Semantic segmentation of black and white aerial photography of riverscapes in Norway

Saeid Shamsaliei, Arild Dalsgård, Odd Erik Gundersen, Knut Alfredsen,
Jo Halvard Hallerake

NorwAI Norwegian Research Center for AI Innovation

NTNU

Abstract

In this work, we proposed to utilize convolutional neural networks to segment black and white (B&W) aerial images into different habitat types and provide GIS maps which can be easily used for further processes to evaluate the changes of riverscapes over time.

Introduction

- Human developments put pressure on rivers and their surroundings.
- This pressure introduces challenges for preserving biodiversity.
- **Understanding the alteration of rivers** is essential to recognize restoration potentials.
- This is a challenging task due to **lack of data** [1].
  - It requires historical state of rivers. Manually segmenting images is **time consuming**.
  - Data needs to be in a **suitable format** for analysis.
- We propose to use Deep Neural Networks to address this issue.

Methodology

Dataset

The Norwegian mapping authority provides georeferenced historical aerial imagery of the mainland in Norway.

Dataset	Initial	Expanded	Test
Number of images (512x512 px)	1694	6307	927
Augmented	20328	75684	N/A

Table 1: Dataset size.

Training procedure

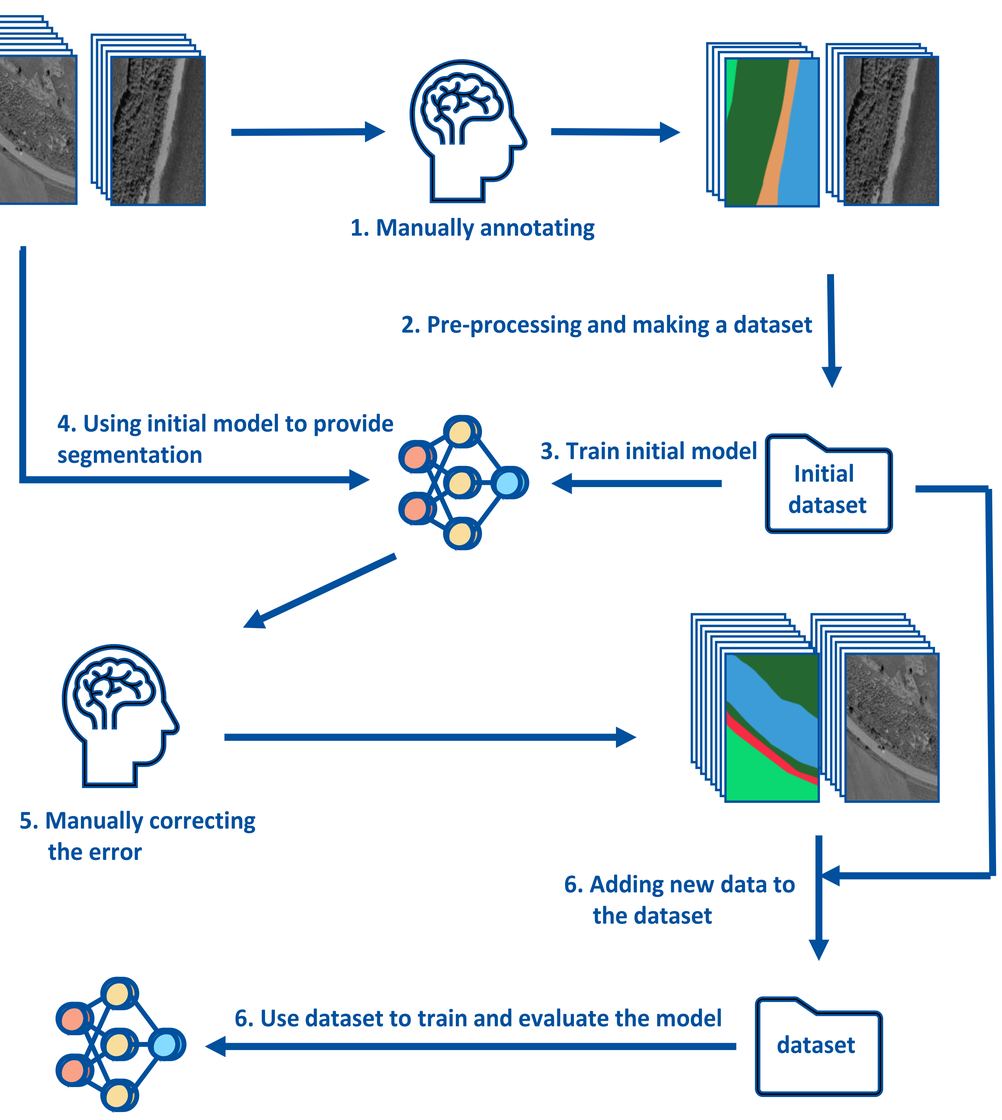

Figure 1: Process of making the dataset and training the model.

A U-net [2] network with VGG16 pretrained on ImageNet as encoder is chosen as our model. VGG16 contains 5 convolutional blocks, our experiments showed that if the first two blocks are untrainable, network achieve better generalization. Figure 1 illustrates the process of training the model. Data augmentation methods such as rotation and mirroring are used in pre-processing.

Results

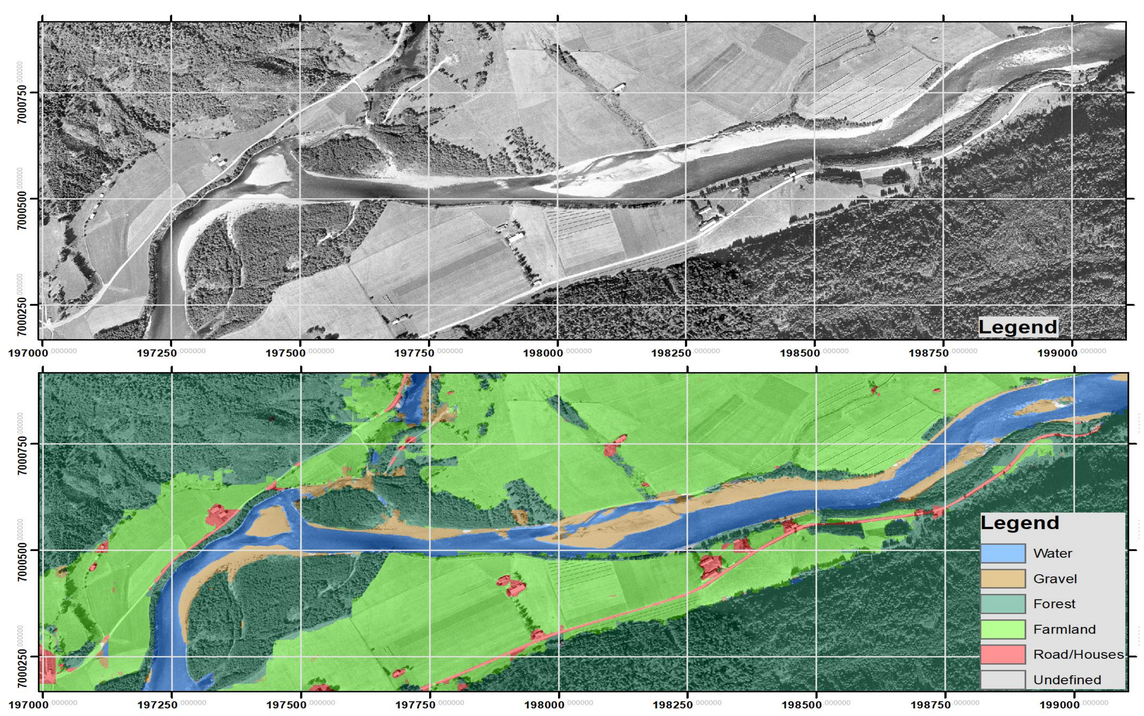

Figure 2: Predicted segmentation map of the model on the images of Surna taken at 1963.

Our method achieved:

- **76.25%** Mean Intersection over Union (mIoU) on validation set.
- **77.49%** on rivers not in training set.
- **53.81%** on rivers in training set in another time points.
- **71.30%** on different parts of rivers in training set.

Nea 1962		Predicted class				
		W	G	V	F	H
True class	W	**95.36**	0.14	1.83	2.39	0.00
	G	22.68	**53.15**	8.04	10.07	6.05
	V	3.14	0.11	**90.51**	4.59	1.64
	F	1.78	0.03	1.12	**96.79**	0.27
	H	0.09	0.00	2.80	14.15	**82.96**

Gaula 1963		Predicted class				
		W	G	V	F	H
True class	W	**91.36**	0.38	1.38	6.93	0.00
	G	7.84	**76.73**	6.72	6.10	2.60
	V	2.10	1.75	**88.96**	2.30	4.90
	F	0.60	2.49	8.37	**88.12**	0.42
	H	2.85	2.19	7.34	9.15	**78.48**

Table 2: Confusion matrix of model on river Nea which was not in the training set and parts of Gaula which was not in the training set. Classes are W : water, G : gravel, V : vegetation, F : farmland and H : human constructions

Conclusion

- Our method segments B&W images into usable format for further analysis of evolution of rivers.
- Segmenting B&W images allows to provide segmentation map for old aerial images which are widely available in Norway.
- Method is end-to-end and segmentation map is predicted relatively fast which makes it suitable to scale up the process and provide adequate data for further analysis.

Acknowledgment

We wish to thank Statkart – Geovekst for access to the aerial imagery.

References

[1] J. Åström, F. Ødegaard, O. Hanssen, and S. Åstrøm. Endring i leveområder for elvesandjeger og stor elvebreddedderkopp ved gaula. forekomst og dynamikk av elveører fra 1947 til 2014. *Norwegian University of Science and Technology*, 1314(32), 2017.

[2] O. Ronneberger, P. Fischer, and T. Brox. U-net: Convolutional networks for biomedical image segmentation. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 2015.