CLASSIFICATION OF SEA GOING VESSELS PROPERTIES USING SAR SATELLITE IMAGES

Authors: Dariusz Kobiela, Tomasz Berezowski

Gdańsk University of Technology, Faculty of Electronics, Telecommunications and Informatics, Gabriela Narutowicza 11/12, Gdańsk 80-233, Poland

Project goal

The goal of the project was to analyze the possibility of using machine learning and computer vision to identify (indicate the location) of all sea-going vessels located in the selected area of the open sea and to classify the main attributes of the vessel. The artificial neural network YOLOv7 was used in order to identify the ships on the images and to classify the 2 basic attributes of the ship: Length and Width. The key elements of the project were to download data from the Sentinel-1 satellite and data on the sea vessels from U.S. Coast Guard Automatic Identification System, then automatically tag data and develop a detection and classification algorithm.

Table 1. Sample of AIS data

MMSI	BaseDateTime	VesselName
367467120	2021-01-05 01:47:53	AVA FOSS
368129380	2021-01-05 01:47:53	HANALEI

LAT	LON	SOG	COG	Heading
33.84183	-118.39218	0.0	237.7	511.0
33.72059	-118.27743	0.0	360.0	511.0

IMO	CallSign	VesselType	Status
IMO7114288	WDF5779	60.0	5.0
IMO0000000	WDL4225	36.0	0.0

Length	Width	Draft	Cargo	TranscieverClass
18.0	5.0	15.0	60.0	A
13.0	8.0	11.4	90.0	B

Source data

Dataset consisted of 50 source images, dated from 6th January 2021 to 21st November 2022 (in about 2 weeks intervals to ensure that ships in the given harbor will change). In total 40 images were used in the training dataset, and 10 were used in the test dataset (each image size is about 900 MB, or 26000 per 17000 pixels). Data contains information such as location, time, vessel type, speed, length, beam, and draft.

Table 2. Datasets statistics

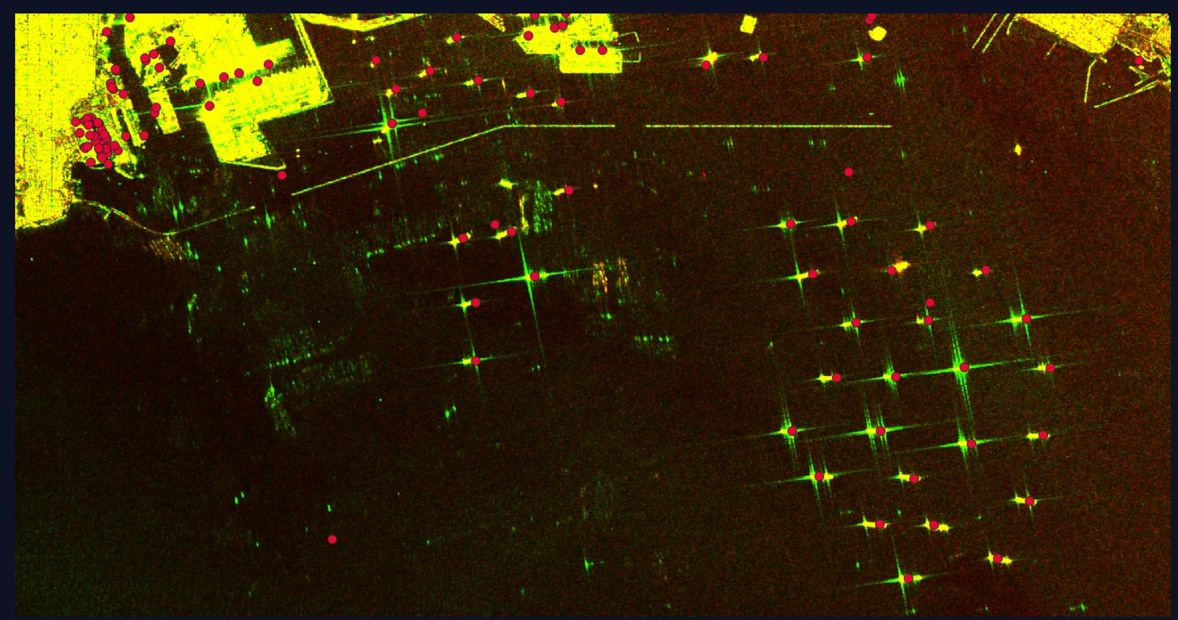
dataset	images	ships	tiny ship	small ship	medium ship	big ship	huge ship
train	592	592	76	138	169	93	116
test	214	214	23	41	56	46	48

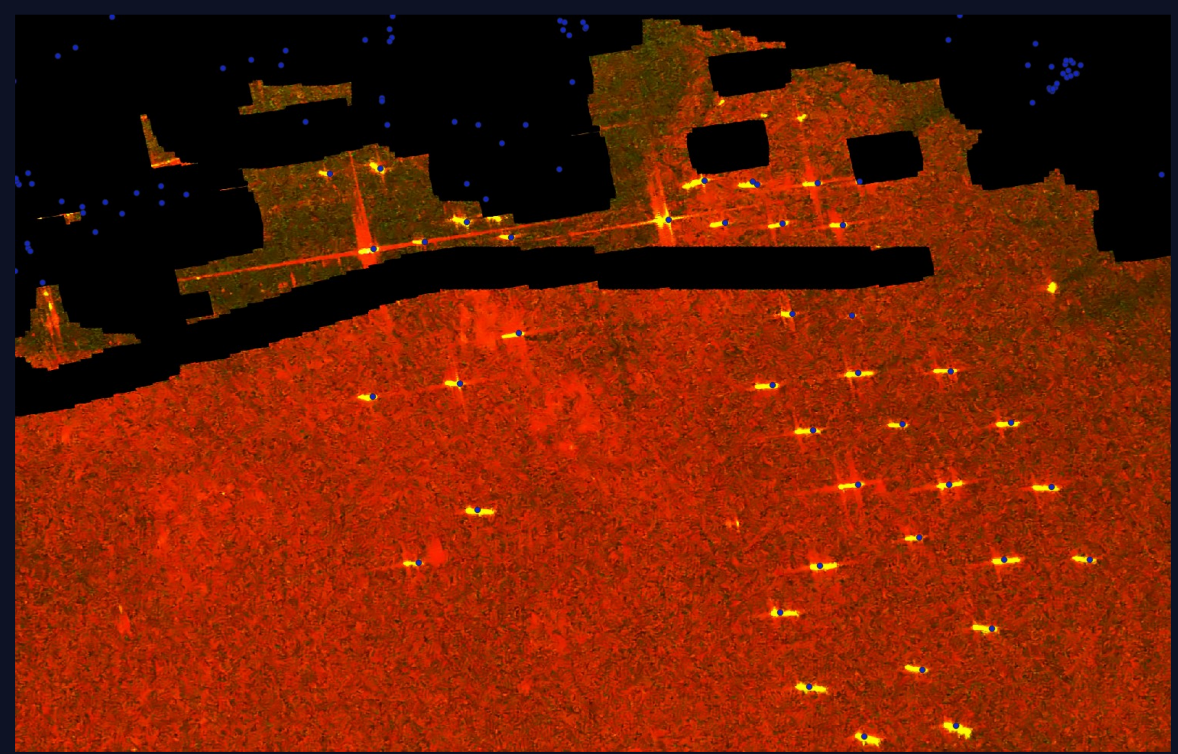
Data processing

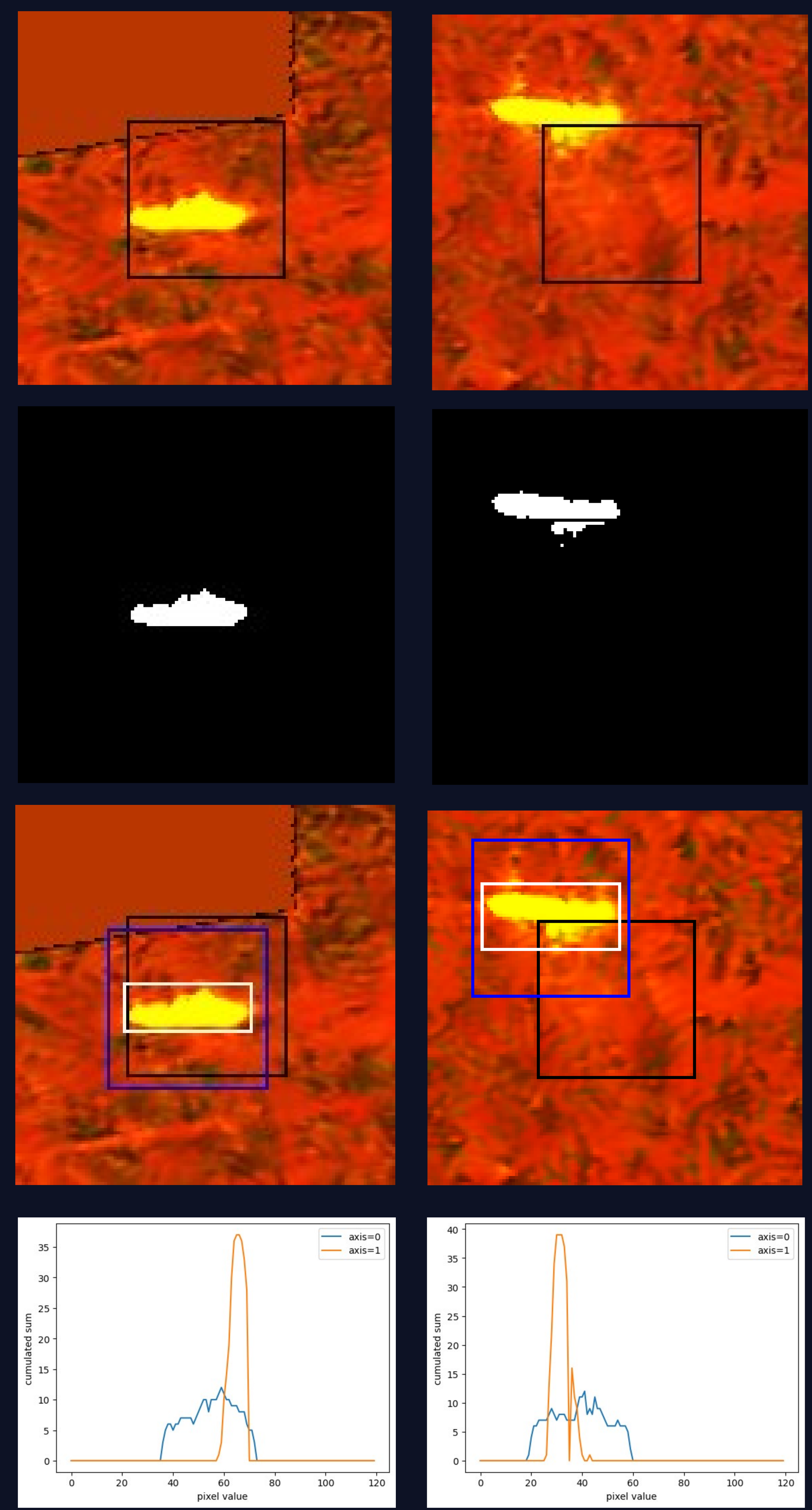
ASF and AIS data were combined together, preprocessed, and put into one raster layer. Image processing steps contained subsetting to the selected coordinates (in order to reduce image size), using a land-sea mask (masking the land and 40 meters offshore) and geometric terrain correction.

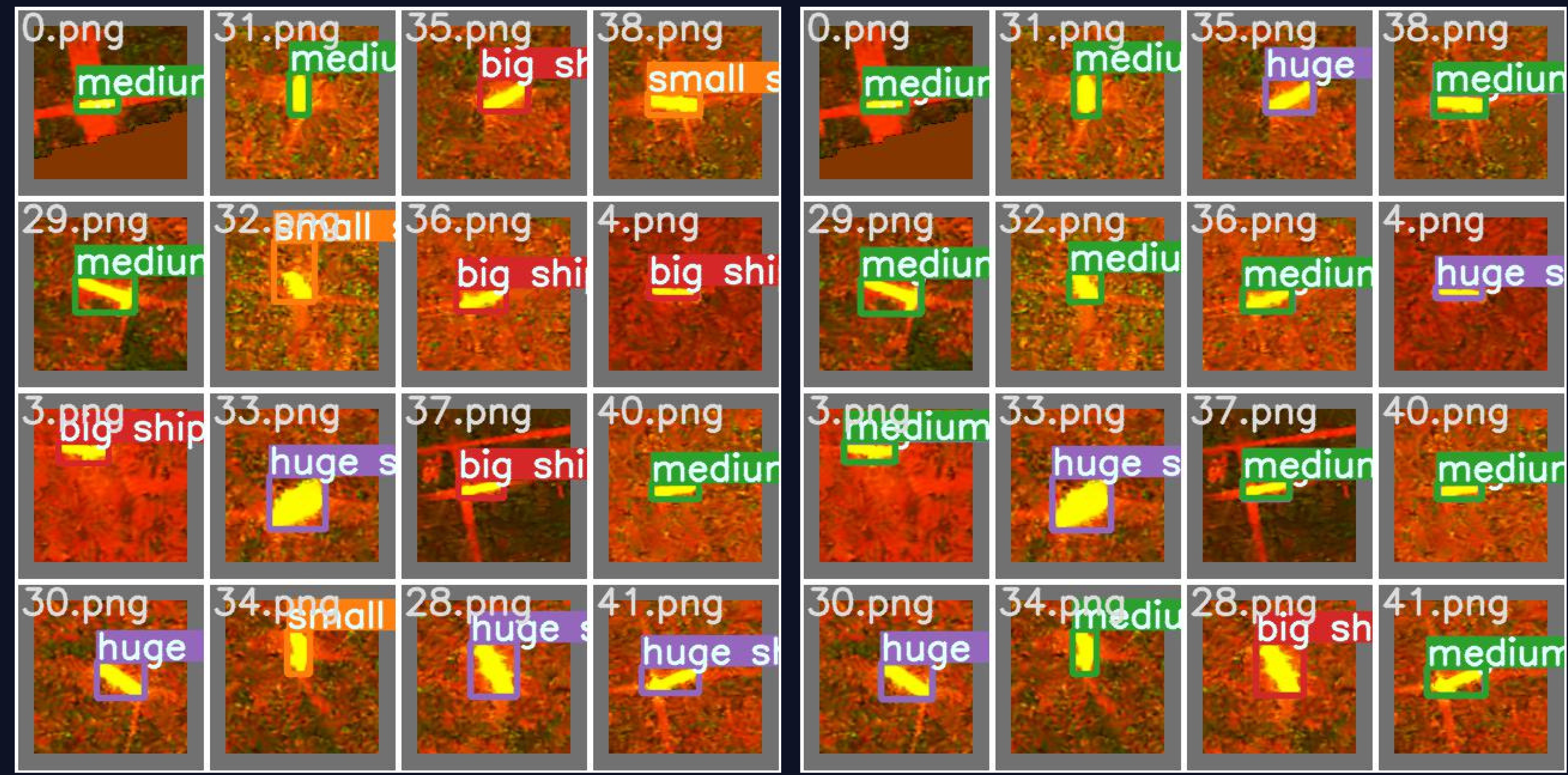
Data processing

Images contained a lot of zeros, thus rescaling intensity was used in order to shrink the intensity levels to from 2nd till 98th percentile. Ready images were converted from TIFF (GeoTiff) to PNG format. In order to make the background more smooth, the image denoising function was applied. Processing steps consisted of filtering the .csv files by corresponding image latitude and longitude, and then by the image timestamp (+/- 10 minutes). Next interpolating ship locations to the moment of making the image (image timestamp) by simple linear regression was conducted by taking the closest point before and after the timestamp. Next steps consisted of automatically tagging the images to the YOLO format using lat and lon attributes from the interpolated AIS data. Images were sliced into smaller tiles, 120x120 px each. Every tile contained one ship of different length and width, marked by the box 50x50 px. Primarily automated tagging was not accurate, thus it was improved by the usage of Otsu' binarization and image thresholding, temporarily converting tiled image to grayscale, summing up pixels on both axis, cutting off images below the threshold (they were black or contained only the sea), correcting (shifting) the center of the ship, and correcting the box by the usage of pixels' sum; the difference between the sea and the ship was clearly visible - usually it was enough to take the moments of jumps to the peaks as the starting and ending point of the box.



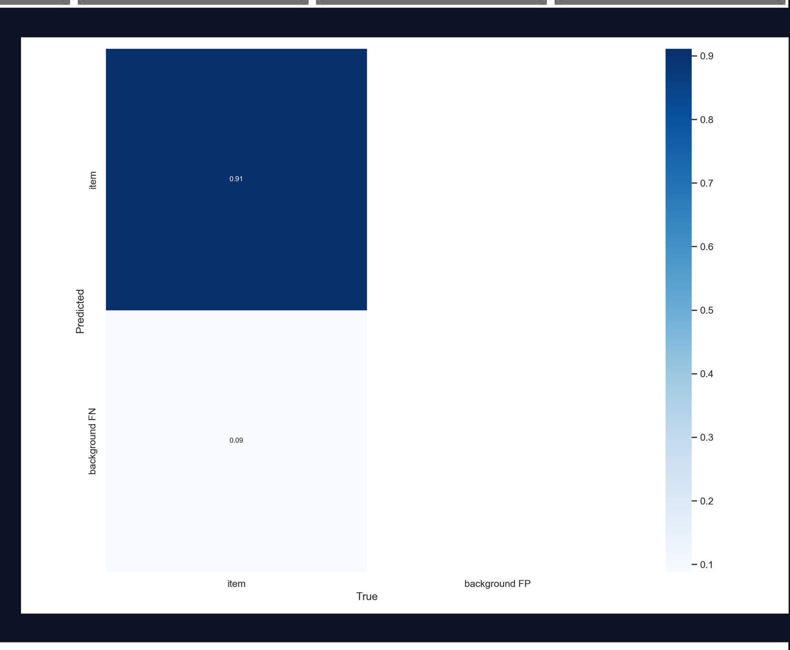






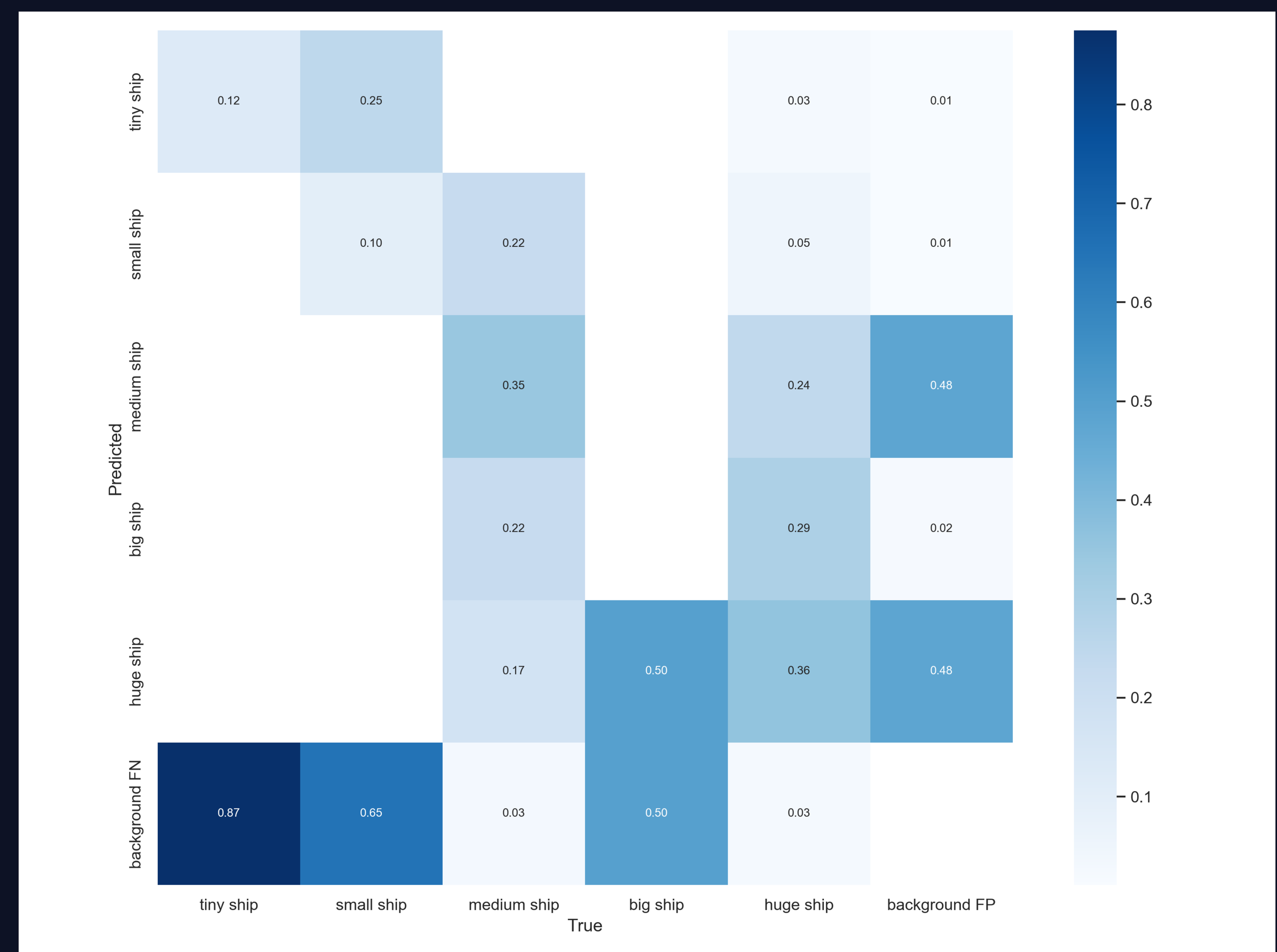
dataset	mAP@.5	precision	recall	f1-score
train	0.961	0.966	0.953	0.96
test	0.913	0.951	0.906	0.93

Class	Images	Precision	Recall	mAP@.5
all	214	0.321	0.755	0.40
tiny ship	23	0.423	0.261	0.279
small ship	41	0.382	0.558	0.343
medium ship	56	0.281	1	0.365
big ship	46	0.259	0.978	0.387
huge ship	48	0.259	0.979	0.667



Results

On the test set, the Mean Average Precision (mAP@.5) of YOLOv7 was 91,3% and F1-score was about 93%. Data was divided into a train set (about 590 ships) and a test set (about 210 ships). The classification of individual ships' properties had lower accuracy. Ships up to 134 meters were classified as "tiny ship", between 135 and 219 meters as "small ship", between 220 and 274 m as "medium ship", between 276 and 324 m as "big ship", and longer than 324 meters - "huge ship". The mean Average Precision for all classes was about 40%, f1-score was about 41%. The model had the biggest problems with classifying small and tiny ships. They consisted of a very small number of pixels and were hard to distinguish from the background. Also, some mistakes between neighboring classes happened (eg. between a medium and a big ship or a medium and a small ship).



This work has been partially supported by Statutory Funds of Electronics, Telecommunications and Informatics Faculty, Gdansk University of Technology. This work was supported in part through the European Regional Development Fund as part of the Project entitled: Academy of Innovative Applications of Digital Technologies under Grant The Operational Programme "Digital Poland 2014-2020" number POPC.03.02.00-00-0001/20-00.