Deep learning-based ship detection in SAR images for fishing effort estimation in the Barents Sea

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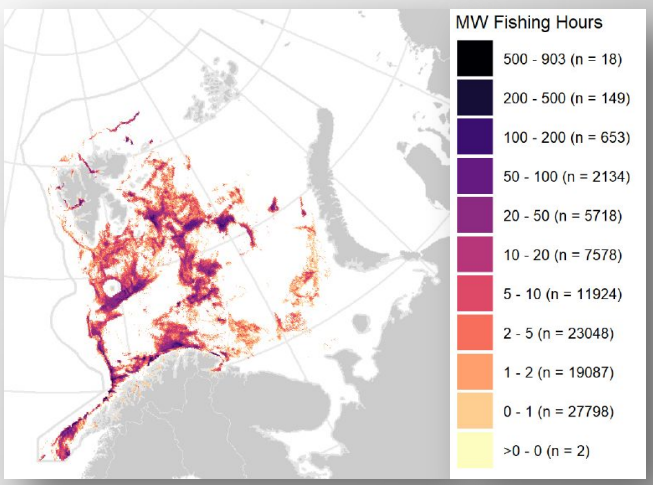
Introduction

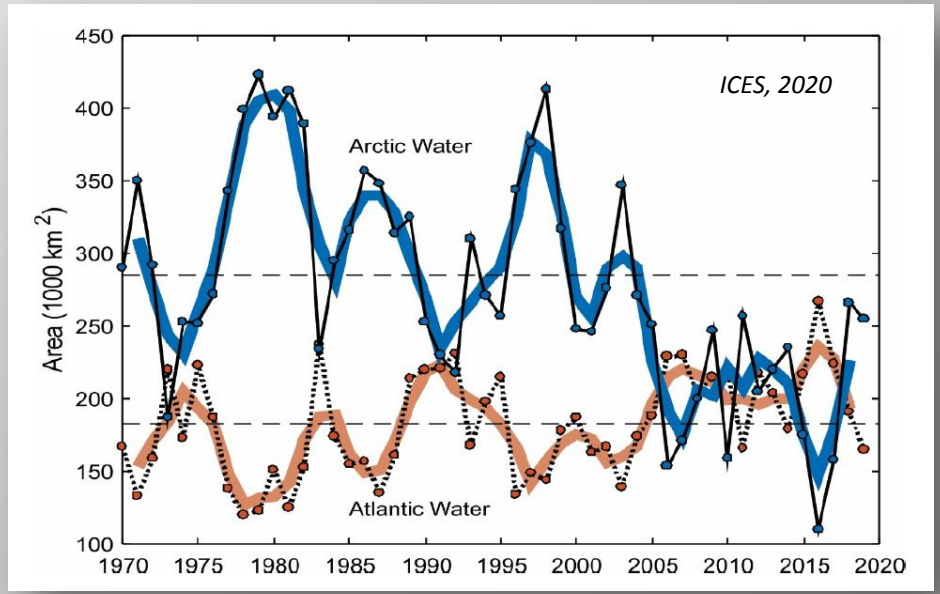
- The **detection** of **fishing vessels** can represent an efficient tool to describe the fishing activities

- Indicators of the fishing resources exploitation are useful for **fisheries management** and the construction of **ecosystem models** and **indicators**

- **The Barents Sea:**
  - rapid warming trend since the mid-1980s, associated with relatively warm and salty **Atlantic waters**
  - geographic shifts in biological communities induced changes in **food web structure** and **ecosystem functioning**



ICES Fisheries Overviews
Barents Sea Ecoregion, 2019



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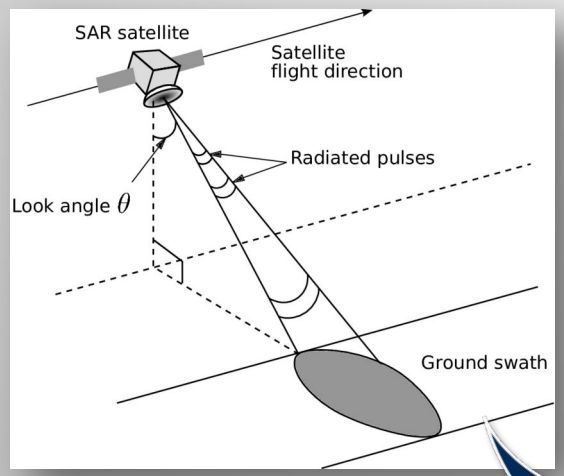
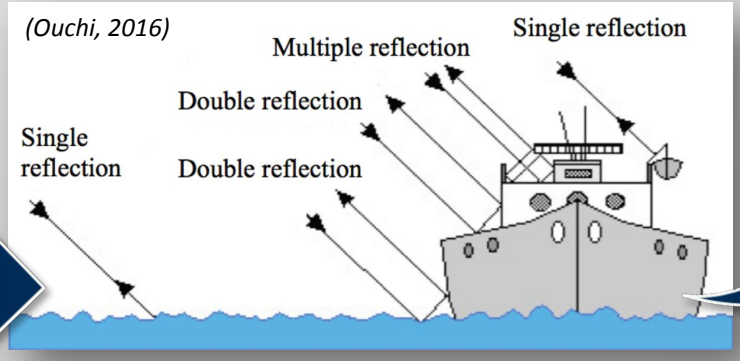
Introduction

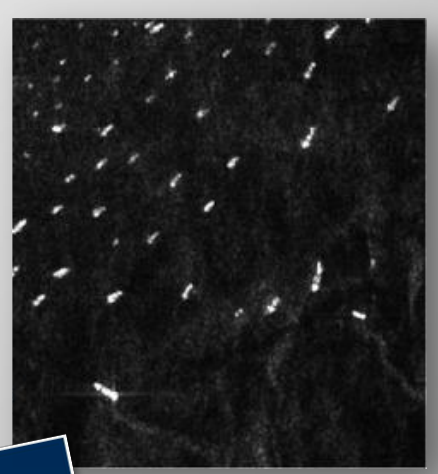
- **Synthetic aperture radar (SAR)** is a reliable tool for ship monitoring (all-weather conditions, no day-night cycles and ships' cooperation)
- Different methods (e.g., **adaptive thresholding** algorithms and **machine learning-based** approaches) have been proposed to detect ships from SAR images



Simplified geometry of a synthetic aperture radar (SAR) system



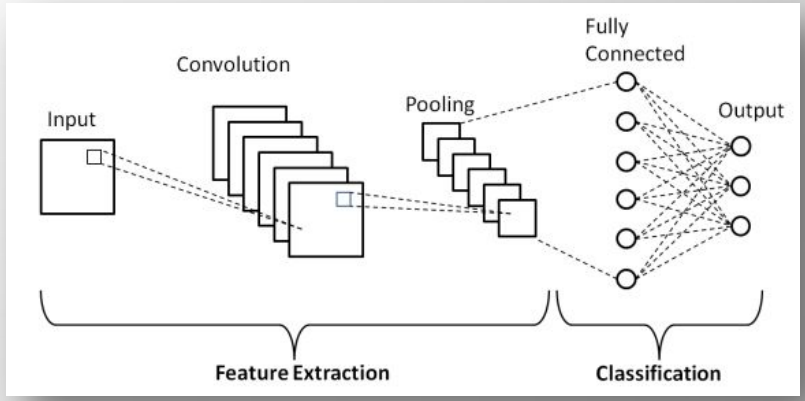
Different scattering mechanisms from the sea surface and a vessel



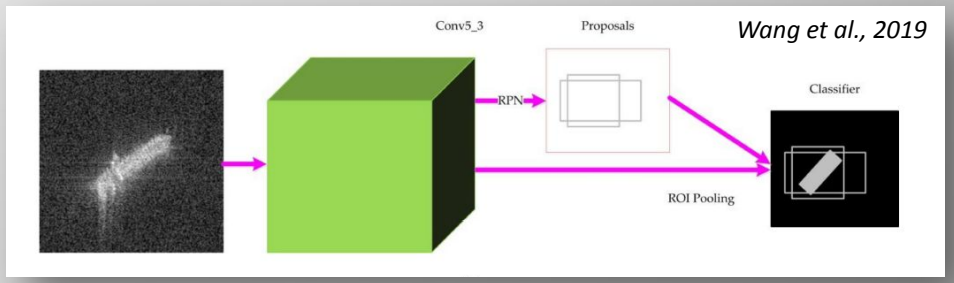
SAR image

Methods

- **Object detection** algorithms based on **deep learning** have been demonstrated higher detection accuracy
- **Convolutional neural networks (CNN)** learn higher-order features in grid-like topology data via convolutions (weighted sum of the pixel values through a sliding window)
- State-of-the-art CNN-based object detection methods:
  - **region proposal-based** methods (two-stage detectors), e.g. faster R-CNN: a set of candidate proposals are classified into foreground classes/background
  - **regression-based** methods (one-stage detectors), e.g. Single Shot Multibox Detector (SSD): a single feed-forward CNN directly predict classes and bounding boxes

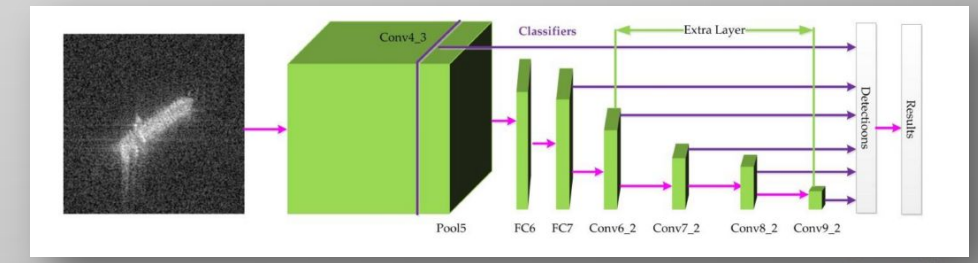


Convolutional neural network (CNN)



Wang et al., 2019

Faster regions with convolutional neural networks (R-CNN)

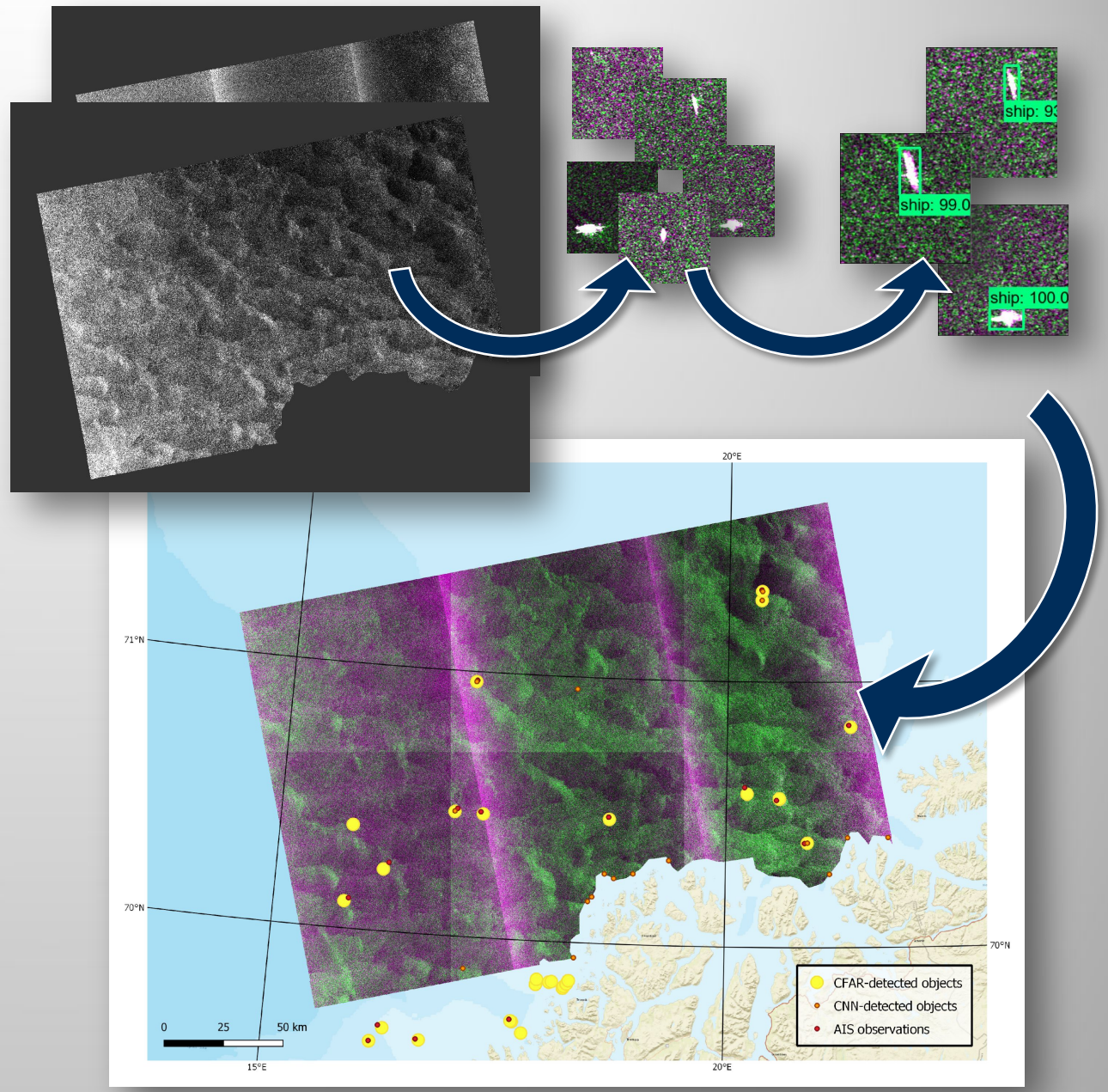


Single Shot Multibox Detector (SSD)

Methods

- **Training** of a deep learning model on previously detected ships to detect the same objects on new **Sentinel-1** SAR data
- Creation of the **training dataset**: crop in several tiles of 192 pixel per side; different polarizations (VH or VV) placed into separate bands
- Labels defined by a **class** and a **bounding box** in normalized coordinates; pre-trained model selection (SSD MobileNet V2 FPNLite)
- Full-scale **detection test** on Sentinel-1 scenes
- **Evaluation** on independent dataset; calculation of accuracy measures:

  Precision = TP/TP+TF = 0.759
  Recall = TP/TP+FN = 0.459



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Future developments

1) Building an **extensive training dataset** (labelling SAR imagery coupled with AIS);
2) test alternative network architectures, evaluating the performances taking into account the potential confounding presence of **sea ice** and the characteristics of the **local fleet**;
3) systematically process Sentinel 1 archives, to estimate the **dynamics** of **ships distribution** in the study area.

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