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

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ABSTRACT:

Ship detection and classification based on SAR data is an important task of maritime and sea border security and surveillance applications. During the previous years, lots of research has been done for improving the classification accuracy of ship targets based on high and very high spatial resolution images, mainly in COSMO-SkyMed and TerraSar-X data. Recently, with the launch of Sentinel missions and the free and open access Sentinel-1 products, new opportunities have arisen to maritime monitoring.

This paper proposes a novel multilevel approach to ship classification in Sentinel-1 SAR images based on artificial neural networks and a robust feature extraction and selection scheme. After performing some standard SAR image pre-processing and CFAR-based ship detection algorithmic procedures, a proper feature extraction methodology is followed. A number of diverse types of features, such as scale, shape, intensity and textural ones, are extracted in order to form the utilized feature pool. The abundance of available features are able to represent the structure, material, orientation and other ship type characteristics that are present in radar data. A two-stage hierarchical feature selection algorithm is utilized next in order to be able to discriminate effectively civilian vessels into four distinct types: cargos, passengers, tankers and small ships. In our analysis, scale and shape features are utilized in order to discriminate smaller types of ships present in the available SAR data, or shape specific ships. Then, the most informative texture and intensity features are incorporated in order to be able to better distinguish the civilian types with high accuracy. A feature selection procedure that

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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, in order to discriminate the most appropriate combination of features for the final classification. The utilized sets of features are finally fed into a two-stage artificial neural network composed of 13 neurons, which effectively classifies the different types of ship targets.

In our analysis, a set of 20 Sentinel-1 SAR data with 10m resolution, coming from the Xios Island in the Aegean Sea of Eastern Greece were used to analyse the detailed characteristics of these types of ships. A total of 198 ships with available AIS data were used in the classification process. The experimental results show that the proposed scheme is able to classify ships at an average precision exceeding 80%, as illustrated in the following confusion matrix which indicates the classification accuracy of all consisting classes (i.e. cargo, passenger, tanker and small ships).

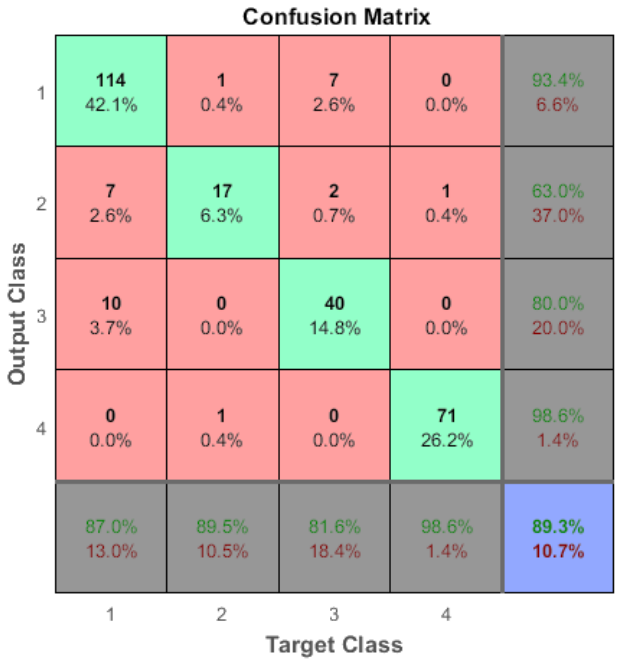

Figure 1. Confusion matrix of the overall classification scheme.

Given the fact that the spatial resolution of Sentinel-1 data is 10m, the specific classification accuracy are very promising and can provide reliable services to near real-time maritime monitoring and sea border surveillance applications. Further investigation of additional features and proper feature selection is currently in progress, as well as database increment through processing of additional Sentinel-1 scenes from the area of interest.