High-Resolution Water Segmentation for Autonomous Unmanned Surface Vehicles: A Novel Dataset and Evaluation

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ABSTRACT

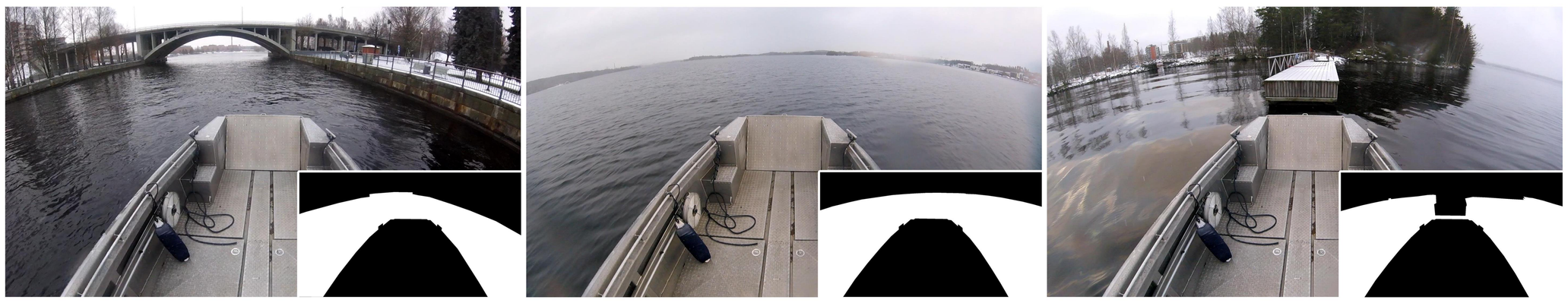
- One of the most vital and fundamental tasks in order to automate and ensure the safety of USV operations is to perform water segmentation.
- The main contribution of this paper is collecting, annotating and releasing a publicly available high-resolution dataset for developing deep learning algorithms for water segmentation in Nordic lake environment.
- Furthermore, we adapt a deep learning algorithm previously applied for road segmentation into water segmentation, and propose and evaluate a novel lightweight fully convolutional neural network architecture, fully adapted to the needs of water segmentation from high-resolution images.

DATASET

- 600 Full-HD quality images and hand-annotated segmentation masks
- 3 sub-sets, 200 images each:
  - Channel area
  - Docking situations
  - Open water
- Recorded: December 2017 – February 2018
- Location: Lake Pyhäjärvi, Tampere, Finland
- Device: GoPro Hero 4 Session

Different datasets and test cases

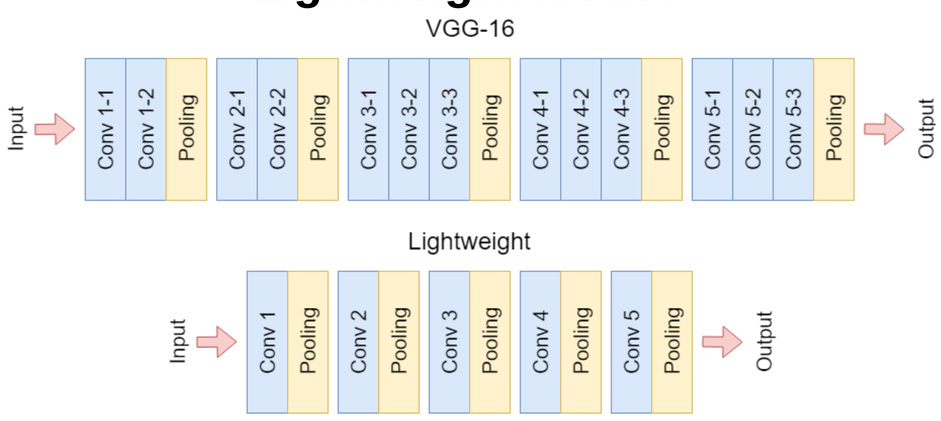
Channel *open* *dock*



Test No.	Training set	Test set	Training samples	Test samples	*Se*	*Sp*	*Prc*	*Acc*	F_1
1	channel	open + dock	200	400	0.9795	0.9777	0.9831	0.9787	0.9813
2	dock	channel + open	200	400	0.9935	0.9841	0.9865	0.9892	0.9900
3	open	channel + dock	200	400	0.9845	0.9401	0.9553	0.9654	0.9699
4	channel + dock	open	400	200	0.9980	0.9939	0.9945	0.9960	0.9962
5	channel + open	dock	400	200	0.9937	0.9428	0.9612	0.9727	0.9772
6	dock + open	channel	400	200	0.9892	0.9851	0.9882	0.9874	0.9887
7	all	all	300	300	0.9960	0.9931	0.9947	0.9947	0.9953
8	all	channel	300	100	0.9957	0.9939	0.9952	0.9949	0.9954
9	all	dock	300	100	0.9958	0.9883	0.9924	0.9928	0.9941
10	all	open	300	100	0.9967	0.9963	0.9967	0.9965	0.9967

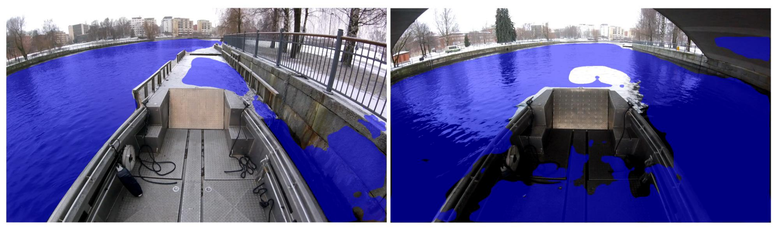
channel = dataset from the channel, dock = dataset with dokking situations, open = dataset with open water,
all = all data with 50/50 training/testing split

Comparison between VGG-16 and Lightweight model

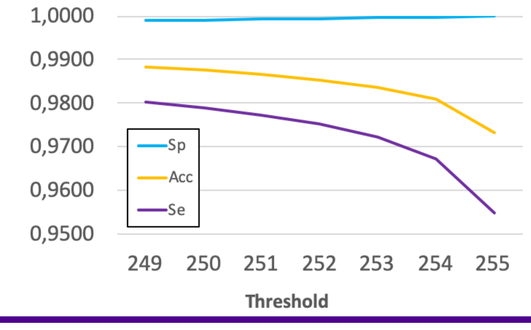


Model	speed (ms)	*Se*	*Sp*	*Prc*	*Acc*	F_1
VGG-16	221	0.9960	0.9931	0.9947	0.9947	0.9953
Lightweight	170	0.9962	0.9928	0.9944	0.9948	0.9953

Difficult situations and adjusting threshold



Specificity can be improved by raising the threshold.



Water segmentation in different situations