ScanMaris : an Adaptive and Integrative Approach for Wide Maritime Zone Surveillance

Michel Morel, Marie-Pierre Gleizes, Aldo Napoli, Anne Littaye, Valérie Bazin, Benjamin Alhadef, Christian Scapel, Bruno Leroy, Jacques Lebrevelec, Daniel Dejardin

ScanMaris: an Adaptive and Integrative Approach for Wide Maritime Zone Surveillance

Michel MOREL (1), Marie-Pierre GLEIZES (2), Aldo NAPOLI (3),
Anne LITTAYE (4), Valerie BAZIN (5), Bernard ALHADEF (6)
Christian SCAPEL (7), Bruno LEROY (8), Jacques LEBREVELEC (9), Daniel DEJARDIN (10)
1 : DCNS B.P.403, 83055 Toulon cedex, michel.morel@dcn.fr
2 : IRIT, Université Paul Sabatier, 118 route de Narbonne, 31062 TOULOUSE CEDEX 9, george@irit.fr
3 : Ecole des Mines, Rue Claude Daunesse, 06904 Sophia Antipolis, aldo.napoli@cindy.ensmp.fr
4 : Ecomer 282 chemin du Val Martin, 06560 Valbonne, anne.littaye@ylahe.net
5 : ONERA, Chemin de la Hunière et des Joncherettes, 91761 Palaiseau, valerie.bazin@onera.fr
6 : SOFRESUD, 777 avenue de Bruxelles, 83500 la Seyne sur Mer, balhadef@sofresud.com
7 : CDMT, 3 Avenue Robert Schuman, 13628 Aix-en-Provence cedex 1, secretariat.cdmt@univ-cezanne.fr
8 : AFMAR, 3 Place de Fontenoy, 75007 Paris, bruno.leroy@equipement.gouv.fr
9 : CROSSA ETEL, 40 avenue Louis Bougo B.P 48, 56410 Etel, cross-etel@equipement.gouv.fr
10 : CROSSMED, Fort St Marguerite B.P 69, 83953 La Garde, daniel.dejardin@equipement.gouv.fr

Introduction

The ScanMaris project is an innovative software workshop conceived to develop and evaluate solutions of prevention and monitoring of wide maritime zones. These solutions rely on tools of tactical picture's exploitation, known as enriched for resulting from the continuous treatment of important volumes of heterogeneous data gathered in real time (sensors) and remote time (intelligence).

The ScanMaris solutions enable supervising the permanent evolutions of the dense vessel traffic in order to follow the flows of transported goods (bulk, containers, energy, chemical, fishery product, passenger, etc.) according to various routes (corridor, motorway of the sea, coastal traffic, etc.) and to detect the criminal traffics (narcotics, smuggling, illegal immigration, illegal resource fishing, etc).

This paper focuses on the technologies involved in the project with their major results. Nevertheless, there is no global analysis of the workshop at this stage, because ScanMaris will be recently funded by the French National Research Agency ANR, and its duration is of 24 months.

The ScanMaris monitoring system

A ship (pleasure, fishing, freight, etc.) can be considered as an agent searching to satisfy a goal coming from a seaport to another. Thus, the maritime transport is a multi-agent system hiding some illicit activities among a great amount of legal behaviors.

To detect these criminal activities, the ScanMaris workshop integrates several modules:

- Database of ship situations (location, speed, and direction).
- Database about environmental conditions: freight, destination, certifications, flag, etc; as well as meteorological information.
- Learning methods to predict a ship itinerary.
- Inference rules to detect abnormal behaviors.
- Man-machine interfaces.

The spatio-temporal knowledge representation is based on the recognition of ships from their legal information, their real-time location and environmental situation. All the detected agents are classified and linked with the referenced ships.

All these previous information enable to create a virtual map where each ship moves in real-time according to the supposed trajectory it has at time t. In this map, each ship moves from time t to (t+Δt) in marking each location step by placing a marker. By analogy with the animal kingdom, these markers are called pheromones. A ship is able to perceive the deposited pheromones in its neighborhood and interacts with the corresponding ships, leading to its Behavior Vector values adjustments.

This system architecture for monitoring will be detailed in this section.

Information Sources and Sensors

A maritime surveillance and control system has to be able to collect and fusion heterogeneous data provided by various sensors (radars, IR or classical cameras, AIS receivers, satellite and aircraft imageries, etc.) and external data sources (TF2000, LLOYDS, EQUASIS, TROCS, SATI, etc.). The fusion of all this huge information set has, as far as we know, never been applied for civil wide maritime zone permanent surveillance. An efficient system will have to overcome the difficulties inherent to data fusion and the combination of inputs from different sources, in different places and at different times.

A High Frequency Surface Wave Radar (prototype has been developed by ONERA on DGA funding) is integrated in the project. For a HFSW radar, the sea surface guides electromagnetic waves, such qualified as surface waves. Ships or low flying objects send back through the radar a portion of the incident surface wave as a backscattered surface wave which can be detected. The radar system can measure temporal and spatial properties of objects

simultaneously over thousands of square kilometers.
Performances of a HFSW radar are related to its design and the geographic place where the sensor is located. The illuminated area on the sea is called a radar cell and its size is a function of the array length and of the observed range. The range resolution is obtained by a ratio between the wavelength and the size of the array. The more the array is spread, the more precise the target localization will be.
The overall cost-efficiency of a HFSW radar installation is therefore very interesting. Raytheon (USA), Daromont (Australia) operate and sell HFSW radars but they are very reticent when it comes to giving pertinent data about true performances. China is already developing its own radar. ONERA deployed during the first quarter 2007 a long range HF radar in the Bay of Biscay (4). We develop in this section some results on recognition based on this sensor by the ONERA partner. In the frame of ScanMaris this HFSW will be completed with an AIS receptor and eventually with conventional coastal radar.

Reasoning Mechanisms on Behaviors

The classical approach to detect illicit behaviors is to use Predictive Analysis. Predictive analysis encompasses a variety of techniques from statistics and data mining that process current and historical data in order to make "predictions" about future events. Such predictions rarely take the form of absolute statements, and are more likely to be expressed as values that correspond to the odds of a particular event or behavior taking place in the future.
Concerning maritime traffic, we use inference rules (5) to detect illicit behaviors.
Unfortunately, because a great amount of contextual rules could be used at a time, but only few ships are suspicious, we complement this approach by an adaptive agent technology which is quoted by DARPA (2) as being relevant for Predictive Analysis for Naval Deployment Activity. This is coherent with the choice of AMAS technology (1) where each agent reaches (or tends to) its individual goals (the destination port of a ship, for example) while the whole system reaches an overall adequate functionality. This adequacy should be optimal or pareto-optimal as predicted by the AMAS theory, but it still remains a conjecture in a general case. Benefits can be expressed in terms of efficiency, distribution (minimizing shared knowledge, maximizing privacy), openness and flexibility (adding/removing agents or knowledge) and robustness (minimizing problem-dependent parameters). This means that the system has the capability, through the agents composing it, to adapt to global or local changes, at runtime, and to provide nearby solutions between changes, even when there is no evaluation function to guide the convergence such as for predicting suspicious maritime activities.
We present results of these two mechanisms in the full paper.

Related Works

European States should have a coherent and common vision in order to prevent illicit activities (3). In this context, the creation of the European Security Board (ESB) has been proposed by the European Security Research Advisory Board (ESRAB) and the FRONTEX. The Presidency conclusions of the Brussels European Council in 2006 called "for enhanced efforts on maritime operational cooperation with a view to developing adequate surveillance capacities at the sea borders".
The available Vessel Traffic Management Services and the maritime C4ISR systems do not incorporate all the functionalities proposed in ScanMaris enabling the treatment of a huge amount of information in order to detect abnormal behavior.
From our knowledge, PANDA (Predictive Analysis for Naval Deployment Activity) is the only project having approached aims of the DARPA from U.S.A.

Conclusions

The ScanMaris key features will be new sensor capabilities, more efficient and less expensive, allowing to cover wider areas; improved data fusion algorithms, allowing a quicker and better information; innovative behavior analysis methods, allowing automated facilities for detection of illicit traffics; customization options, for total compliance with relevant legal and organizational constraints and maximum adaptability.

References

1 Carole Bernon, Valérie Camps, Marie-Pierre Gleizes, Gauthier Picard. Engineering Adaptive Multi-Agent Systems: The ADELFE Methodology. In : Agent-Oriented Methodologies. Brian Henderson-Sellers. Paolo Giorgini (Eds.), Idea Group Pub, USA, V. ISBN1-59140-581-5, 2005.
2 Darpa, Predictive Analysis for Naval Deployment Activity – Report of the Defense Advanced Research Projects Agency - 2005.
3 European Communities, Towards a future Maritime Policy for the Union: A European vision for the oceans and seas, Green Paper SEC(2006) 689.
4 Fabbro O V.; Combes P.-F.; Guillet N., Apparent radar cross section of a large target illuminated by a surface wave above the sea, Progress in Electromagnetics Research Volume 50, 2005.
5 Wybo J.L, Colardelle C., Poulossier M.P., Cauchois D., 2002, A methodology for sharing experiences in incident management, International Journal of Risk Assessment, Vol 3, n°2/3/4.