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EXECUTIVE SUMMARY

Approval

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Version History

Version #	Implemented by	Revision Date	Approved by	Approval Date
1.0	MapSat, CNR-IIT, CNR-ISTI, SisTer		Michele IAPAOLO	

Applicable Documents

Ref.	Title	Document	Date
AD1	OSIRIS SoW	ESA-EOPG-GSTP-SOW-0001	16/06/2015

Reference Documents

Ref.	Title	Document	Date
RD1			

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1. Introduction

The OSIRIS project (Optical/SAR data and system Integration for Rush Identification of Ship models), was initiated by MapSat jointly with CNR and Sistemi Territoriali, in order to address the emerging Maritime Surveillance from satellite market.

Overall objectives were:

- the use of intelligent data fusion between satellite imagery and AIS data, in order to extract value added information from images;
- the acquisition and processing of satellite remote sensing imagery from different data sources, data types, data formats and different scales of sea images;
- the use of intelligent image processing methods, analysis and processing to produce ship identification and classification;
- the AIS data fusion to investigate the behaviour of ships and their finally cross-correlation (identification);
- production of additional Value Added Products (VAPs) related to movement information extracted from the input data, namely the ship kinematic extraction and ship route prediction;
- uploading VAPs on a dedicated platform to present and share the information with potential users.

2. New Products Developed

The flow diagram below shows the sequence of developed software modules. It's a chain of processing steps that performs the data pre-processing and value added information extraction.

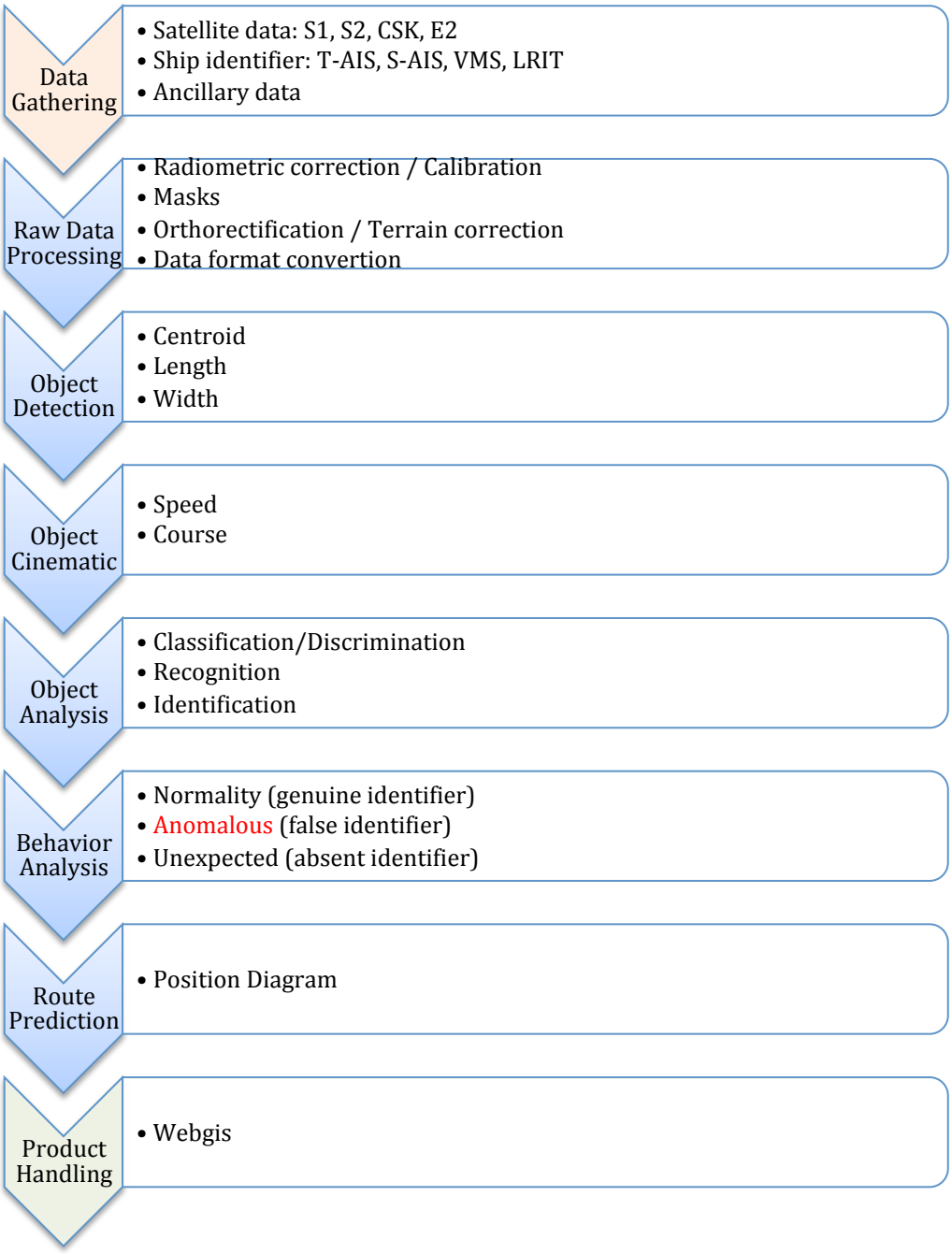

Figure 1 – processing chain

DPP, SD and DPE modules

DPP (Data Pre-Processing) is a generic module handling the satellite input data. It performs the processing activities in order to produce the raster and shapefile required by next modules.

SD performs the Ship Detection, producing the shapefile of target centroids as output. It also performs the rough calculation of target length and width.

DPE (Data Processing for Exchange) produces the crops of targets detected in the previous step and, for radar imagery, performs the correction of duplicated targets, putting a flag for each target that can be likely considered a ghost.

SC and SKE modules

SC (Ship Classification) and SKE (Ship Kinematic Extraction) are two mutually interacting modules devoted to ship classification and estimation of the ship velocity vector. SC takes input data from DPE and produces refined estimates of the centroid, the length overall and the beam overall of each target. Moreover, SC produces an estimate of the ship heading up to an ambiguity of 180 degrees. The classification system provides a ground truth database, to be populated during the OSIRIS operational phase, to help a finer classification based on geometric and/or scatterometric features. SKE takes input data from DPE and waits for the SC-estimated centroid and heading. Then, it evaluates the velocity vector of each target, analysing either the length of the cusp wave characterizing the ship wake, for optical and SAR inputs, or the azimuth shift between the wake tip and the target centroid, only for SAR inputs. When a velocity vector is evaluated, SKE also disambiguates the heading estimate from SC and produces a refined course estimate.

SBA module

The SBA (Ship Behaviour Analysis) algorithm is implemented as a set of PHP scripts. It takes as input a set of vectors representing ships' locations at a specified time interval, other information extracted from satellite images such as size (length - width) and speed, if available, and a series of AIS data corresponding to an area at the time interval of interest. The algorithm provides, for each vector, the MMSI (Maritime Mobile Service Identity) of a possible matching vessel derived from AIS data, with a confidence score for the match. If the score is too low or there is no candidate ship for a match, the input vector is

marked as anomalous. The complete output, returned as a CSV file, consists of different matching scores computed for ship position, type, and speed, an overall matching score derived from the previous ones, the MMSI of the ship with the best matching score, a flag for anomaly detection. In addition, the module provides some of the data regarding the matching ship, such as width, length and heading, that are useful for the WebGis module.

SRP module

The SRP (Ship Route Prediction) module was implemented in python and exploited the scikit-learn library. It implements the following algorithms: K-Nearest Neighbor, Decision Tree, Multilayer Perceptron, Bernoulli and Gaussian Naive Bayes, Linear Support Vector Machines, One-vs-rest, Kernel Approximation and Stochastic Gradient Descent.

The module takes the following parameters as input: ship position (latitude and longitude), course over the ground, speed, size (small or big), day of the year and hour of the day. As output, the module produces a GEOjson containing the matrix of all non-zero probabilities that each cell of the grid (representing the area of interest) will be occupied after 30, 45, 60 and 120 minutes.

Experiments demonstrated that the K-Nearest Neighbor was the best algorithm in terms of precision, recall and accuracy, reaching a precision, recall and accuracy of about 0.7 in the best case.

WebGIS and Control Panel

The WebGIS module consists of a modern, flexible and multi-device web interface and is the OSIRIS component that integrates all the other.

From an architectural point of view, the WebGIS can be considered as an abstraction level that hides from the user the complexity of the other modules of the system, thus simplifying and speeding up the activities related to vessel monitoring.

In fact, thanks to WebGIS, users can access all the features that OSIRIS provides, such as, for example:

- Display of AIS data in real time;
- Browsing historical AIS data;
- Display the route a vessel has travelled in a given time interval;
- Creation of monitoring requests for a specific geographical area;

- Display of planned satellite acquisition areas;
- Display of a graphical representation of the data generated as a result of the processing of satellite images.

A set of specific map themes allows the user to understand the structure of the data acquired before even consulting its details. This leads to a more immediate and global view of the information as well as significantly reducing the analysis time and improving the user experience.
Through the Control Panel, the operator user can access backend features such as the management and editing of monitoring requests. A specific graphical interface allows the OSIRIS Operator to filter the list of requests and set the fields for each of them.
All information on the progress of the requests is automatically notified to the users without the operator having to take any action.
In a specific section of the Control Panel, the operator user can also schedule the download of satellite raster images from ESA hubs:

https://scihub.copernicus.eu/dhus/#/home
https://collhub.copernicus.eu/MATERA

Images are automatically downloaded and ingested into the system allowing OSIRIS administrators to download or process them to fulfil a user-monitoring request.
Finally, the modular architecture on which the WebGIS is based allows obtaining a good degree of configurability and customization. The system guarantees excellent performance in terms of response time and speed of execution even in stressful conditions in which it may be able to manage several hundred (if not thousands) of geographical layers at the same time.

3. Conclusions

The OSIRIS project was initiated in March 2016 (Kick off meeting on 1st March 2016) and successfully implemented a set of interacting modules, which produce a baseline for a Maritime Awareness System.