Area Feature Reconstruction From Historical Topographic Maps Using Different Deep Learning Architectures

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Historical maps contain a vast amount of valuable geographic information that can be used to analyse the past. However, automatically extracting information from historical maps is challenging due to several factors [1], such as inferior graphical quality and inconsistency of cartographic symbols. Deep learning technology has great potential to deal with such complex tasks because deep learning has already established its superiority in computer vision. In this study, the performance of different deep learning architectures was compared to extract area features from the historical topographic map series of Germany named "Milage Sheets of Saxony". Deep learning based semantic segmentation and object detection strategies were used to extract buildings, rivers, lakes and forest areas from map scans, and the performance was evaluated.

Deep Learning in Digital Map Processing

Deep Learning (DL) has recently been recognised as the gold standard in the machine learning field. It is a subset of machine learning representing a network of computing units inspired by a human brain structure named a neural network (NN) [2]. Hence training a neural network is called Deep Learning. Due to deep learning, a machine can execute cognitively demanding tasks such as feature extraction from maps, outperforming traditional machine learning techniques.

Objective

Evaluate different deep learning CNN [3] architectures for digital map processing focusing on areal feature reconstruction from historical topographic maps.

Feature Extraction Strategy

1. Semantic Segmentation: Classifying each pixel and assigning a class

- Performed to extract Buildings, Rivers and Lakes, where the area of the cartographic symbol has geographic meaning.
- DL CNN algorithm: UNet, Inception-ResNet, ResNet

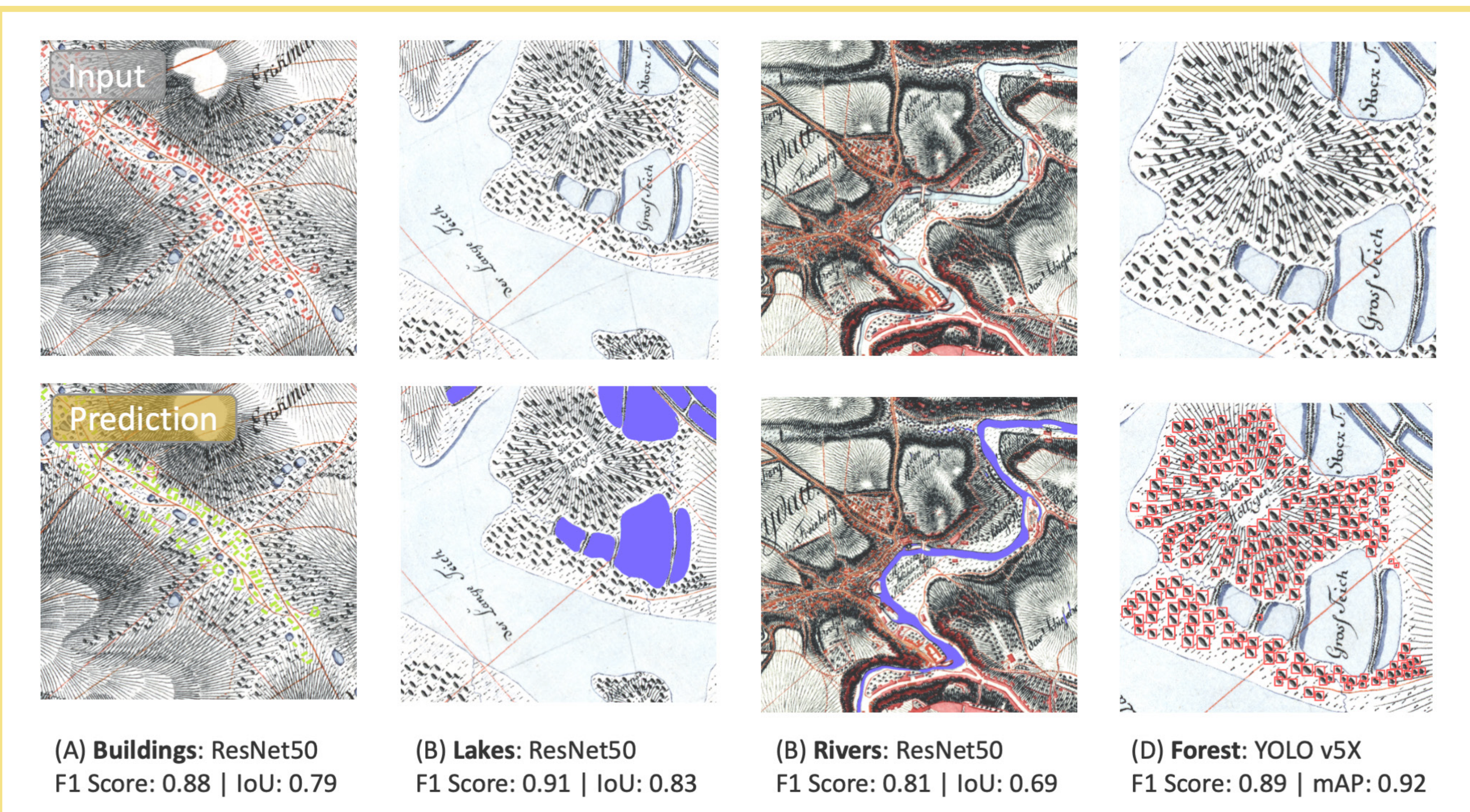
2. Object Detection: Detect the cartographic symbol via bounding box

- Performed to extract forest area where the area of individual symbol does not have a geographic meaning.
- DL CNN algorithm: YOLO

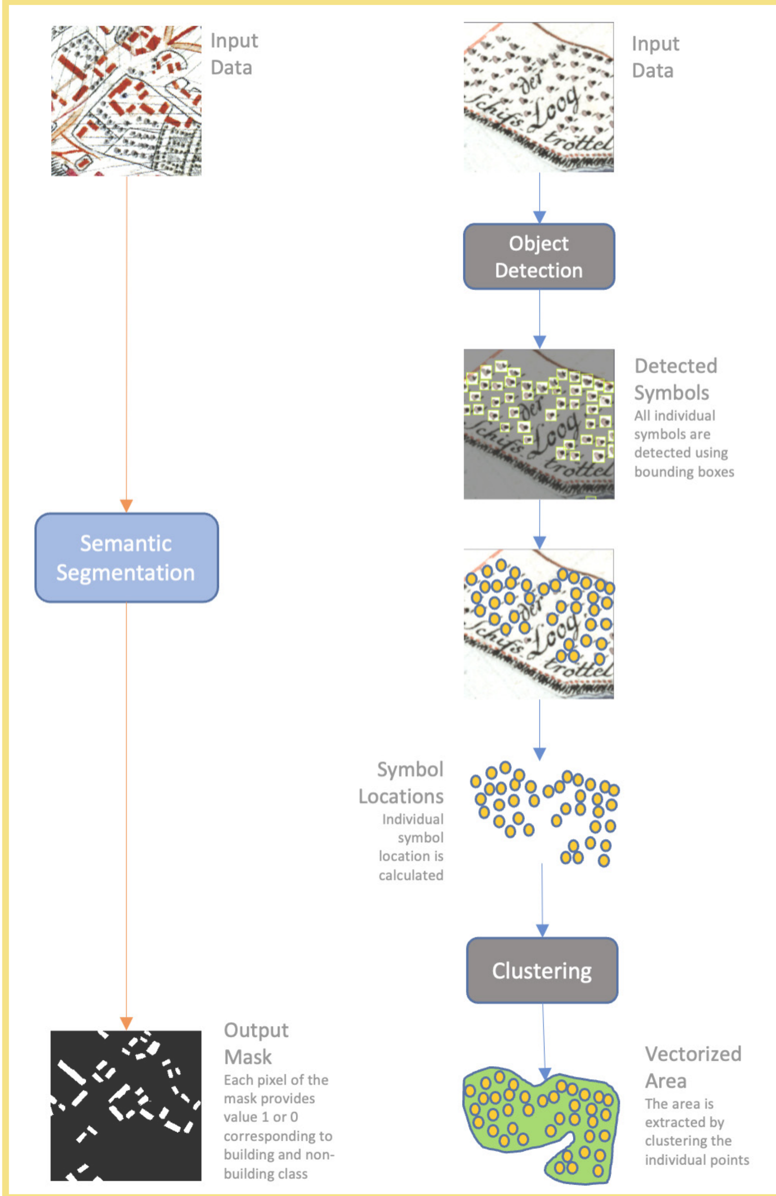
Dataset

Selected map scans of Mileage Sheets of Saxony (or "Sächsische Meilenblätter" DE), a series of historical topographic maps created between 1780 and 1825 in Germany.

Results and Limitations



Results of the feature extraction of the best performing models and accuracies (F1 Score, Intersection over Union (IoU), Mean average precision (mAP)



General workflow of semantic segmentation (left) and object detection (right)

In semantic segmentation, ResNet architecture showed the best performance in terms of accuracy and efficiency, achieving a F1 score of 0.86 and an IoU of 0.77. In object detection, YOLO v5X architecture outperformed the rest by achieving a mAP of 0.92 and a F1 score of 0.89. A deep learning pipeline was developed to train, evaluate, and visualise the performance of the models. The major limitation of this study was the lack of training data. A simple yet ef-fective software was developed to extract training data from map scans.

Conclusion

This study showcased that selection of a proper deep learning architecture has a significant influence in terms of performance and accuracy, which is an impactful factor when deploying the models in real-world applications. However, it also demonstrates that solving the fundamental challenges of deep learning, such as scarcity of training data, should be addressed first to unlock the technology's full potential.

This study demonstrates the unmatching capability of deep learning technology in performing complex feature extraction tasks in digital map processing. With the findings of this study, It can be concluded that deep learning is the technology that can make a change in digital map processing to unlock the vast amount of data hidden in his-torical map archives.

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References

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