A MULTILEVEL APPROACH TO SHIP CLASSFICATION ON SENTINEL-1 SAR IMAGES USING ARTIFICIAL NEURAL NETWORKS

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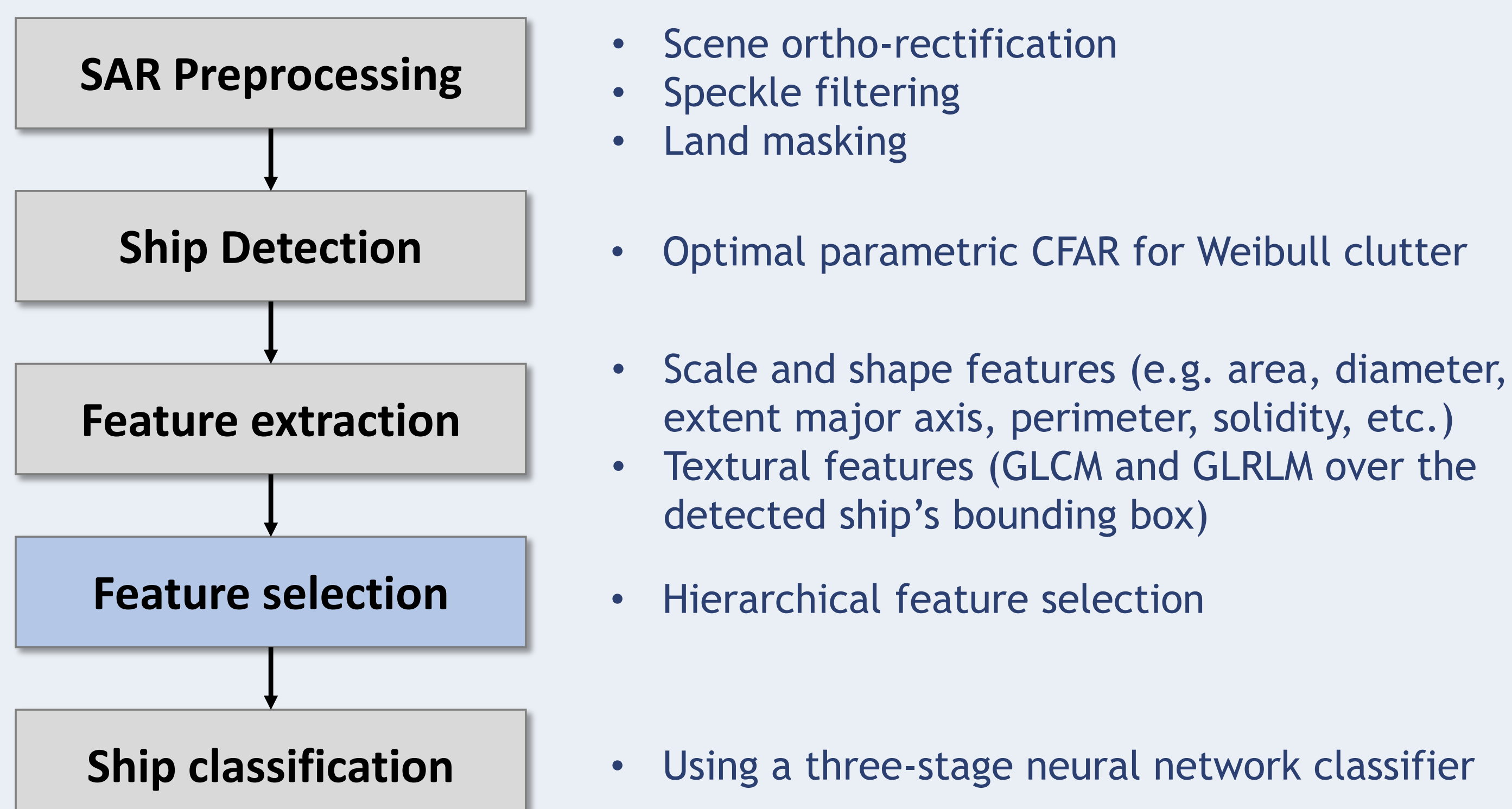
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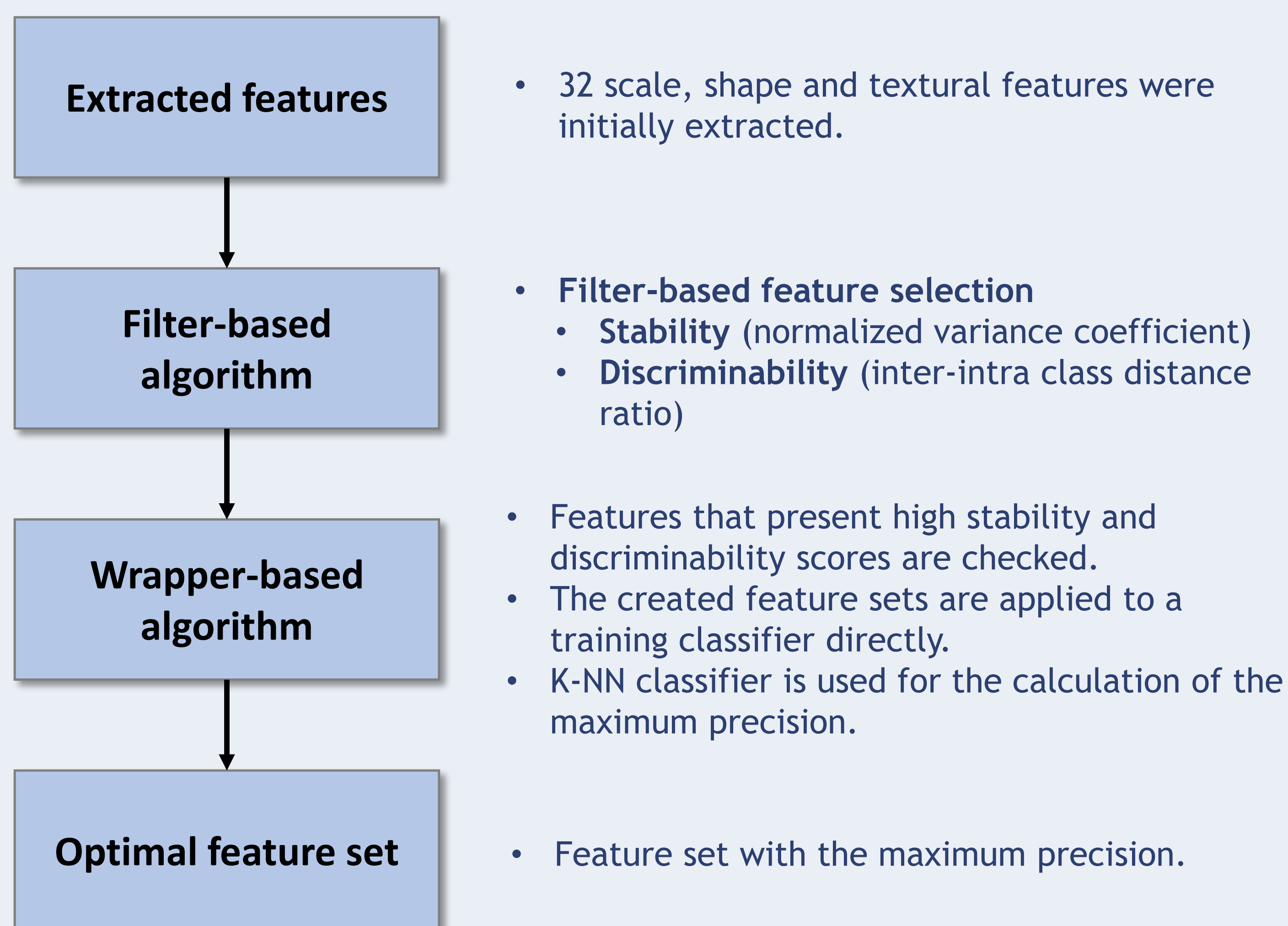
ABSTRACT

A multilevel approach to ship classification in Sentinel-1 SAR images is presented based on artificial neural nets and a robust feature extraction and selection scheme that utilizes scale, shape and texture features hierarchically. A three-stage hierarchical feature selection algorithm is used for discriminating civilian vessels into four types: cargos, passengers, tankers and small ships. The most informative texture and intensity features are incorporated in order to better distinguish vessels with high accuracy. The proposed method overall accuracy reaches 89%.
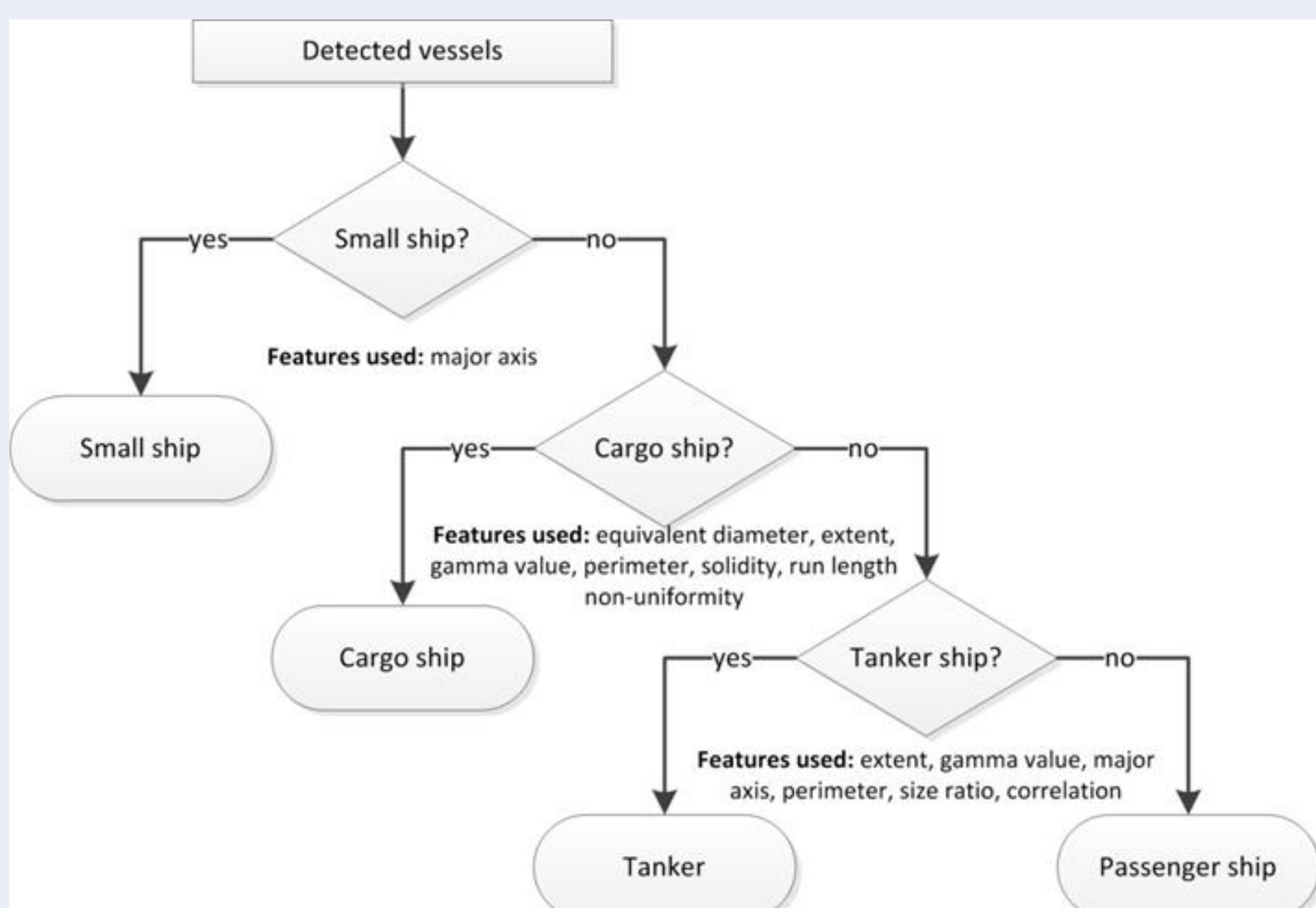
GENERAL METHODOLOGY

SAR Preprocessing
- Scene ortho-rectification
- Speckle filtering
- Land masking

Ship Detection
- Optimal parametric CFAR for Weibull clutter

Feature extraction
- Scale and shape features (e.g. area, diameter, extent major axis, perimeter, solidity, etc.)
- Textural features (GLCM and GLRLM over the detected ship's bounding box)

Feature selection
- Hierarchical feature selection

Ship classification
- Using a three-stage neural network classifier

HIERARCHICAL FEATURE SELECTION

Extracted features
- 32 scale, shape and textural features were initially extracted.

Filter-based algorithm
- **Filter-based feature selection**
  - **Stability** (normalized variance coefficient)
  - **Discriminability** (inter-intra class distance ratio)

Wrapper-based algorithm
- Features that present high stability and discriminability scores are checked.
- The created feature sets are applied to a training classifier directly.
- K-NN classifier is used for the calculation of the maximum precision.

Optimal feature set
- Feature set with the maximum precision.

HIERARCHICAL-BASED VESSEL CLASSIFICATION

EXPERIMENTAL RESULTS

- **Sentinel-1 SAR data** at the region of the Xios Island, Aegean Sea, Greece – Dual-pol, 10x10m, from ESA's data scihub.
- AIS data were also used in order to classify the detected ships.
- Four main categories were used for the evaluation of the methodology

Vessel Types	NN training	Evaluation
Cargo	512	122
Passeneger	107	27
Tanker	316	50
Small ships	43	72
TOTAL	**978**	**271**

1st stage discrimination: small ships
- Overall classification accuracy for the first stage is 99.30%.

2nd stage discrimination: cargo ships
- Six features are selected (equivalent diameter, extent, gamma value, solidity, run-length, non-uniformity).

3rd stage discrimination: tanker and passenger ships
- Seven features are selected (extent, gamma value, major axis, perimeter, size, ratio, correlation).

CONCLUSIONS

- Different types of feature extraction algorithms are implemented to form the utilized feature pool, able to represent the structure, material, orientation and other vessel type characteristics.
- A three-stage hierarchical feature selection is utilized o discriminate effectively vessels into four types: cargos, passengers, small ships and tankers.
- A feature selection process that utilizes heuristic measures based on features' statistical characteristics, followed by an exhaustive research with feature sets formed by the most qualified features is carried out.
- A total of 271 ships were used in the classification process, while AIS data were applied to verify the effectiveness of the algorithm.
- Experimental results show that this method has good performance in ship classification, with an overall accuracy reaching 89%.

References

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Acknowledgements