

Chapter 69

From Finding to Explaining: Information Retrieval to Support Maritime Anomaly Analysis

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ABSTRACT

Supporting anomaly analysis in the maritime field is a challenging problem because of the dynamic nature of the task: the definition of abnormal or suspicious behaviour is subject to change and depends on user interests. This paper provides a novel approach to support anomaly analysis in the maritime domain through the exploration of large collections of interpretation reports. Based on observables or more sophisticated patterns, the approach provides information retrieval strategies going from basic facts retrieval that guide short-term corrective actions to more complex networks of related concepts that help domain experts to understand or to explain abnormal vessel behaviours. Semantic integration is used to link various information sources, by using a commonly adopted standard. The paper seeks to explore different aspects of using information retrieval to support the analysis and interpretation of abnormal vessel behaviours for maritime surveillance.

1. INTRODUCTION

Maritime safety is an important aspect for coastal nations since security requirements in ports receives increasing attention and is intended to cover various aspects such as: surveillance of maritime traffic, prevention of pollution at sea, control of fishing activities, or identification and assessment of risk of threats and illegal activities. A typical scenario to detect abnormal behaviour involves operators analyzing a situation picture created by fusing video, radars, and intelligence information. Some information assets can be critical and then alerts are triggered in order to notify analysts of maritime incidents, highlighting abnormal and possibly threatening vessel behaviour. An investigation is then undertaken, aiming at identifying whether the behaviour is threatening or not, and it is completed by an investigation report.

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As people having different experience perform analysis differently (Endsley & Bolstad, 1994), subjective factors shape the outcome and each report provides an individual interpretation of the situation. Hence, reports differ not only in terms of data, but also in terms of how the analyst interprets the scene, according to its own knowledge. While this collection is a valuable resource, domain experts willing to have access to reports are faced with the complexity of documents that are highly heterogeneous and possibly interdependent of each other. Thus, it is essential for maritime domain practitioners to rely on systems that are able to provide various strategies to retrieve documents related to maritime incidents they are working on. This paper addresses the problem of providing support for efficient search and forensic analysis of large collections of documents and proposes an approach to retrieve documents on the basis of their semantic content. It is based on semantic analysis and integration to structure, query and browse collections of interpretation reports. Domain knowledge is at the core of this approach, which is supported by an ontology and associated instances.

After a review of related work in section 2, this paper introduces the application context in section 3. Semantic integration is dealt with in section 4, along with the model for document representation and the ontology used for this work. Section 5 gives details of information retrieval strategies and discusses evaluation aspects. Conclusion and directions for future work end this paper.

2. RELATED WORK

Approaches related are presented from two perspectives: first, a selection of systems aiming to support surveillance in the maritime field, and then several solutions dealing with information retrieval over semantically integrated document collections

2.1. Systems for Maritime Surveillance

This section discusses several research efforts aiming at providing automatic support to practitioners in charge of maritime surveillance. Developing such solutions raises numerous important research challenges: the development of systems able to identify ships having a suspicious behaviour, the acquisition and formalization of domain knowledge and the enrichment of the situation provided to end users, as discussed hereafter.

A first solution for abnormal behaviour identification is developed by Roy and colleagues (Roy & Davenport, 2009; Roy, 2009). The authors developed a knowledge-based system, using a set of rules and inferences engines to identify suspicious vessels and they describe in (Roy & Davenport, 2010) a proof-of-concept prototype of an system using automated reasoning capability and ontologies to support the maritime staff in detecting anomalies, in classifying vessels of interest, and in identifying and categorizing maritime threats.

The same topic is addressed by Lane and colleagues (Lane et al., 2010), who developed a statistical approach to identify patterns of abnormal vessel behaviours.

While previous solutions are based on domain knowledge, several research efforts tackled the problem of knowledge acquisition and modelisation for maritime safety applications. Among them, Nilsson and colleagues (Nilsson & Ziemke, 2008) describe a case study conducted to identify a set of empirical rules used by domain experts to support maritime surveillance while an ontology of the maritime domain is

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