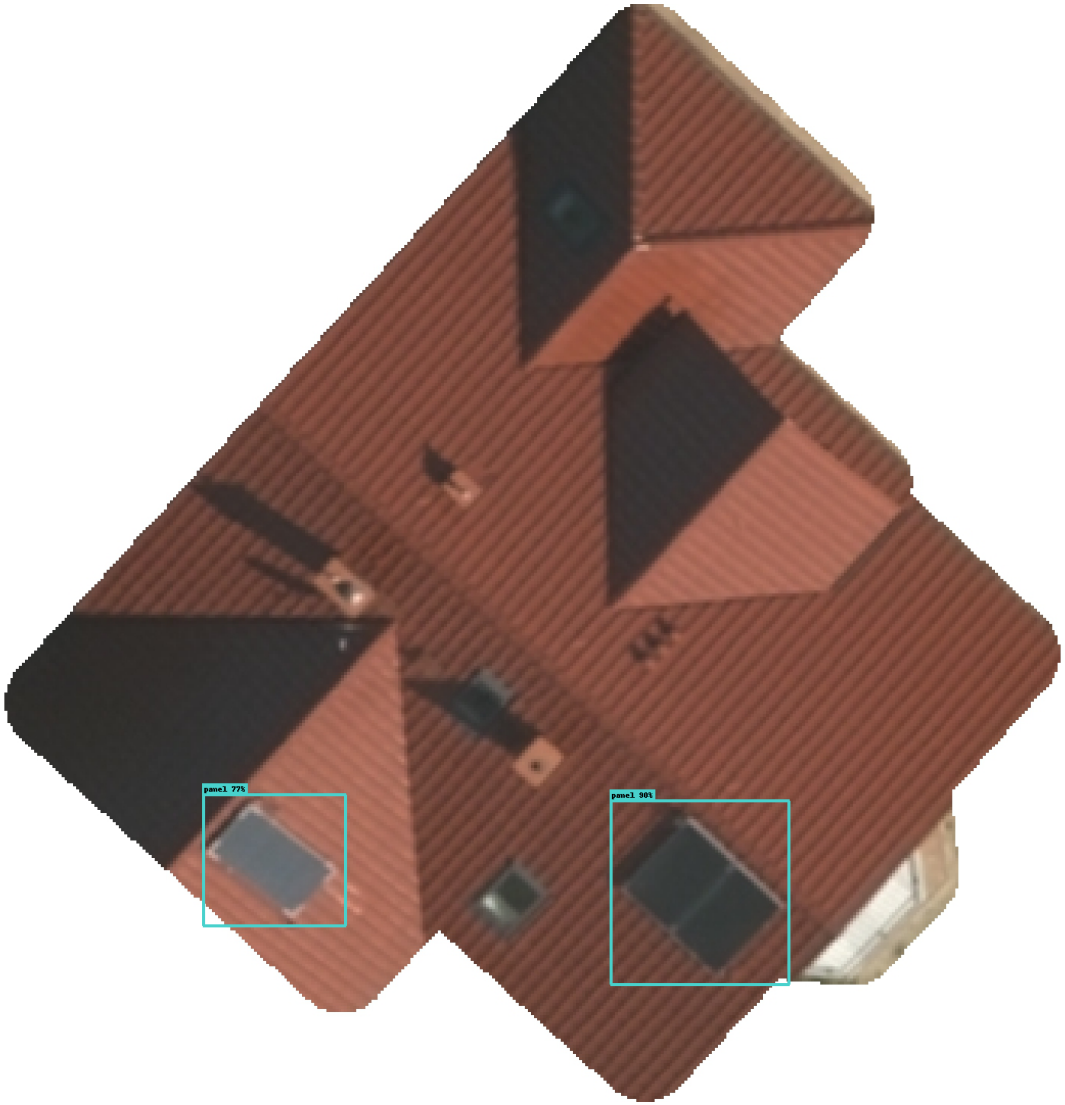
True / Prediction	**Panel**	**No Panel**	**Total**
Panel	2497	0	2497
No Panel	148	2322	2470

Precission: 0.944, Recall: 1, Precision of selection: 0.9388.

True / Prediction	**Panel**	**No Panel**	**Total**
Panel	621	2	623
No Panel	50	600	650

Precission: 0.925, Recall: 0.997.

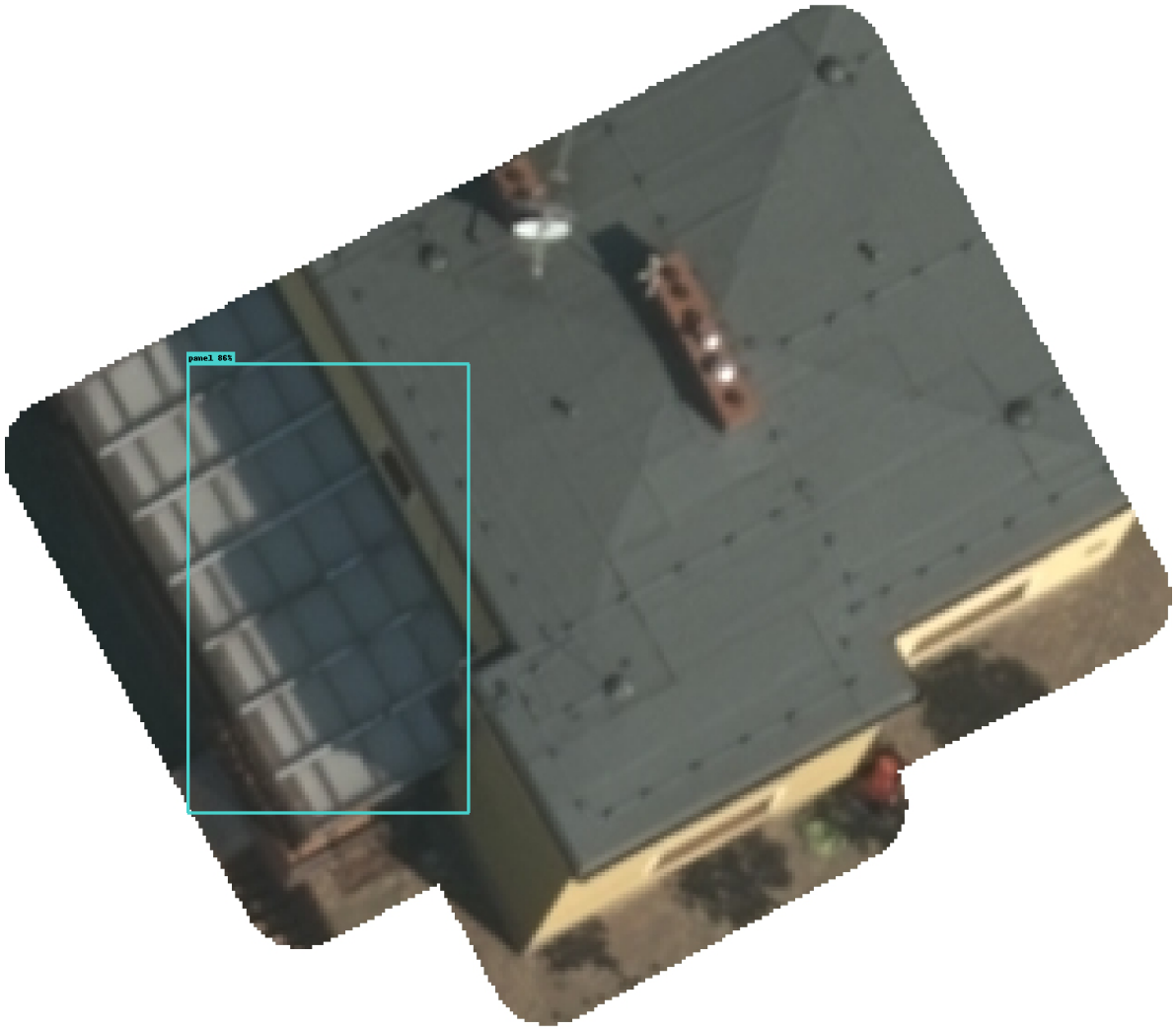
Example results – correct



Example results – correct

Example results – uncertain

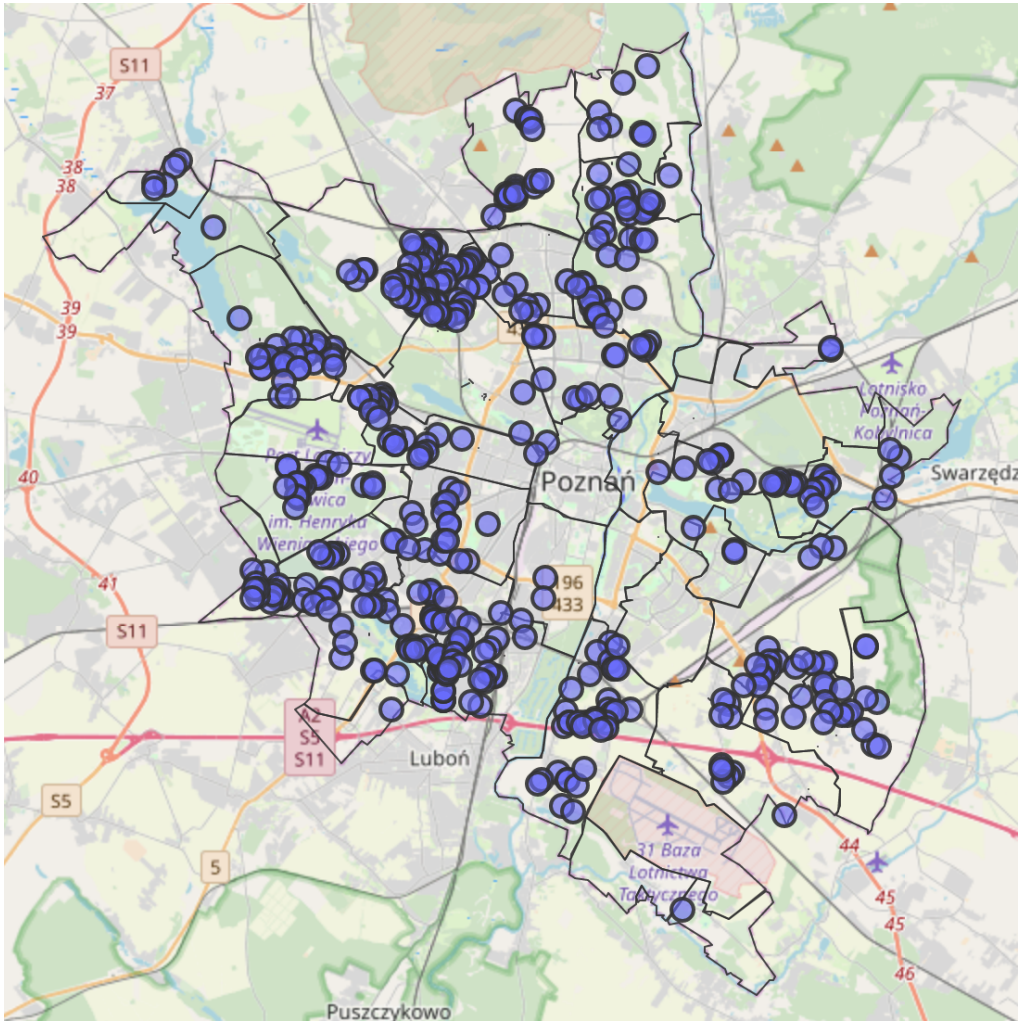
Example results – not valid



Examples of results – unrecognised

Examples of results – unrecognised

Poznań districts – RE location in 2016



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Summary

- There were 476 collectors and solar panels identified, located on the roofs of residential buildings in Poznań in 2016 (which constituted about 2% of the buildings).
- To the best of our knowledge, this is the first study of its kind in Poland.
- The algorithm has a greater problem with recognizing panels where they are not there than not recognizing them where they are.
- The results are very promising, but the experiences of colleagues from *Statistics Netherlands* indicate that a model taught in one city will not necessarily be good for another city/village.
- An example of joint usage of R and Python.

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Bibliography (selected)

- Yu, J., Wang, Z., Majumdar, A., & Rajagopal, R. (2018). DeepSolar: A Machine Learning Framework to Efficiently Construct a Solar Deployment Database in the United States. Joule, 2(12), 2605-2617.
- Chollet, F. & Allaire, J. J., (2019) Deep Learning. Praca z językiem R i biblioteką Keras. Wydawnictwo Helion.
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Thank you for your attention!