Optimal Detection and Estimation of Marine Oil Spills Through Coherent Pluralism

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ABSTRACT

An important area of environmental science involves the combination of information from diverse sources relating to a similar endpoint. Majority of optical remote sensing techniques used for marine oil spills detection have been reported lately of having high number of false alarms (oil slick look-a-likes) phenomena which give rise to signals which appear to be oil but are not. Suggestions for radar image as an operational tool has also been made. However, due to the inherent risk in these tools, this paper presents the possible research directions of combining statistical techniques with remote sensing in marine oil spill detection and estimation.

Keywords: Coherent Pluralism, Detection, Estimation, Oil Spills, Optimality, Remote Sensing, Statistical Techniques

INTRODUCTION

In oil spills incidence, Synthetic Aperture Radar (SAR) images are widely used to detect and monitor oil pollution on the sea surface since they provide regularly images both day and night and are insensitive to meteorological effects. As it is sensitive to surface roughness, the presence of oil film on the sea surface decreases the backscattering of the sea surface resulting in a dark feature patches in SAR images (ESA, 1998). Among the available oil spills detection techniques, remote sensing has been the most widely used (Topouzelis, 2008; Pavlakis, 1996; Gade & Alpers, 1999; Karathanassi et al., 2006). According to Marghany (2004), Synthetic Aperture Radar (SAR) is one of the most active remote sensors, which captures two dimensional images. The brightness of the captured image is a reflection of the properties of the target-surface. The main systems to monitor sea-based oil pollution are the use of airplanes and satellites equipped with (SAR). But the possibility of detecting an oil spill in a SAR image relies on the fact that the oil film decreases the backscattering of the sea surface resulting in a dark formation that contrasts with the brightness of the surrounding spill-free sea (Brekke & Solberg, 2005; Marghany et al., 2007). Space borne SAR sensors are

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also extensively used for the detection of oil spills in the marine environment, as they are independent from sun light and are not affected by cloudiness, they cover large areas and are more cost-effective than air patrolling (Keramitsoglou et al., 2006). However, there are problems with the majority of optical remote sensing techniques used for oil spill detection which is the high number of false alarms (oil slick look-a-likes) phenomena which give rise to signals which appear to be oil but are not (Mercier & Girard-Ardhuin, 2006; Topouzelis et al., 2007). It is believed that visible satellite systems are susceptible to false alarms due to sun glint, wind sheen, bottom features, cloud shadows, and biogenic material such as surface weeds and sunken kelp beds (Serra-Sogas, 2008; O’Neil, 1983; Goodman, 1989, 1992; Schnell, 1992; Goodman, 1988; 1989).

According to Mansor et al. (2010), there are certain times when visual techniques and optical satellite image are unsuitable for mapping of oil spill; it is in these cases where radar remote sensing is required. These situations include spills covering vast areas of the marine environment, and when the oil cannot be seen or discriminated against the background. The discrimination of oil in these circumstances presents several unique problems. The remotely sensed data collected in these situations often provide complex signatures, which must be deciphered in order to locate the spilled oil. Environmental conditions such as precipitation, fog, and the amounts of daylight present also may pose problems especially in optical images.

Given the complexity of remote sensing tool and due to the risk inherent in dependence on radar images, there is a sustainable benefit in aiding the combination of different tools for spill detection and estimation. Thus, we proposed a pluralistic strategy known as coherent pluralism (Jackson, 1999) that involves the combination of remote sensing with sound statistical techniques as essential tool. Considering this as a linear system, the important aspect of this proposal is the application of Bayesian classification, Gaussian error analysis, and statistical estimation for the linear system.

THE CONCEPTS OF COHERENT PLURALISM

An important area of environmental science involves the combination of information from diverse sources relating to a similar endpoint. A common rubric for combining the results of independent studies is to apply a meta-analysis (Piegorsch & Bailer, 2005). The term suggests a move past an analysis of standalone data or of a single analysis of pooled, multisource data, to one incorporating and synthesizing information from many associated sources. It was first coined by Glass (1976) in an application combining results in multiple social science studies and is now quite common in many social and biomedical applications (Wang & Wall, 2003; Piegorsch & Cox, 1996).

The typical goal of this so called meta-analysis is to consolidate outcomes of independent studies, reanalyze the possibly disparate results within the context of their common endpoints, increase the sensitivity of the analysis to detect the presence of environmental effects, and provide a quantitative analysis of the phenomenon of interest based on the combined data. The result is often a pooled estimate of the overall effect. For example, when assessing environmental risks of some chemical hazard, it is increasingly difficult for a single, large, well designed ecological or toxicological evaluation to assess definitively the risk(s) of exposure to the chemical. This informs our proposition of coherent pluralism (meta-analysis), which involves the combination of remote sensing technique and statistical methods in spills detection and estimation.

Pluralism, according to Jackson (1999) can be viewed as the use of different methodologies, methods and/or techniques in combination. Jackson’s explanation put more light on the need for coherent pluralism in practice as pluralism encourages flexibility in use of the widest variety of methods, models, tools and techniques in any intervention. In Operations Research/ Management Science field, the concepts of coherent pluralism have gained a wider ground. Many in literature are the works.
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