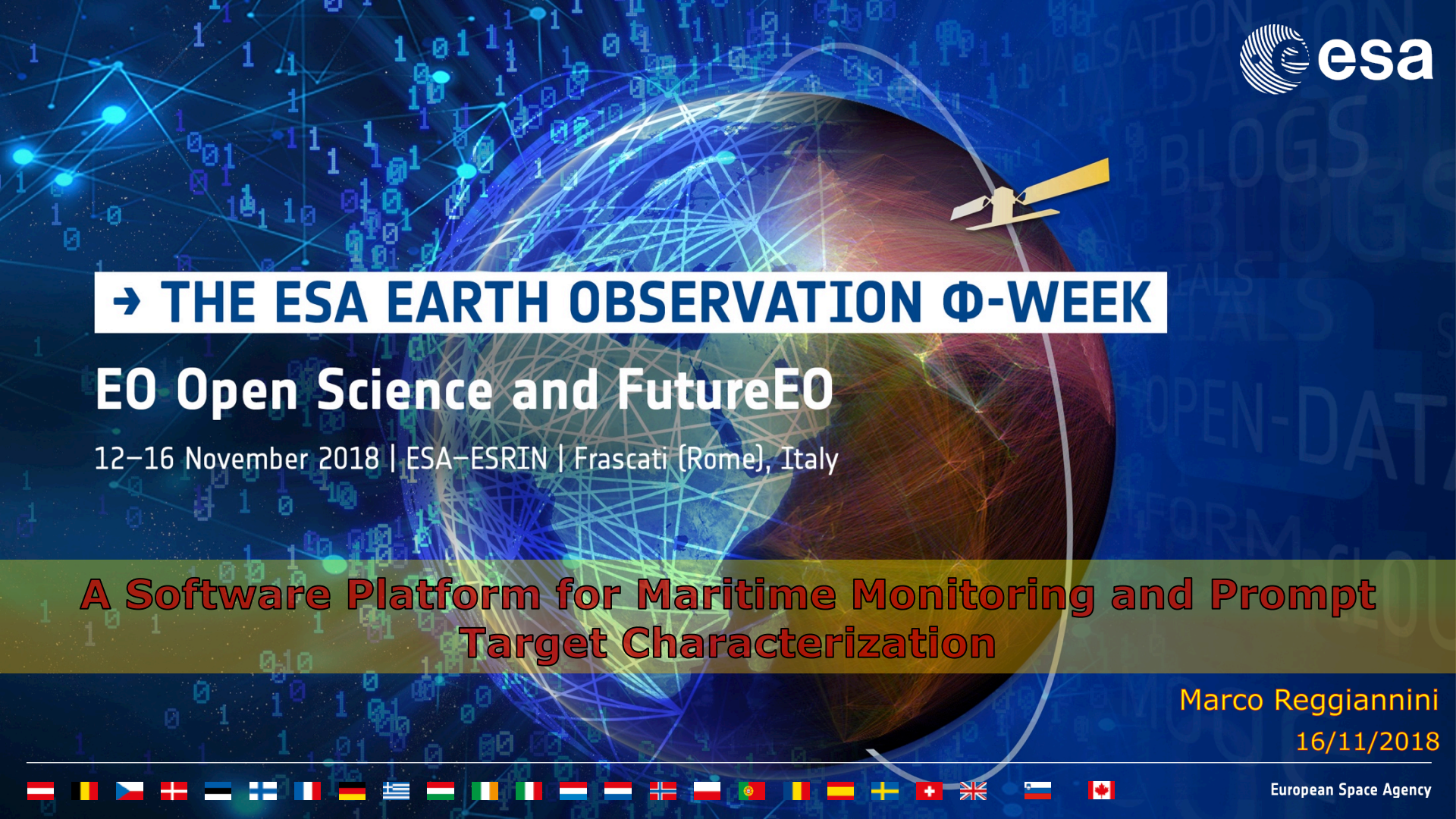

A Software Platform for Maritime Monitoring and Prompt Target Characterization

Marco Reggiannini

16/11/2018

Why?

Saving our heritage, our future: The worrying state of Mediterranean fish stocks

APR 03 2017

Fish stocks in the Mediterranean Sea are deteriorating at an alarming rate. A recent analysis shows that 93% of the assessed fish stocks are overexploited, and a number of them are on the verge of depletion. In addition, the Mediterranean Sea has lost 41% of its marine mammals and 34% of the total fish population over the past 50 years.

The Mediterranean Sea is characterised as a low-productivity ecosystem and thus it is very easy to overfish the existing stocks ©Fotolia Microgen

An estimated 10 000 to 12 000 marine species inhabit the Mediterranean Sea, but this extraordinary biodiversity is in grave danger, as it is threatened by pollution, climate change and overfishing. Further delays in concerted action could result in irreversible damage and a collapse of key stocks that are essential to the fisheries sector.

Marine mammals and fish on the decline

In a study published in Nature's *Scientific Reports*, Joint Research Centre (JRC) scientists warn about pressures on the Mediterranean Sea that might push the ecosystem beyond the point of no return. The analysis looks at the historical changes in the Mediterranean Sea food web driven by environmental drivers and fishing efforts. It concludes that, over the past 50 years, the Mediterranean has lost 41% of the number of marine mammals and 34% of the total amount of fish. The largest reductions were found in the Western Mediterranean Sea and the Adriatic Sea (- 50%), while the reduction was much less in the Ionian Sea (- 8%).

The Mediterranean is vulnerable

Overfishing

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The Mediterranean is vulnerable

Overfishing

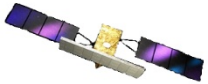
Migration crisis

Pollution

Maritime observation through satellite missions

- SAR

CSK (ASI)



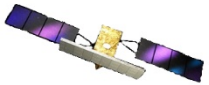
Sentinel I (ESA)

Maritime observation through satellite missions

- SAR
- Optical

Sentinel II (ESA)

CSK (ASI)



Sentinel I (ESA)

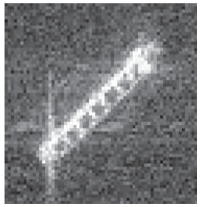
EROS-B (ImageSat)

Vessel identification through remote sensing data

⇩

A software platform to

Detect



Vessel identification through remote sensing data

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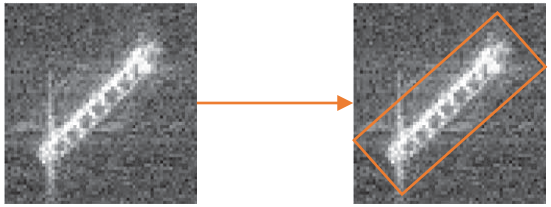

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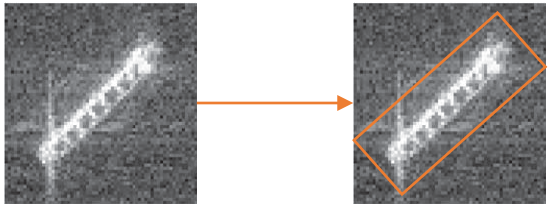
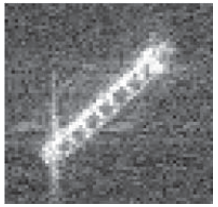


Classify



Vessel identification through remote sensing data

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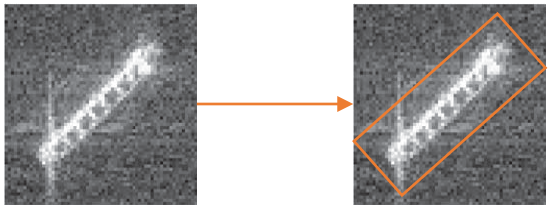
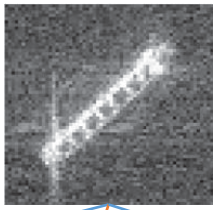


Classify



Tanker

Bulk Carrier

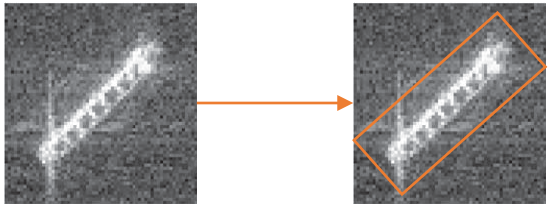
Cruise ship

Vessel identification through remote sensing data

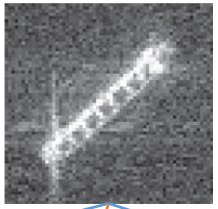
⇩

A software platform to

Detect



Classify

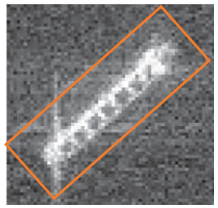


Tanker

Bulk Carrier

Cruise ship

Estimate

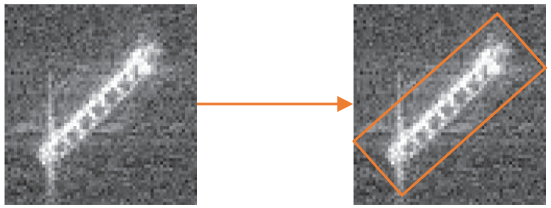


Vessel identification through remote sensing data

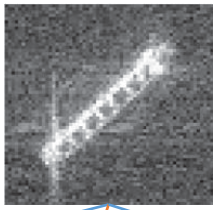
⇩

A software platform to

Detect



Classify

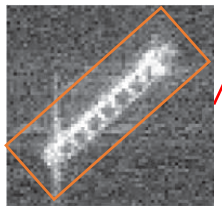


Tanker

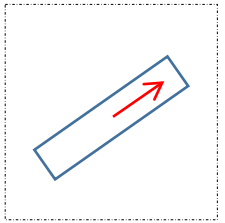
Bulk Carrier

Cruise ship

Estimate



- Velocity
- Route



Vessel identification through remote sensing data

⇩

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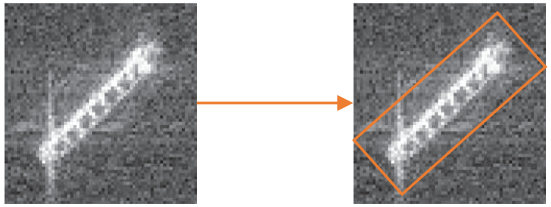
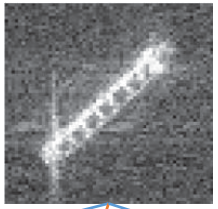


Classify

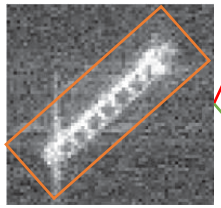


Tanker

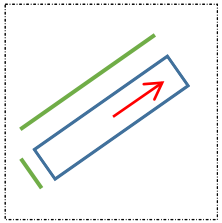
Bulk Carrier

Cruise ship

Estimate



- Velocity
- Route



- Coordinates
- Shape

Detection

Constant False Alarm Rate

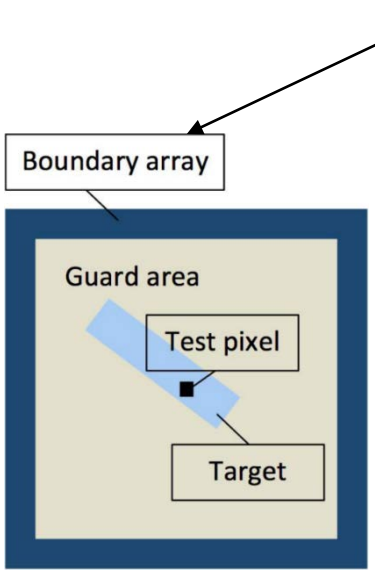
Detection

CFAR → Hypothesis on background statistics → Gaussian distributed

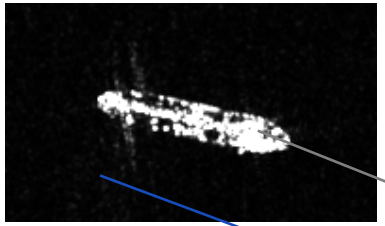
Detection

CFAR → Hypothesis on background statistics → Gaussian distributed

Locally estimated in moving windows

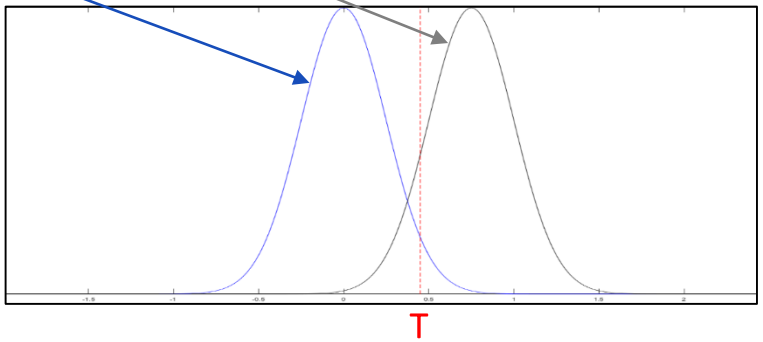


Detection

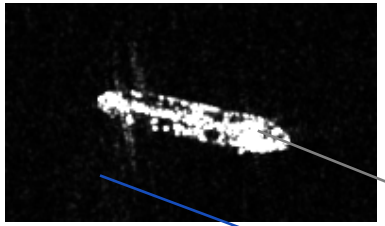


signal larger then the local threshold

positive detection



Detection



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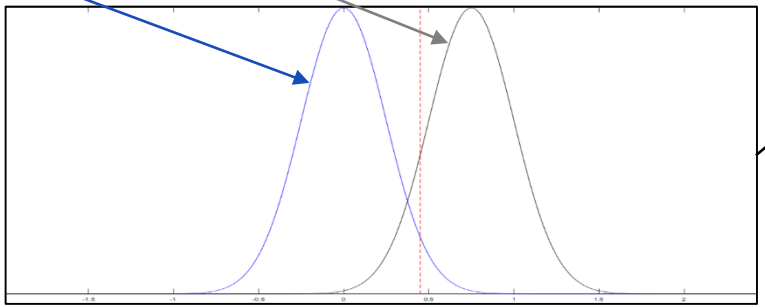
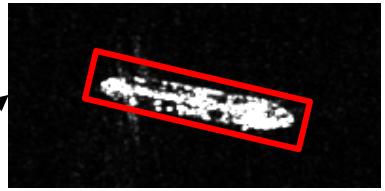
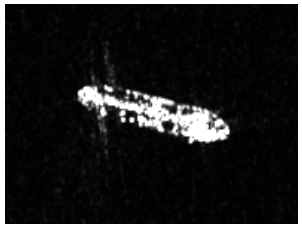




Ship centroid coordinates

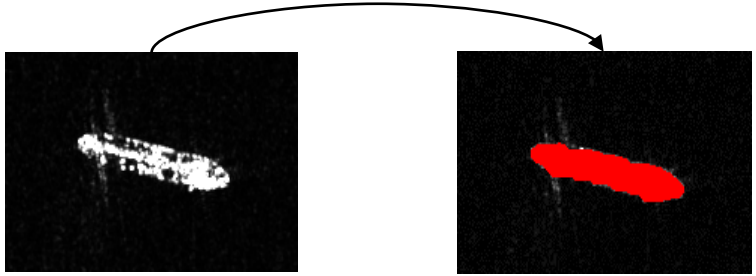
Segmentation/classification

Morphological information



Segmentation/classification

Iterative procedure based on sigma-thresholding



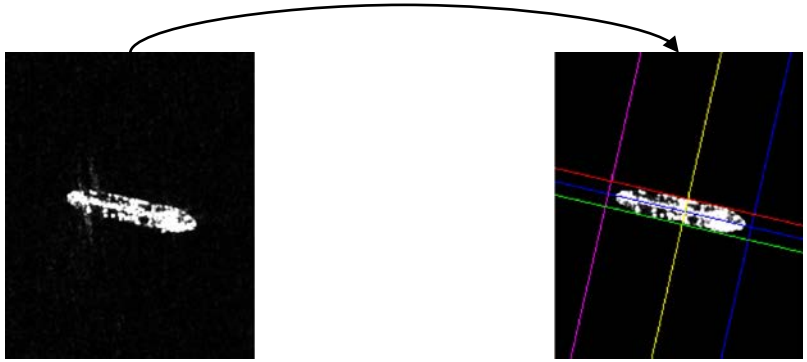
- Refined ship centroid
- Ship footprint

Segmentation/classification

Geometrical information

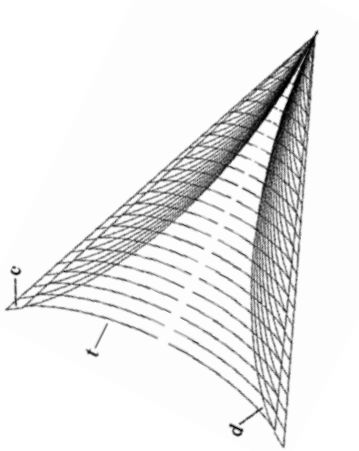
Segmentation/classification

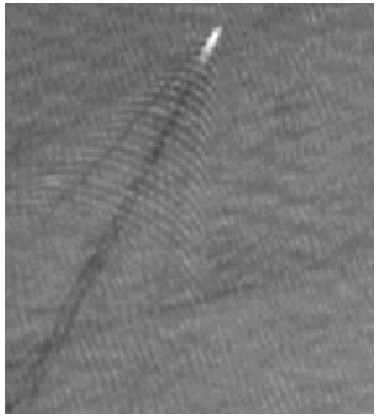
Principal inertia axes



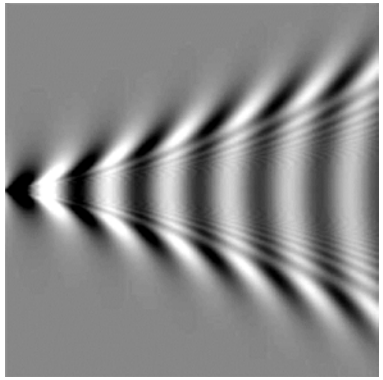
- Ship dimensions
- Ship route

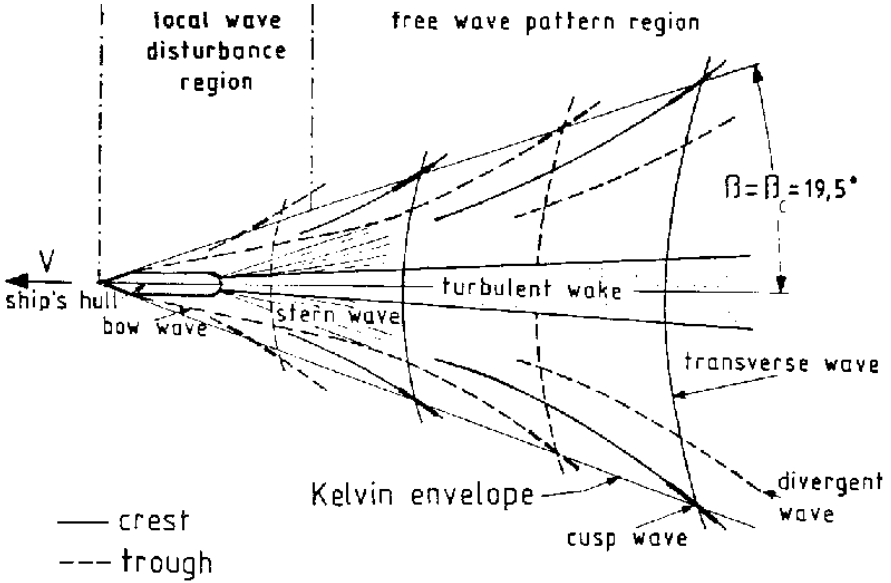
Estimation - Vessel Kinematics





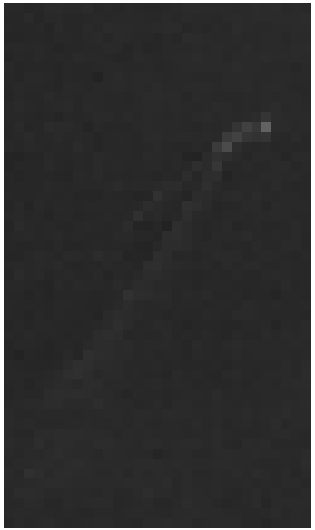
Wake pattern





Wake detection

Input Patch

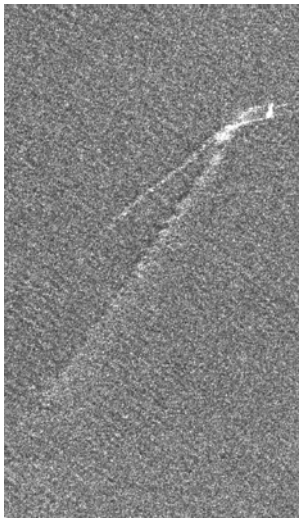


Wake detection

Input Patch

↓

Signal enhancement

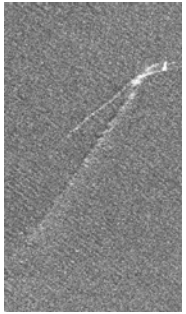


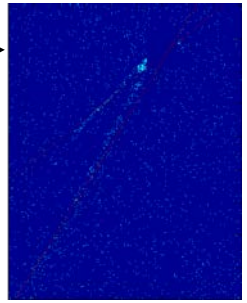
Wake detection

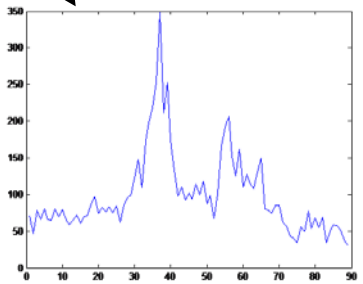
Input Patch

Signal enhancement

Radon transform







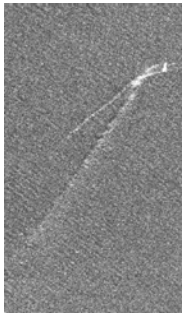
Wake detection

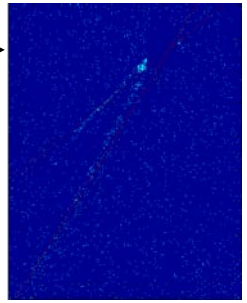
Input Patch

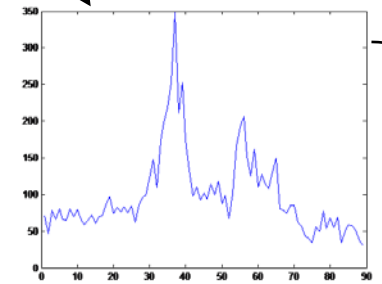
Signal enhancement

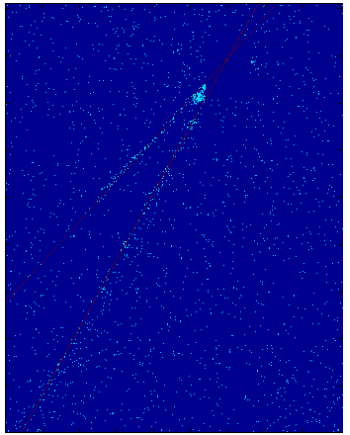
Radon transform

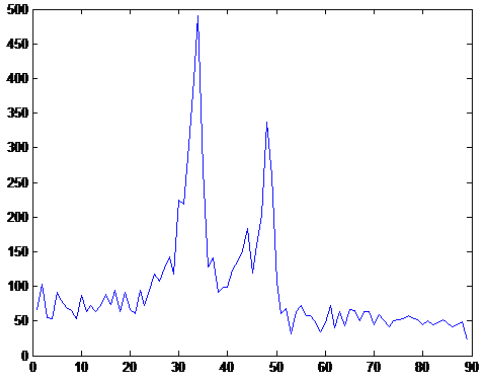
Angular histogram and peak extraction





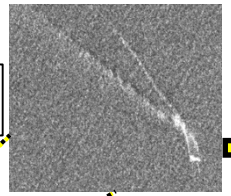


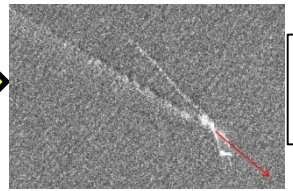




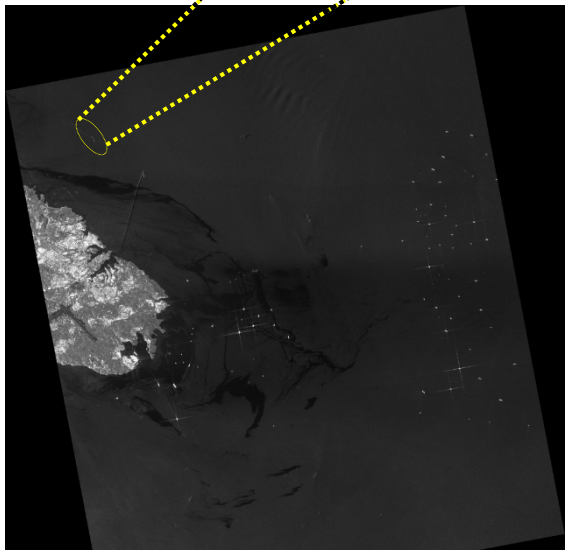
Kinematics – Velocity 1

Wake analysis



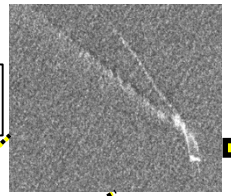


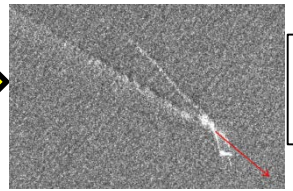
Velocity Estimation - 1



Kinematics – Velocity 1

Wake analysis





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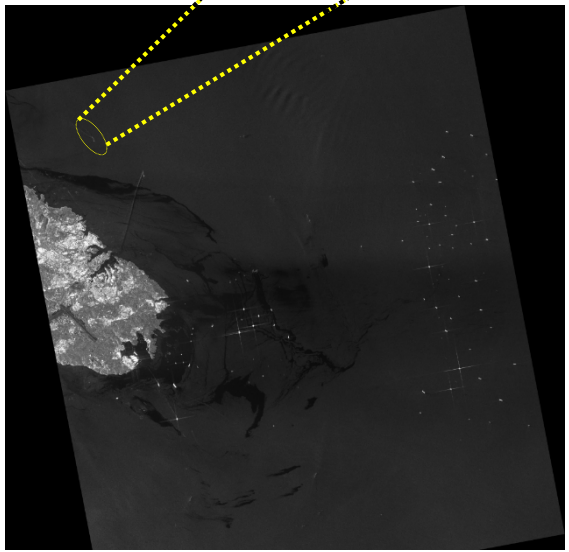
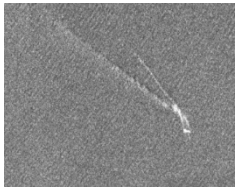
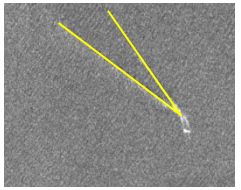
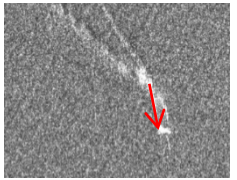


Line detection by RT

Estimate separation between wake tip and ship centroid

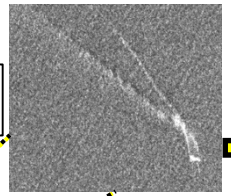


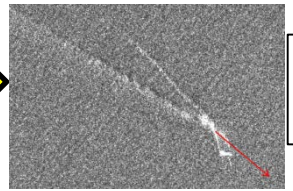




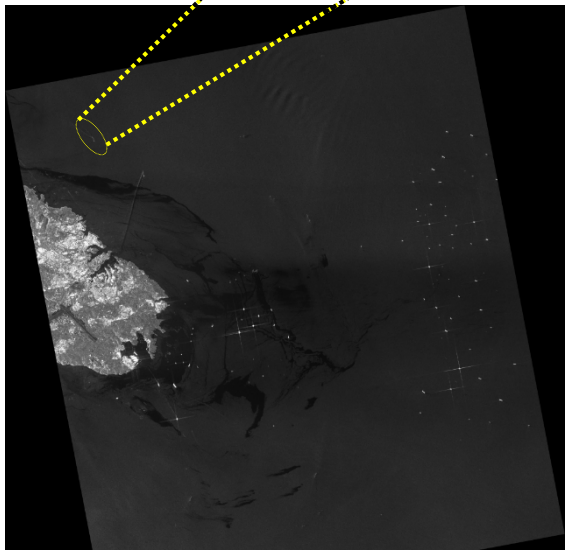
Kinematics – Velocity 2

Wake analysis



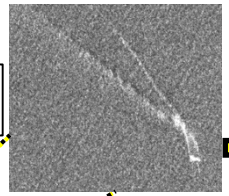


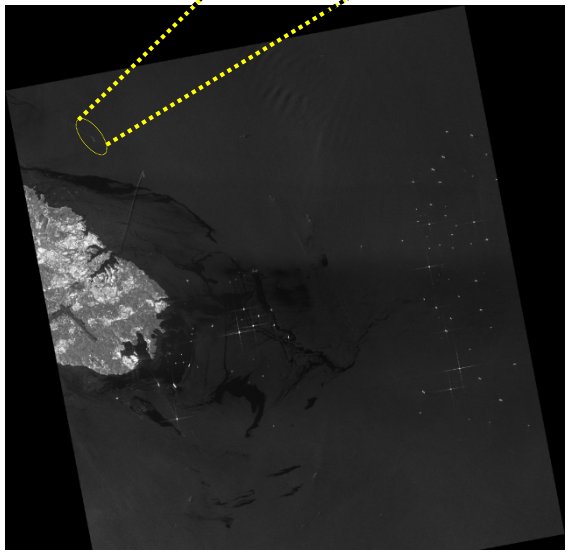
Velocity Estimation - 2

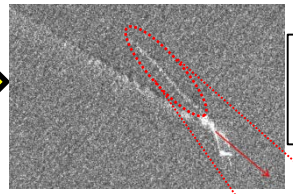


Kinematics – Velocity 2

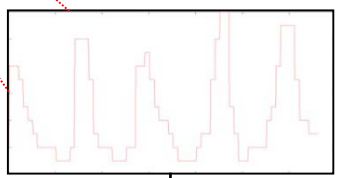
Wake analysis

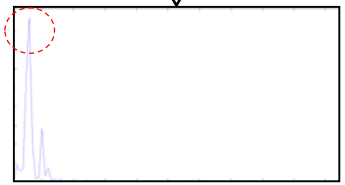






Velocity Estimation - 2





λ_{peak}

$$V_{ship} = \sqrt{\frac{\sqrt{3} g \lambda_{peak}}{4\pi}}$$

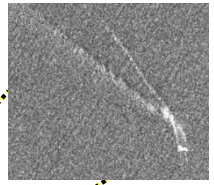
Ship's wake cuts

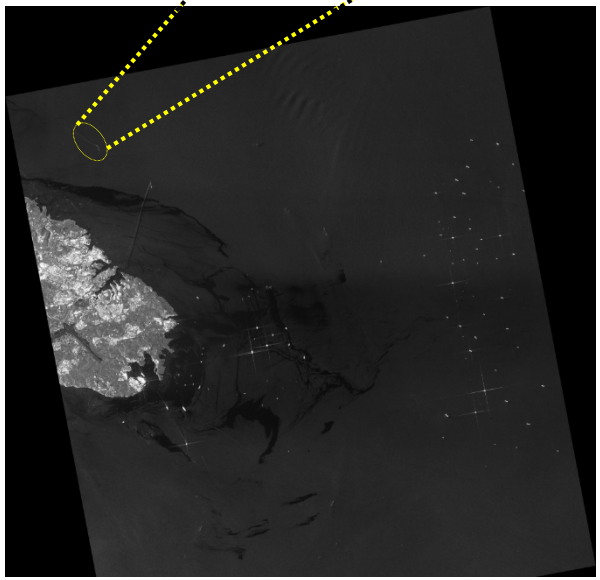
Cusp wave frequency analysis

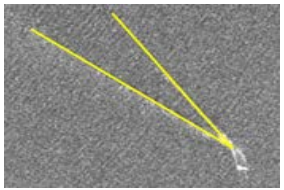
Cusp wave λ peak

Conclusions

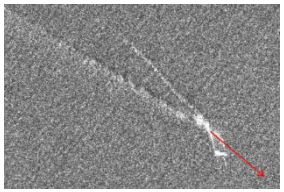
Wake analysis







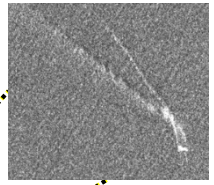
Heading estimation

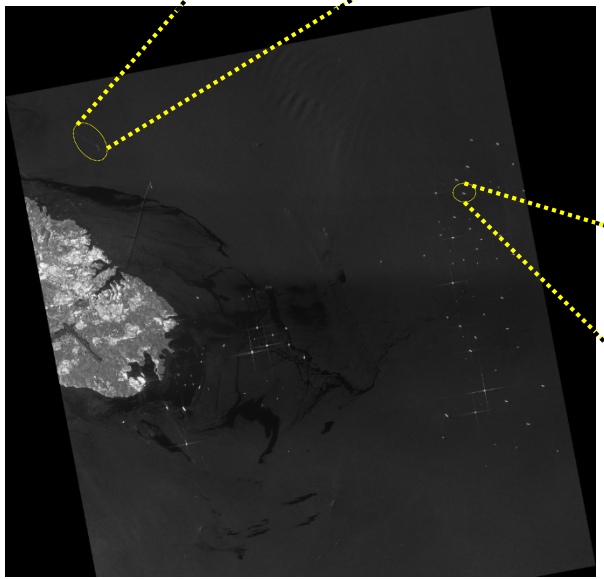


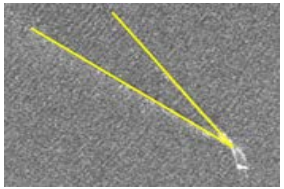
Velocity estimation

Conclusions

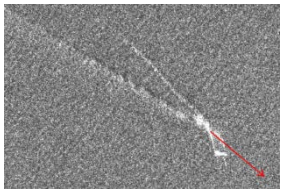
Wake analysis







Heading estimation

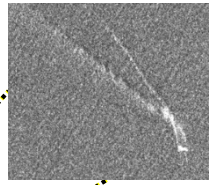


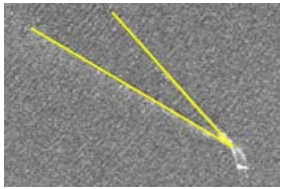
Velocity estimation

Vessel detection

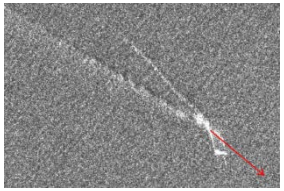
Conclusions

Wake analysis

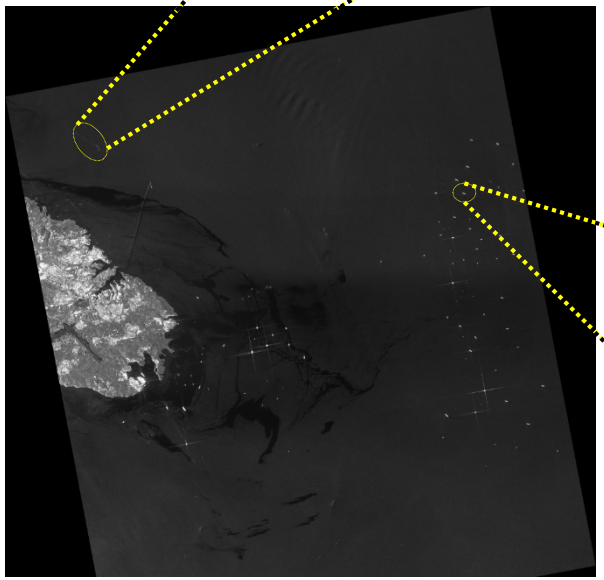




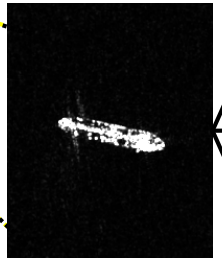
Heading estimation



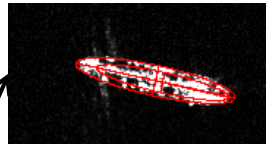
Velocity estimation

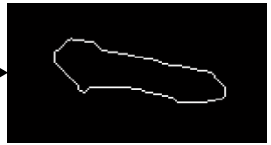


Vessel detection



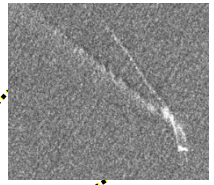
Feature extraction

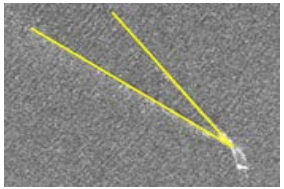




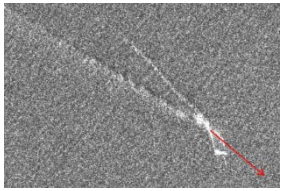
Conclusions

Wake analysis

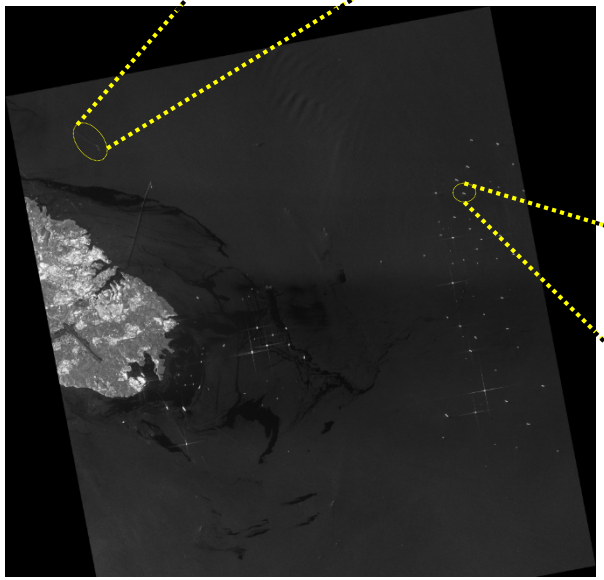




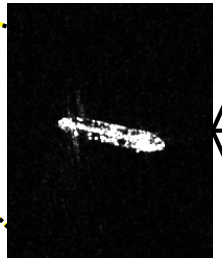
Heading estimation

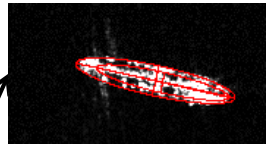


Velocity estimation

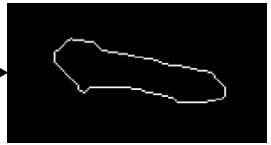


Vessel detection





Feature extraction



Feature DB interrogation

Vessel classification

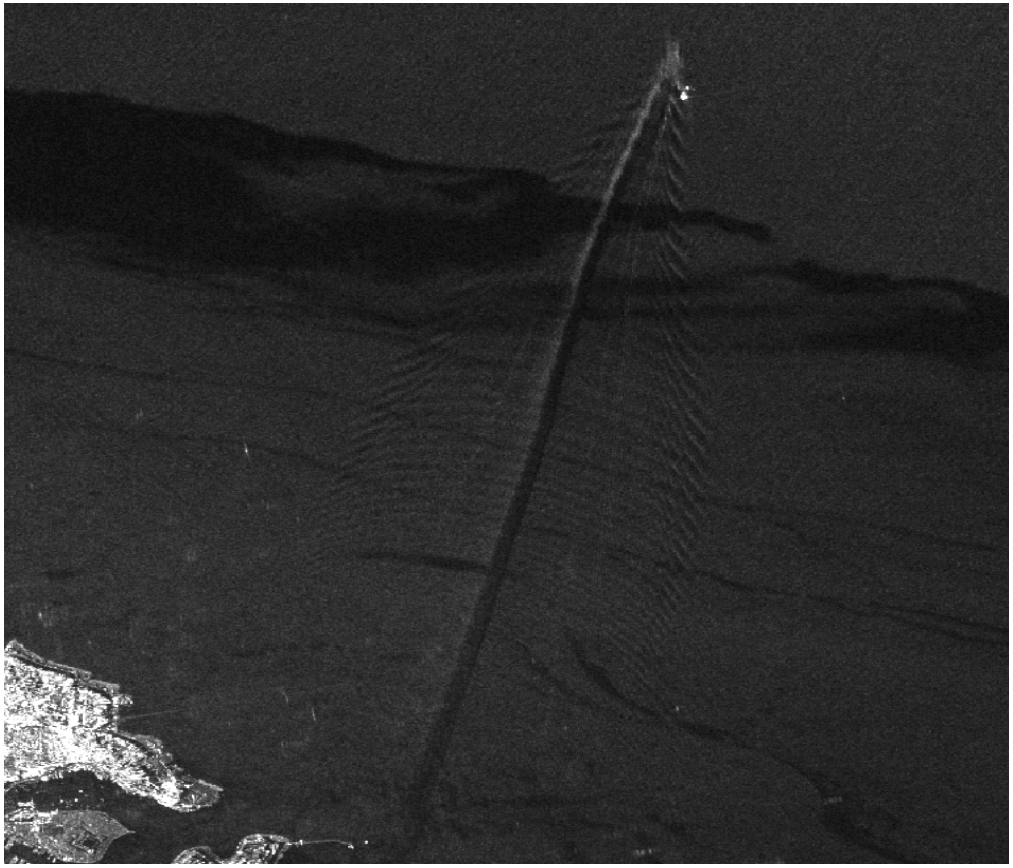
OSIRIS

Optical/SAR data and System Integration for Rush Identification of Ship models

https://wiki.services.eoportal.org/tikiindex.php?page=OSIRIS

Thank you

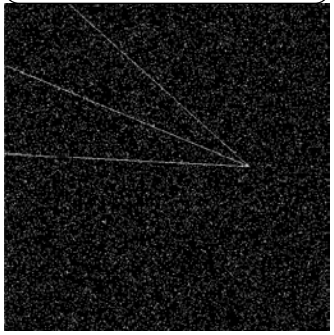
Wake pattern: SAR visual feature providing information about the vessel kinematics



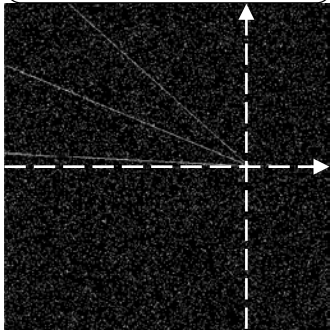
Stripmap HImage
5m px resolution

Novel method for wake detection

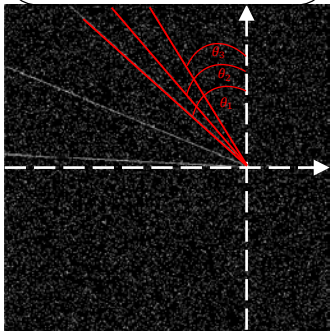
Signal thresholding and vessel masking



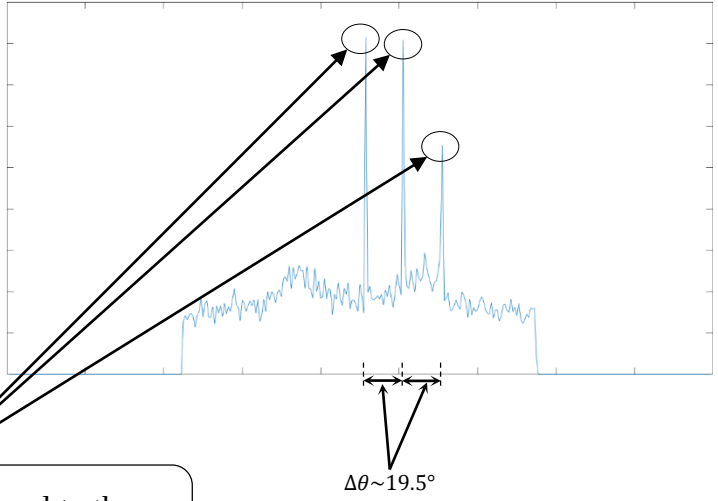
Frame with origin on the vessel centroid



Family of straight lines passing through the supra-threshold points and the frame origin

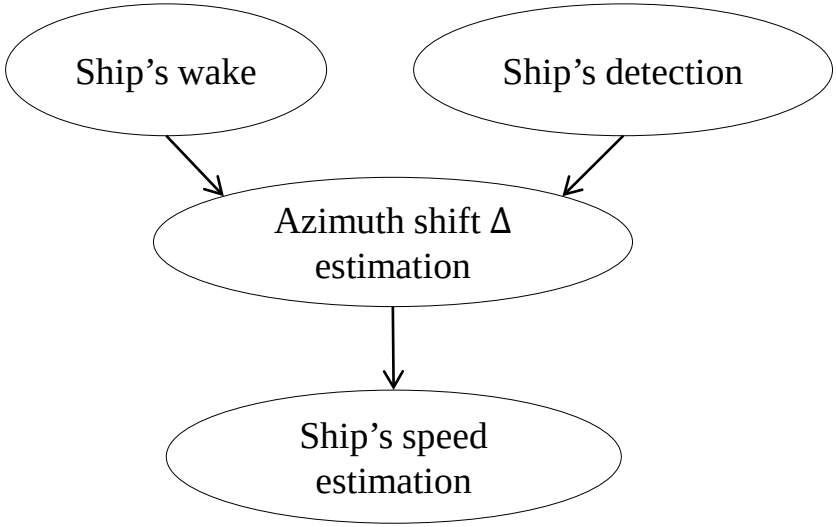


slopes histogram



A number of peaks equal to the number of wake components…

…with the expected angular apertures

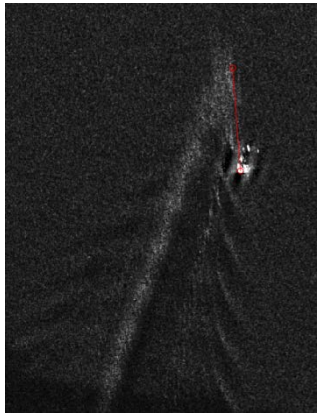


$$V_{sat} \approx 7.5 \cdot 10^3 \; m/s$$

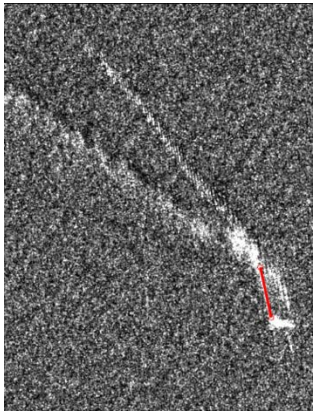
$$R \approx 704 \cdot 10^5 \; m$$

$$V_{ship,r} = \frac{V_{sat} \cdot \Delta}{R}$$

Δ estimated from the image



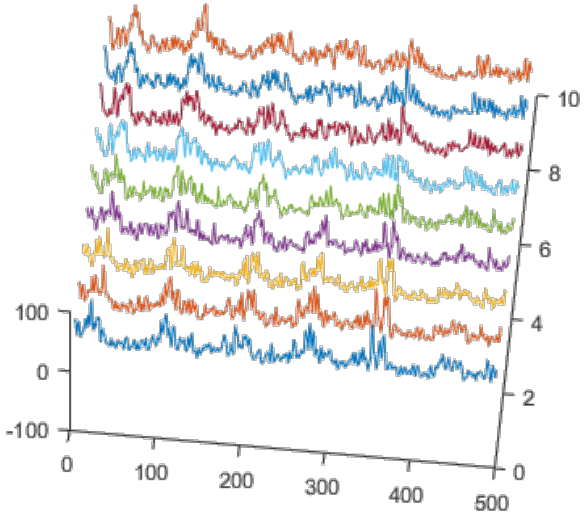
$\Delta \approx 1645 \; m, V_{ship,r} \approx 33.95 \; kn$

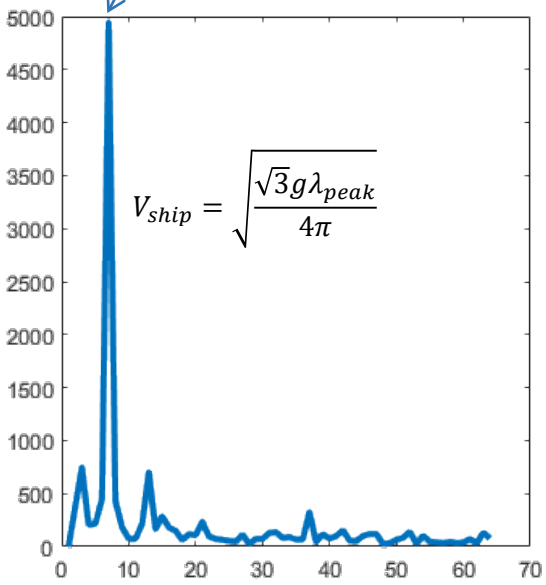


$\Delta \approx 175 \; m, V_{ship,r} \approx 3.63 \; kn$

Ship's speed - 2

Ship's wake → Cusp wave frequency analysis → Cusp wave λ peak

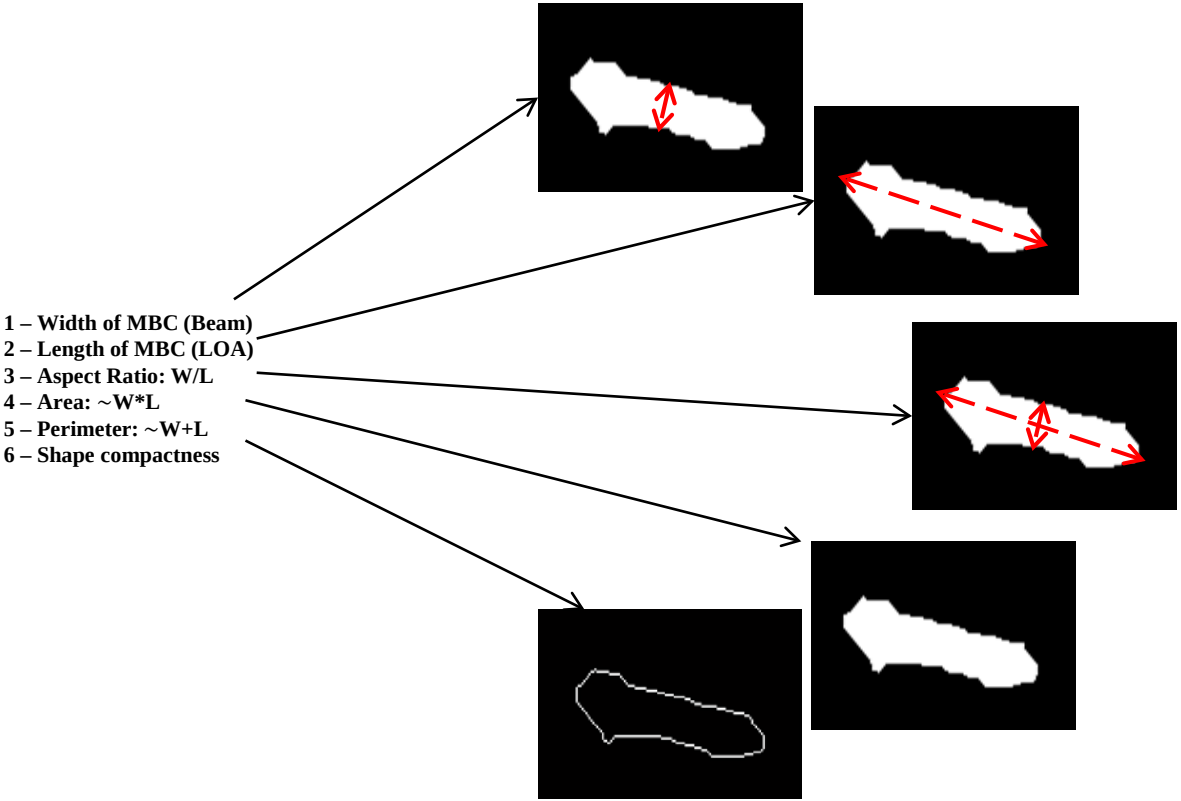




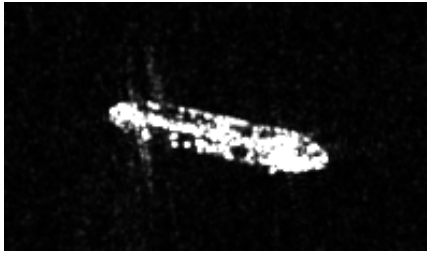
Future Prospects

- Implementation of a novel method for wake detection in SAR maps
- Joint exploitation of wake analysis results and fine segmentation output

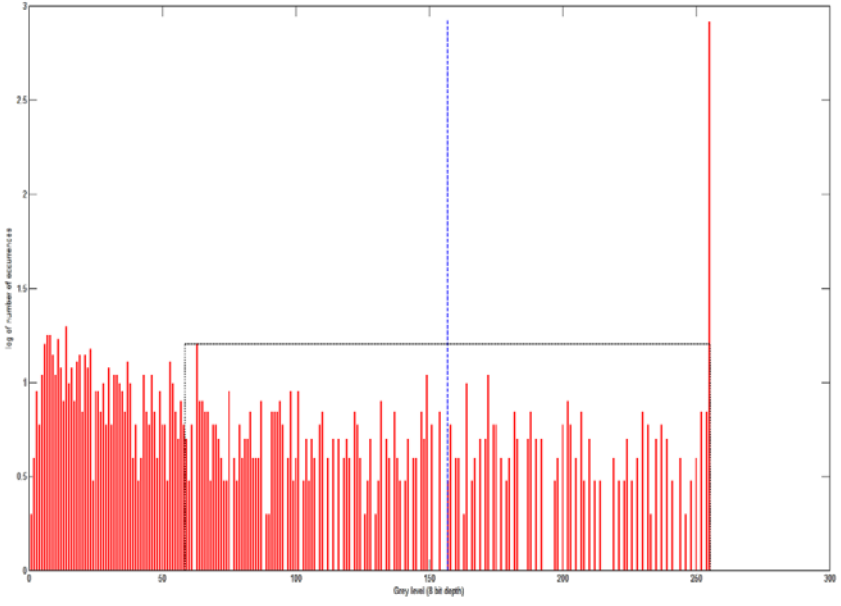
Morphological Features for classification



Radiometric Features for classification

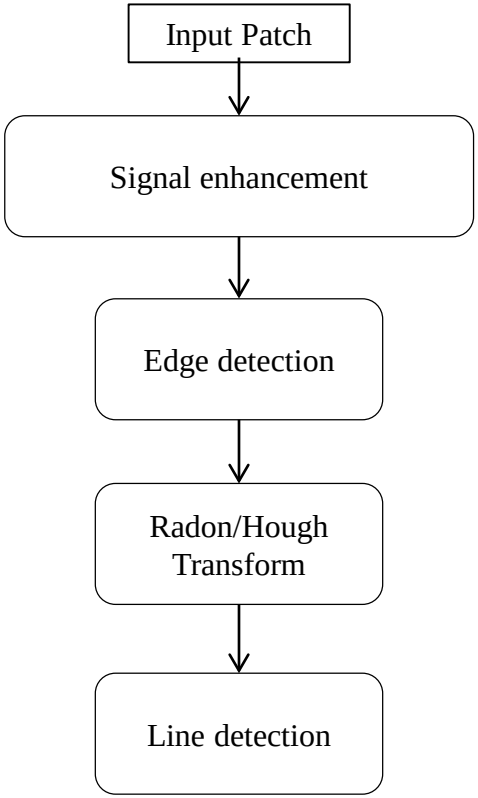


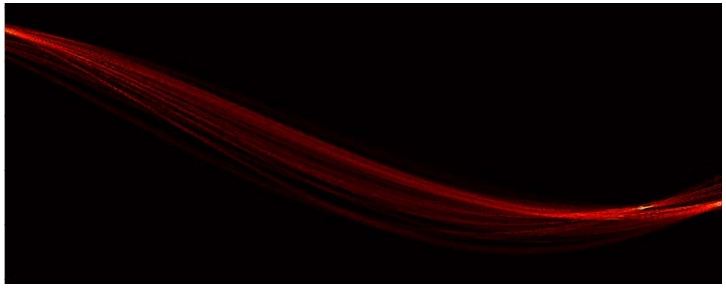
1 – Mean value of RCS
2 – Standard Deviation of RCS
3 – Ratio of Standard Deviation and Mean
4,5 – Normalized centers in x, y direction
6÷12 – Hu Invariant Moments
13 – Fractal dimension
14 – Power filling ratio
15 – Space filling ratio

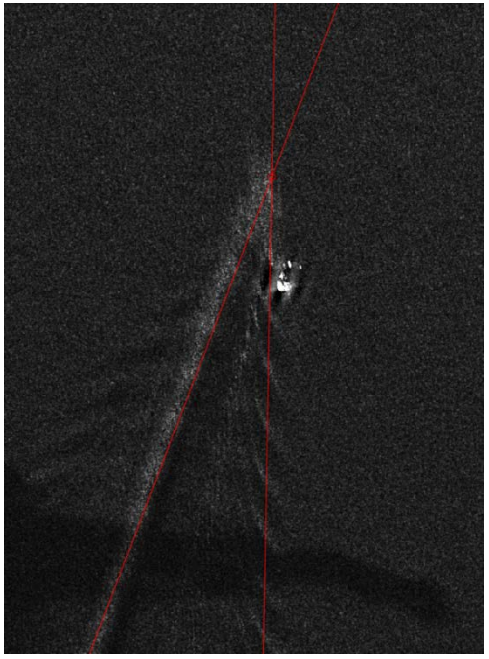


Features from SAR imaging

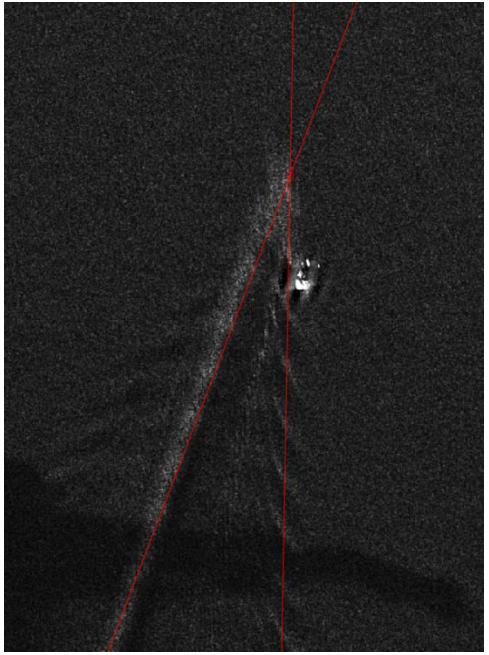
Wake detection



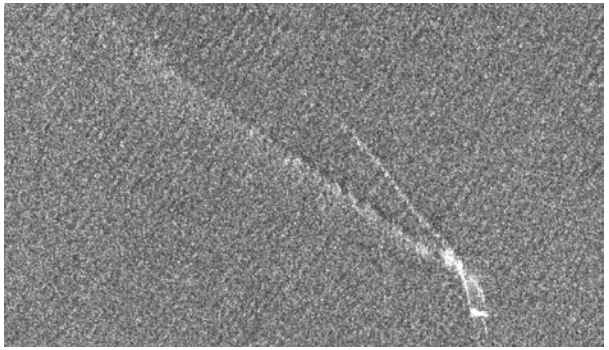


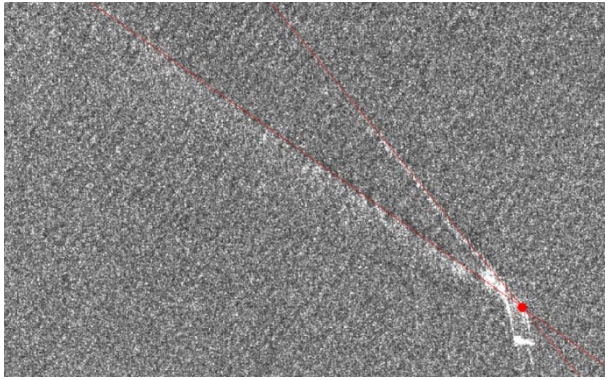


Wake detection



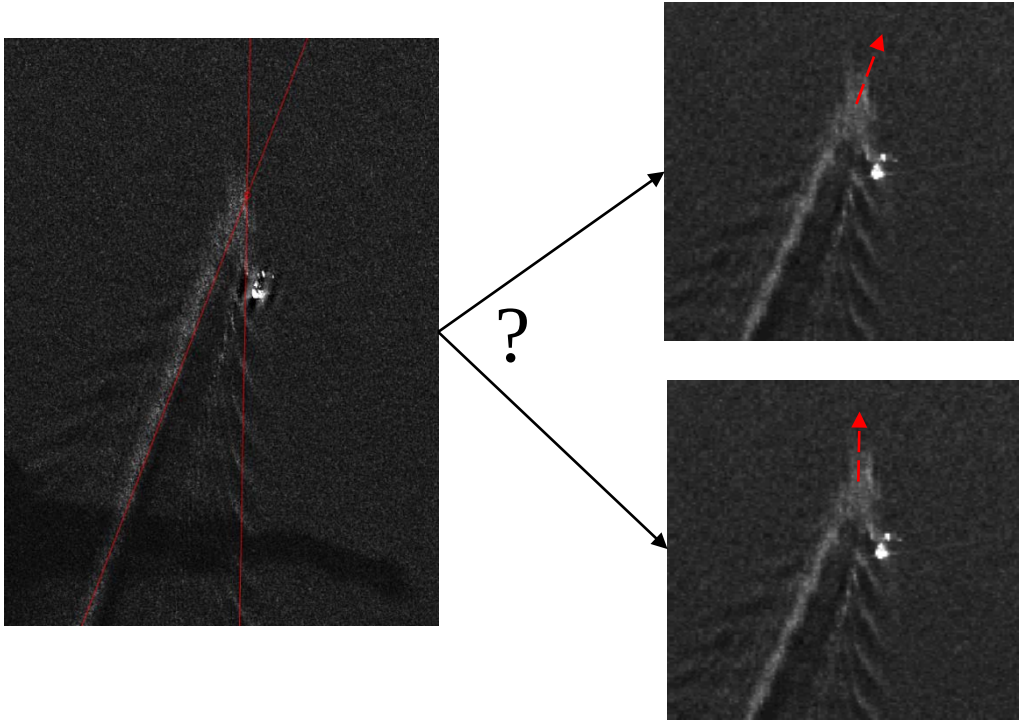
$\hat{\theta} = 19.5°$





$\hat{\theta} = 17.75°$

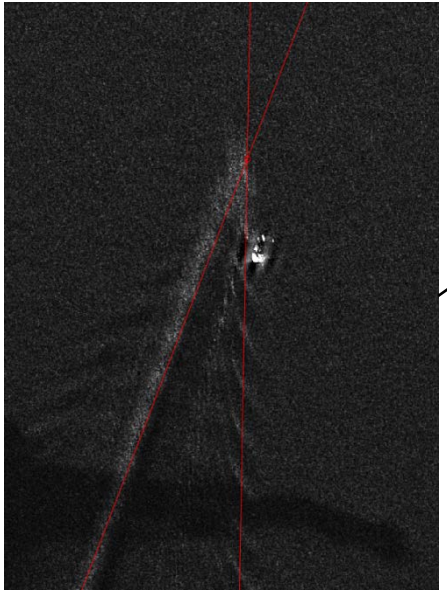
Heading

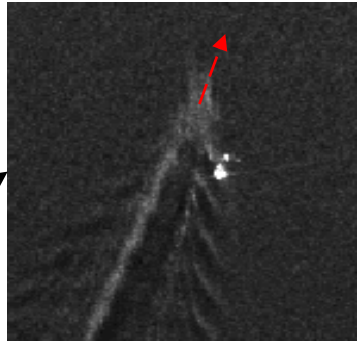


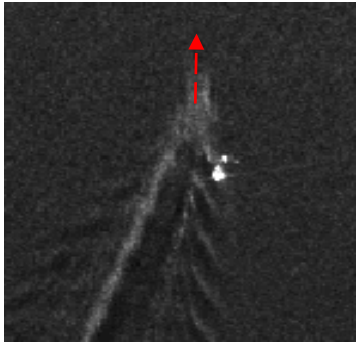
Considerations

- Bisector if three components are observed
- Turbulent direction (brightest component)
- No sinusoidal component is observed
- Nearest one to the Ship segmentation estimation

Heading







Considerations

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- Turbulent direction (brightest component)
- No sinusoidal component is observed
- Nearest one to the Ship segmentation estimation