
# Visual Analytics for Maritime Anomaly Detection

av

**Maria Riveiro**

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Opponent: Professor Mikael Jern
National Center for Visual Analytics
Linköpings Universitet, Sverige

Örebro universitet
Akademin för
naturvetenskap och teknik
701 82 ÖREBRO

# Abstract

The surveillance of large sea areas typically involves the analysis of huge quantities of heterogeneous data. In order to support the operator while monitoring maritime traffic, the identification of anomalous behavior or situations that might need further investigation may reduce operators' cognitive load. While it is worth acknowledging that existing mining applications support the identification of anomalies, autonomous anomaly detection systems are rarely used for maritime surveillance. Anomaly detection is normally a complex task that can hardly be solved by using purely visual or purely computational methods.

This thesis suggests and investigates the adoption of visual analytics principles to support the detection of anomalous vessel behavior in maritime traffic data. This adoption involves studying the analytical reasoning process that needs to be supported, using combined automatic and visualization approaches to support such process, and evaluating such integration.

The analysis of data gathered during interviews and participant observations at three maritime control centers and the inspection of video recordings of real anomalous incidents lead to a characterization of the analytical reasoning process that operators go through when monitoring traffic. These results are complemented with a literature review of anomaly detection techniques applied to sea traffic. A particular statistical-based technique is implemented, tested, and embedded in a proof-of-concept prototype that allows user involvement in the detection process. The quantitative evaluation carried out by employing the prototype reveals that participants who used the visualization of normal behavioral models outperformed the group without aid. The qualitative assessment shows that domain experts are positive towards providing automatic support and the visualization of normal behavioral models, since these aids may reduce reaction time, as well as increase trust and comprehensibility in the system. Based on the lessons learned, this thesis provides recommendations for designers and developers of maritime control and anomaly detection systems, as well as guidelines for carrying out evaluations of visual analytics environments.

**Key words:** visual analytics, anomaly detection, maritime traffic monitoring, analytical reasoning, information fusion