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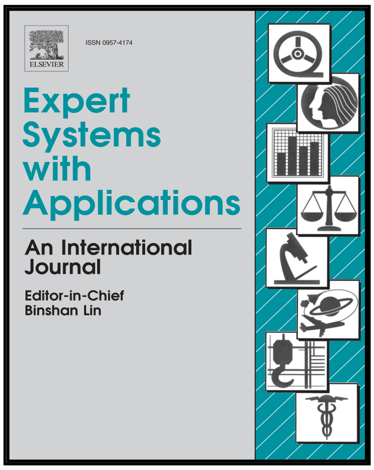

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Intelligent Hybrid System for Dark Spot Detection using SAR Data

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Abstract: Synthetic Aperture Radars (SAR) are the main instrument used to support oil detection systems. In the microwave spectrum, oil slicks are identified as dark spots, regions with low backscatter at sea surface. Automatic and semi-automatic systems were developed to minimize processing time, the occurrence of false alarms and the subjectivity of human interpretation. This study presents an intelligent hybrid system, which integrates automatic and semi-automatic procedures to detect dark spots, in six steps: (I) SAR pre-processing; (II) Image segmentation; (III) Feature extraction and selection; (IV) Automatic clustering analysis; (V) Decision rules and, if needed; (VI) Semi-automatic processing. The results proved that the feature selection is essential to improve the detection capability, keeping only five pattern features to automate the clustering procedure. The semi-automatic method gave back more accurate geometries. The automatic approach erred more including regions, increasing the dark spots area, while the semi-automatic method erred more excluding regions. For well-defined and contrasted dark spots, the performance of the automatic and the semi-automatic methods is equivalent. However, the fully automatic method did not provide acceptable geometries in all cases. For these cases, the intelligent hybrid system was validated, integrating the semi-automatic approach, using compact and simple decision rules to request human intervention when needed. This approach allows for the combining of benefits from each approach, ensuring the quality of the classification when fully automatic procedures are not satisfactory.

Keywords: Synthetic Aperture Radar; Digital Image Processing; Oil Spills Detection; Feature Selection; Cluster Analysis; Computational Intelligence.

1. Introduction

Remote sensing technologies have been widely accepted as effective providers of geospatial data to support oil and gas activities in offshore areas, from the exploration, until the production and transportation phases. During the last decades, the diversity of satellites operating in different spectral ranges, with multiple spatial resolutions and frequencies of acquisition were successfully applied to detect, map and monitor oil spills during routine or emergency situations (Engelhardt, 1999; Brekke et al., 2005; Topouzelis, 2008; Leifer et al., 2012; API-JITF, 2013; IPIECA, 2014; Fingas & Brown, 2014).

Particularly, Synthetic Aperture Radars (SAR) are consolidated as the main instrument to support the oil spill response (OSR), being delivered in near real time - sometimes - with a daily acquisition capability combining different microwave bands, resolutions, incidence angles and polarization modes. SAR provide cost effective data, covering wide areas with synoptic surveys, during day and night, almost independent of weather conditions (IPECA, 2014; Genovez et al., 2017; Konik & Bradtke, 2016).

In the microwave spectrum, oil slicks are identified as dark spots, regions with low backscatter at sea surface. Despite SAR is being effectively used, oil spills detection still remains a challenge (Bentz et al., 2012), due to the ambiguities caused by different biological, meteorological and oceanographic phenomena with backscatters similar to the oil, originating false alarms. Algae bloom, biological oils, low wind intensities, wind shadows, rain cells, upwelling, oceanic fronts, internal waves, suspended sediments as well as man-made occurrences as turbulent ship wakes, are examples of ambiguities frequently observed in SAR data.

Historically, trained interpreters are able to conduct the operational monitoring visually, distinguishing oil spills and look-alikes, as well as extracting the location and geometries of the slicks manually (Calabresi et al., 1999; Fiscella et al., 2000; Solberg et al., 2003; Topouzelis, 2008; Mera et al., 2014; Mera et al., 2017). The multi-sensor approach together with contextual information regarding the platform position, pipelines,