PREDICTING WELL BEING
BASED ON FEATURES VISIBLE FROM SPACE - THE CASE OF WARSAW

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BACKGROUND

- data from space (night-time lights intensity or high-resolution day-time images) are increasingly used as a **proxy of economic activities at the regional and local level** (Jean et al., 2016)
- can be **easily aggregated for any territorial units**
- **independent** of politicians and response rates in surveys
- proxies for **economic well-being** or **market potential** can be calculated for **non-administrative areas**

OBJECTIVES

- use features visible from space to proxy the level of well-being
- extract features from day-time satellite images
- apply various machine learning tools to link extracted features with the measure of well-being for administrative units
- predict the level of economic well-being or economic potential for non-administrative or poorly labelled areas
- apply on sample data for Warsaw
- **work in progress**

CONCLUSIONS

- semantic segmentation on satellite images requires **large computing power** and **good training data**
  - bad or outdated labels, images taken at an angle cause problems
  - model predicts long buildings better
- green areas can be extracted better through cutting color channels
- districts are too big administrative areas for model training but they are the lowest level for which well-being/socio-economic data is available (model outcome)

FURTHER STEPS

- label images manually to obtain better training sample
- consider classification instead of regression problem
- add new features to the model, e.g. building height, roof type, building type (offices, houses, apartment blocks)
- obtain data over time to observe changes
- extend the analysis to other(rural) areas since metropolies are relativelly homogenous
- combine features extracted from daytime images and night-time light intensity

REFERENCES

Jean, N., Burke, M., Xie, M., Davis, W., Lobell, D. and Ermon, S. (2016), "Combining satellite imagery and machine learning to predict poverty", *Science* , Vol. 353, pp. 790–794.

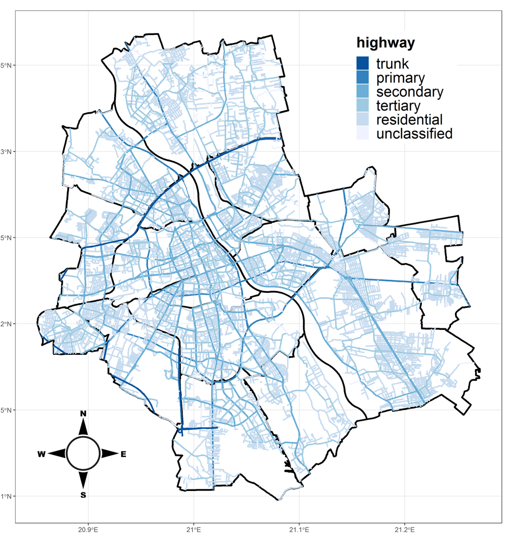
DATA AND METHODS

- **Open Street Map**: localisation of buildings, streets, rivers and lakes, green areas, public transport, bike rental, fuel stations, supermarkets and malls were used as: (1) model features; (2) inputs for labeling images
- **Google Maps**: 6000+ high-resolution daytime images of Warsaw (zoom 16)
- **socio-economic indicators** for Warsaw districts (budget spendings, income, share in PIT/CIT, population, no of vehicles, life expectancy)
- **Convolutional Neural Networks, transfer learning**: U-net and ResNet101 architectures pretrained on ImageNet used for semantic segmentation
- selected machine learning tools (**Random forest, LASSO**) applied to find relationships between features visible from space and economic well-being indicators

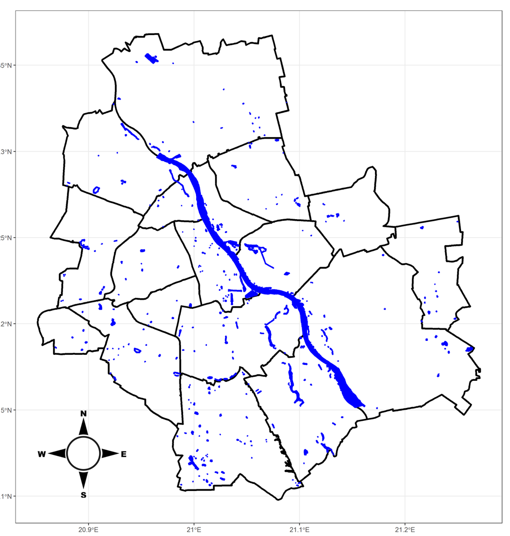
RESULTS

OSM DATA FOR LABELING

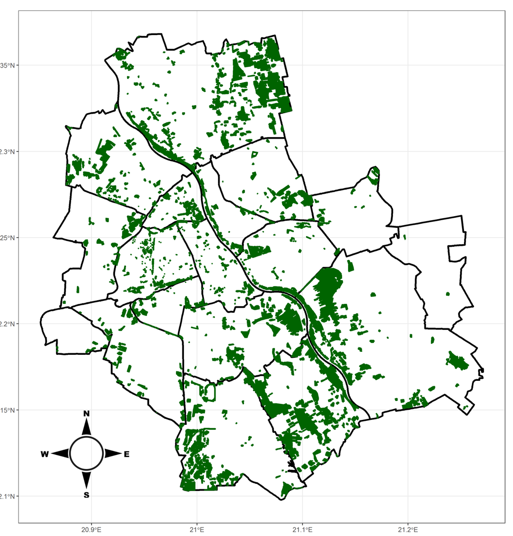
buildings



streets by type



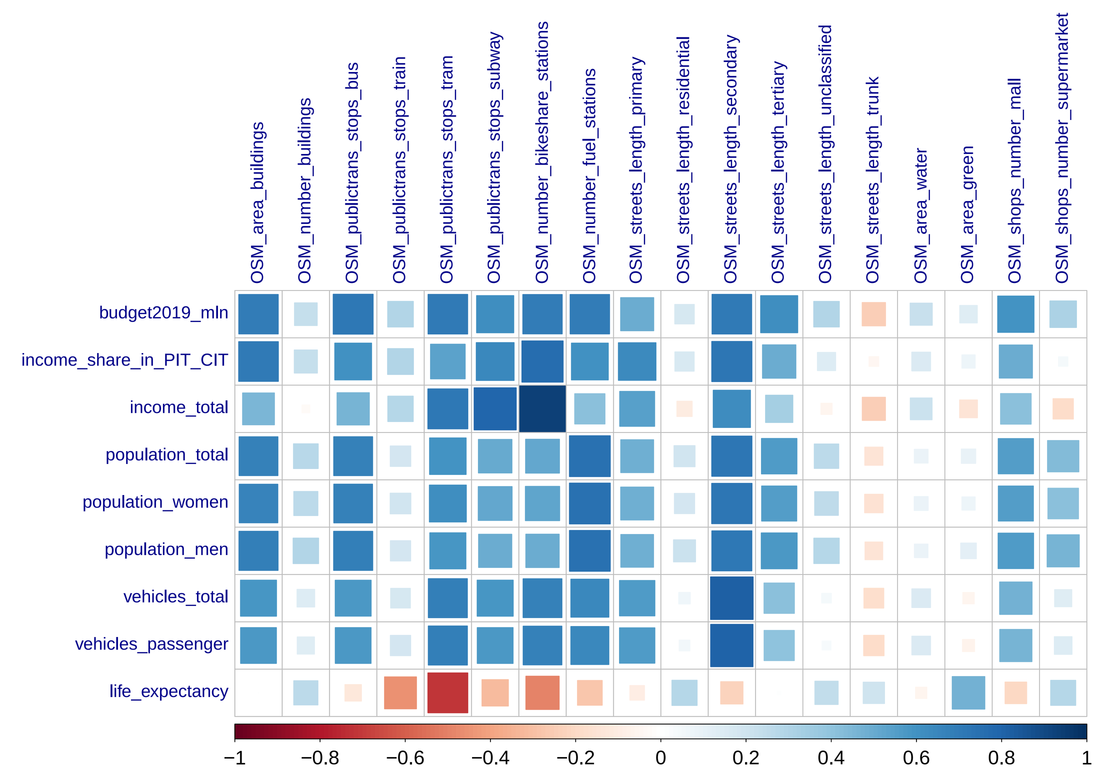
water



green areas

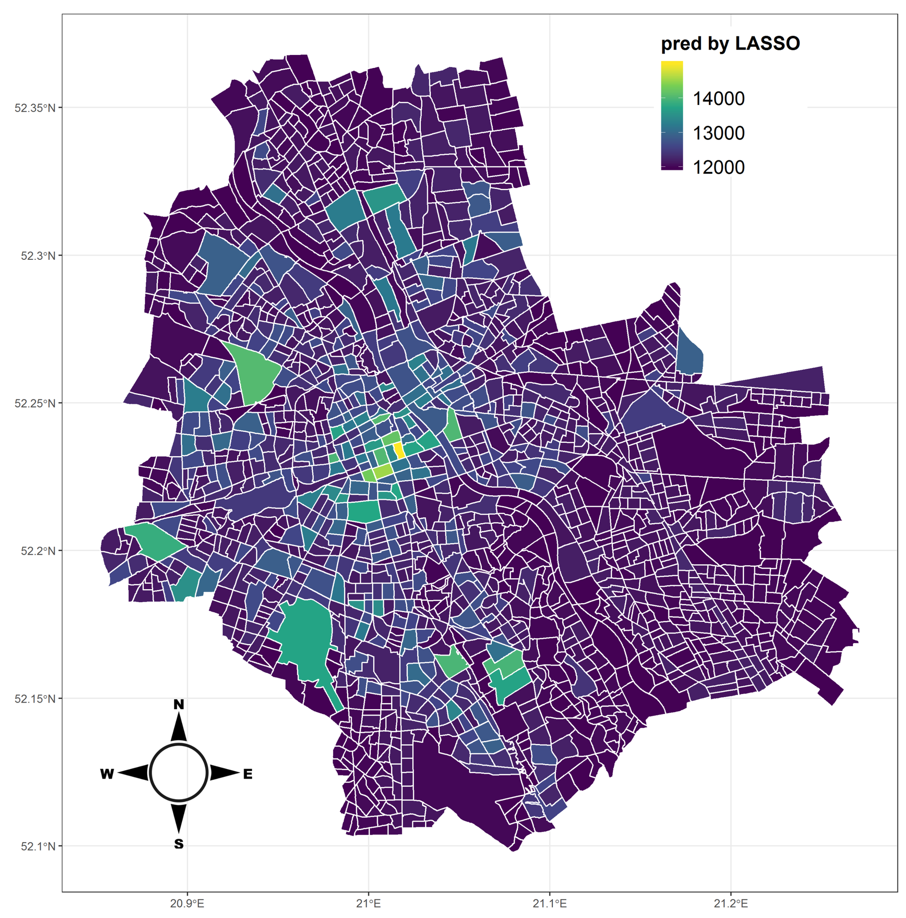
OSM BASED LABELING APPLIED

CORRELATION OF EXTRACTED FEATURES AND WELL-BEING INDICATORS



	variable	budget2019_mln	income_share_in_PIT_CIT	income_total	population_total	population_women	population_men	vehicles_total	vehicles_passenger	life_expectancy
LASSO	OSM_number_bikeshare_stations		1	2	6	4		2	2	5
	OSM_number_fuel_stations			4	5	1	1	4	4	8
	OSM_publictrans_stops_bus				7	3	2			7
	OSM_publictrans_stops_tram				3	2				4
	OSM_shops_number_mall			6	2			1	1	1
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	OSM_area_buildings		3	13	14					14
	OSM_area_green				13			8	8	16
	MAE	197.25	19270.77	52750.28	47211.16	23124.53	19630.11	33544.59	29918.29	4.62
	MAPE	0.649	0.600	0.846	0.539	0.632	0.636	0.550	0.588	0.060
LASSO (w/ pred variables)	OSM_number_bikeshare_stations		2	2	4	4		1	2	6
	OSM_number_fuel_stations		6	4	3	1	1	4	4	8
	OSM_publictrans_stops_bus				6	3	2			7
	OSM_publictrans_stops_tram		7		5	2		5	5	4
	OSM_shops_number_mall		1					2	1	5
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	OSM_area_buildings_pred		15							15
	OSM_area_green_pred							9	9	16
	MAE	197.25	32043.48	56837.23	40367.19	23124.53	19553.72	34638.79	30788.64	4.28
	MAPE	0.649	1.026	0.846	0.526	0.632	0.633	0.570	0.598	0.056

Feature importance in models



Predictions of LASSO for districts

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