ETH zürich

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Deep Feature Learning for Digital Elevation Models with Auto-encoders

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1 Introduction

Landscapes can be classified into different classes such as mountains, hills or plains based on their terrain structure. This master thesis aims at investigating auto-encoder neural networks to obtain characteristic features from a Digital Elevation Model of Switzerland.

2 Methods

Auto-encoders consist of an encoder, which maps the input data to a compressed latent represention, and a decoder which reconstructs the original input using the latent vector. The final auto-encoder model used is based on the SegNet architecture (Badrinarayanan et al., 2015). It is a deep convolutional network involving five segments of two to three convolutional layers followed by batch normalization, a rectified linear unit (ReLU) and a 2x2 max-pooling layer in the encoder part, while the decoder is mirrored (see Figure 1).

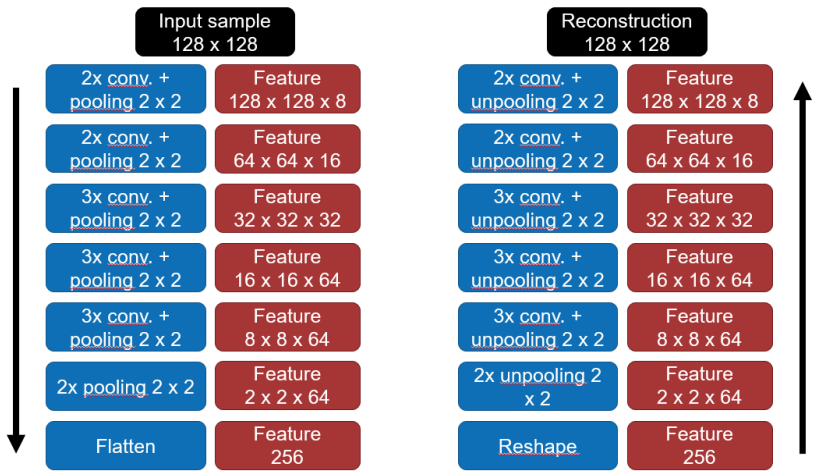

Figure 1: Schematic representation of the modified SegNet architecture

Adjustments to the original SegNet architecture and the values for the hyperparameters were chosen on a trial and error basis. The performance tests were conducted on a study area centered around Sargans, which contains a variety of relevant landscapes. Both the reconstruction results (see Figure 2) and clustering results were taken into consideration.

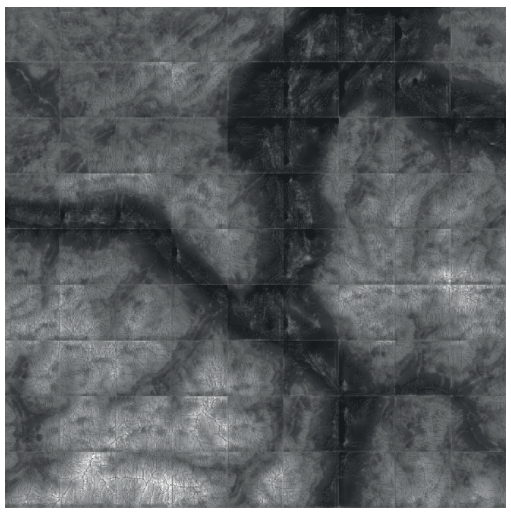

Figure 2: Reconstruction of the digital elevation model through the auto-encoder

3 Results and Discussion

Using an auto-encoder network trained on the entire datset, the area of Switzerland is grouped into ten landscape classes with the k-means algorithm. Those classes are further merged manually to four meaningful landscape classes. The result in Figure 3 showcases the classes, which can be described semantically as Plains (pink), Hills (yellow), Lower Alps (green) and Higher Alps (red).

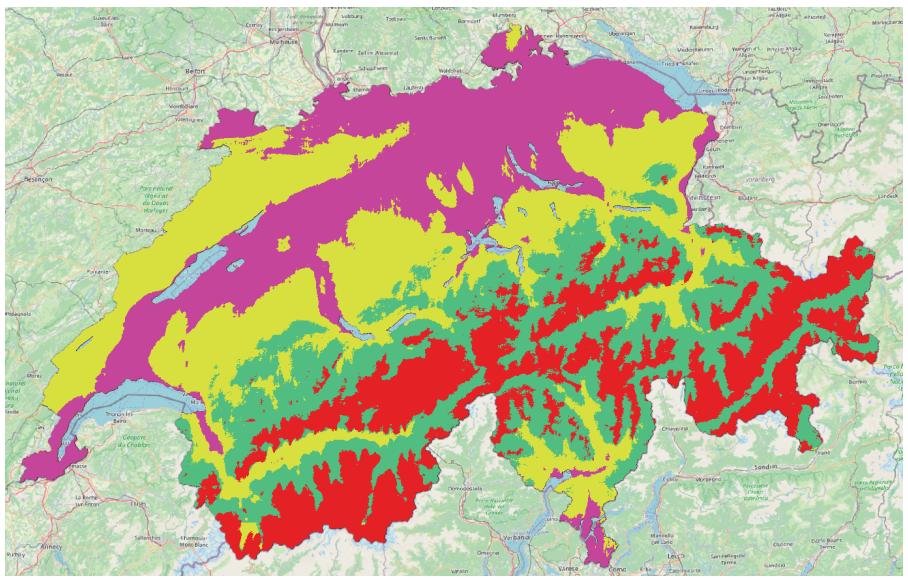

Figure 3: Clustering results after manually joining similar classes

A comparison with the *Landscape Typology of Switzerland*, published by the ARE, BAFU and BFS, shows a somewhat different classification, which is to be expected, as the model training approach is completely unsupervised. Visually, most of the class borders still seem plausible. However, it would be desirable to be able to further subdivide some of the resulting classes. The yellow class for example should be split into a Jura, a Pre-Alps and a Alpine Valleys class. By comparing the results with an altitude threshold based approach, it can also be seen that the results are not purely based on altitude.

4 Conclusion

The results show that basic landscape classes, which are derived from elevation and slope, can be found using an auto-encoder model. However it remains challenging to differentiate more complex types of classes. Additionally, some manual post-processing is still needed. A supervised learning approach would likely deliver improved results. The thesis also outlines the tensions that arise between the necessity of using deeper and more complex models to obtain better results and the challenges that lie within the large amount of data to process.

References

Badrinarayanan, V., Kendall, A., and Cipolla, R. (2015). Segnet: A deep convolutional encoder-decoder architecture for image segmentation. CoRR, abs/1511.00561..