Master's Thesis
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Image Geolocation Using Deep Learning

- **Image geolocation** is the task of defining the geographical location where an image was taken.
- **Image metadata (EXIF)** as other Internet geolocation information can be **manipulated**. Therefore, it can be worthwhile **defining the location from the image pixels** as a computer vision problem.
- Application area in **open-source intelligence (OSINT), geospatial intelligence (GEOINT), and imagery intelligence (IMINT)**
- **Challenging problem due to the variety of images**

- **Research problem**: How to **geolocate outdoor** street-view **images** using computer vision?
- **RQ1**: How to **geolocate** a **street-view** image using **deep learning**?
- **RQ2**: How to **utilize satellite imagery/maps** for **street-view image geolocation**?

Implementation of Outdoor Image Geolocation in Finland:

1. Geocell partitioning

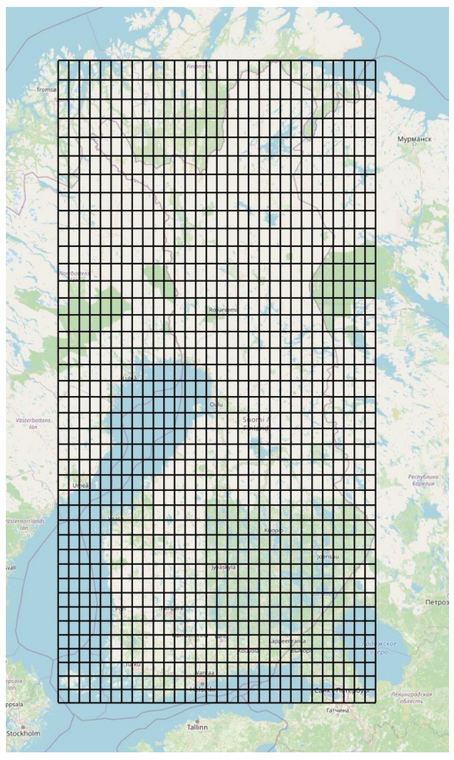

Figure 1: Geocells. Partitioning of the selected rectangular area of Finland into geocells of 40x30.

2. Predict geolocation

Figure 2: Trained model predicting geolocation for a sample outdoor image. Black dot indicates the true location, geocells from dark to light indicate probabilities that the image was taken there.

3. Shapley Additive exPlanations (SHAP)

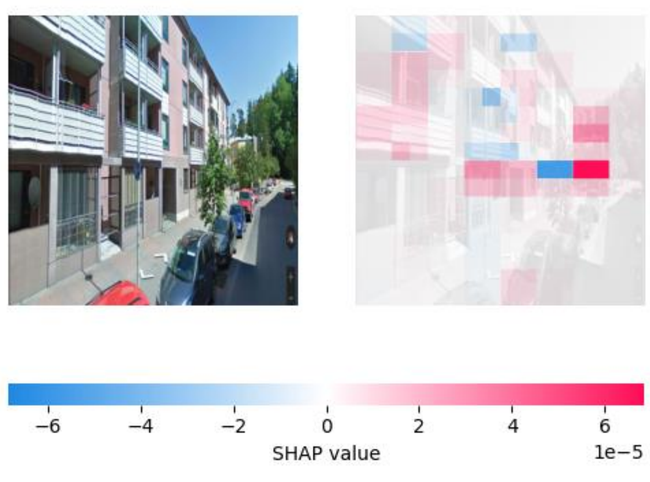

Figure 3: Explainable AI (XAI). Why was the image located like that? SHAP values show the positive and negative impacts on the prediction.

4. Utilizing satellite imagery

Figure 4: Cross-view image geolocation (CVIG). Are the street-view and satellite-view images from the same location?

Conclusions

- **Using deep learning**, street-view image geolocation can be solved as a **classification problem** (RQ1).
- **Utilizing satellite imagery/maps** for street-view image geolocation can be solved as a **binary classification/ similarity problem** (RQ2).

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