Extraction of Suspicious Behavior of Vessels in the Exclusive Economic Zone

#Florent JANGAL[1], Marie Anne GIRAUD (SOFRESUD), Anne LITTAYE (ECOMER), Michel MOREL (DCNS), Jean-Pierre MANO (IRIT), Aldo NAPOLI (Mines ParisTech)
[1] ElectroMagnetism and Radar Department (DEMR), ONERA – The French Aerospace Lab
Chemin de la Hunière 91761 Palaiseau Cedex, florent.jangal@onera.fr

1. Introduction

Constant growth of world maritime transport and significant economic stakes of territorial water management have prompted the international community to invest in maritime global security research [1]. In this context, the ScanMaris project, which is founded by the French National Research Agency (ANR), aims to continuously monitor activities in the Exclusive Economic Zone (EEZ) activities and detect abnormal behavior using both observation systems and external data sources.

The ScanMaris software workshop is based on the assumption that global surveillance of the EEZ cannot only use target detection systems. Indeed, whatever the performances of tracking algorithms are, they cannot estimate how suspicious the vessel tracks are. Some external information, like insurance database or transported goods, can improve behavior analysis.

We propose to collect numerous information on the observed area (i.e. vessel locations and tracks, weather condition, previous committed offenses, destination, etc.) in order to create an enriched map of the scene. Then, the map is analyzed and abnormal behaviors are picked out.

ScanMaris consists in four complementary layers: observation of maritime activities with several kind of sensor, fusion of sensed data, enrichment of information with heterogeneous sources (e.g. EQUASIS safety-related base, weather condition, LLOYDS insurance base, history of vessels, delimitation of maritime zones, etc.) and classification of the overall behavior.

The issues of such an approach are target detection up to the EEZ limits, management of a large amount of data, analysis of each vessel activity and classification of behaviors.

2. Sensors

We have chosen the High Frequency Surface Wave Radar (HFSWR) to detect targets up to the EEZ limits. Other sensors like Automatic Identification System (AIS) or VHF radars will complete or overlay surface wave measurements.

2.1 HFSWR

High Frequency Surface Wave Radar is a promising low-cost surveillance system of the EEZ. In the high frequency band (from 3 MHz to 30 MHz) waves can be propagated along the interface between the earth and the air. HFSWR takes advantage of this property to detect targets over the horizon [2].

ScanMaris will use vessel tracks acquired by a full digital HFSWR demonstrator which has been recently set up in the southwest of France. As shown in Fig. 1 the demonstrator aerials are located very close to the shoreline in order to maximize the excitation of surface waves.

1.a) Transmitting antenna 1.b) receiving array

Figure 1: French Biscay Bay HFSWR

2.1 Data combination

HFSWR cannot be the sole data source of the project: vessels are tracked but not identified by the radar. AIS, which is a cooperative system, make it possible to get the vessel identification. Information from regional safety a security centers also contain identification numbers.

In the common coverage range, we will associate tracks and identifiers. Then, this information is integrated to the enriched map.

3. Enriched Map and Inference Engine

All available information on the observed scene are kept in a space-time map: each set down element on the enriched map includes an object location (e.g. vessel position) or a validity area (e.g. fishing zones), an event date and a remanence duration.

In the midst of this large amount of information some details point to uncommon behaviors. Nevertheless, uncommon behaviors are not necessarily fraudulent (e.g. fishing vessel sailing slowly outside a stormy fishing zone). Find a classification criterion which remains valid despite law evolutions, vessel locations or weather conditions is not possible.

We are considering the possibility to use several interconnected Inference Engines (IEs) to state either the normality or the abnormality of events [4]. The challenge is to deal with multidisciplinary information (i.e. bathymetry, radar tracks, insurance database, weather, etc.) and to use variable criterion.

IEs will not analyze all the enriched map: this would be needlessly time consuming since fraud is a marginal activity. Thus, interesting details will be extracted beforehand by Adaptive Multi-Agent System

4. Adaptive Multi-Agent Systems

Adaptive Multi-Agent Systems seems to be well-suited to extract uncommon behaviors [3]. There are numerous similarities between ScanMaris issues and some AMAS issues. That is, extract some distinctive behaviors or features from a global scene (i.e. the enriched map) where each element is autonomous (i.e. vessels).

Vessels, which can be thought as cooperative agents, affect the environment by leaving traces. Conversely, each agent is influenced by the environment, in particular, by the traces of other agents. Agents get space-time information from the enriched map and put down traces on it.

When an uncommon event is detected, a request is sent to the IEs. Then, IEs reply the normality/abnormality status of the event. If an accumulation of abnormal event occurs an alert is sent to the user.

As mentioned before abnormality do not signify outlaw. AMAS must have the opportunity to continuously learn which behavior should be pointed out or not. So, the workshop contains two AMAS: learning AMAS and an operative AMAS Fig. 2. As shown bellow, the learning AMAS receives alert acknowledgments from the user. Acknowledgment specifies the relevance of each alert. Moreover, the user can inform the learning AMAS of undetected illicit activity.

Regularly the content of learning AMAS is transferred into the operative AMAS.

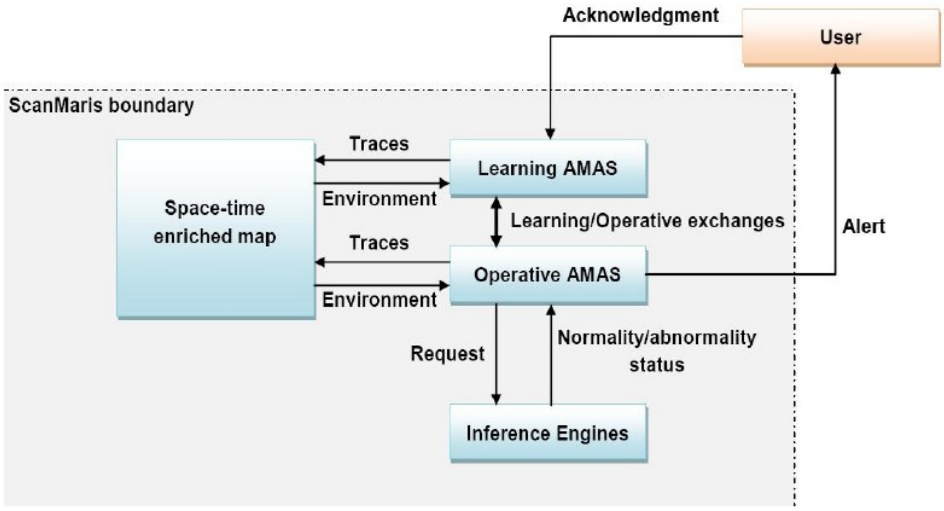

Figure 2: AMAS architecture

In order to adapt the system, each agent of both AMAS will continuously redefine themselves the remanence of leaved traces as well as limits of the space-time vicinity area.

Obviously, data access strategy of AMAS can dramatically impacts the workshop efficiency. High access rate will overload the system while low access rate will reduce the accuracy. This last element highlight, if necessary, the important role plays by data management in the ScanMaris project.

5. Conclusion

Global security of the Exclusive Economic Zone is a present challenge since over 90% of world trade travels by sea. We think that the transversal approach of ScanMaris will improve the EEZ management.

The key points of the projects are: the fusion of several sensor information, in particular data provided by High Frequency Surface Wave Radar; the continuous update of an enriched map using heterogeneous sources; the extraction of uncommon events performed by Adaptive Multi-Agent Systems and the interconnected Inference Engines which state the normality/abnormality of each pointed out uncommon behaviors.

The project has begun since January 2008 and the first results will be presented at the conference.

Acknowledgments

We would like to thank the French National Research Agency for its financial contribution to the project, regional safety and security centers (DAM and CROSS) for their support and all members of the project’s steering committee for their support and advices.

References

[1] “Review of maritime transport”, United Nations Conference on Trade and Development, Geneva, http://www.unctad.org/en/docs/rmt2007_en.pdf, 2007.

[2] M. Menelle, G. Auffray and F. Jangal, “Full digital high frequency surface wave radar: French trials in the Biscay bay”, Proc. IEEE Radar 2008, Adelaide, p. 224-229, 2008.

[3] G. Di Marzo Serugendo, M.-P. Gleizes and A. Karageorgos, “Selforganisation and emergence in multi-agent systems: an overview”, Informatica, Vol 30, No 1, pp 45-54, 2006.
[4] J. Iris, A. Napoli and F. Guarnieri, “Evaluation of Spatial Multidimensional Approach for the Analysis of Disaster Data”, Proc. 25th Urban Database Management Symposium, Denmark, 2006.