SHIP DETECTION AND RECOGNITION IN HIGH-RESOLUTION SATELLITE IMAGES

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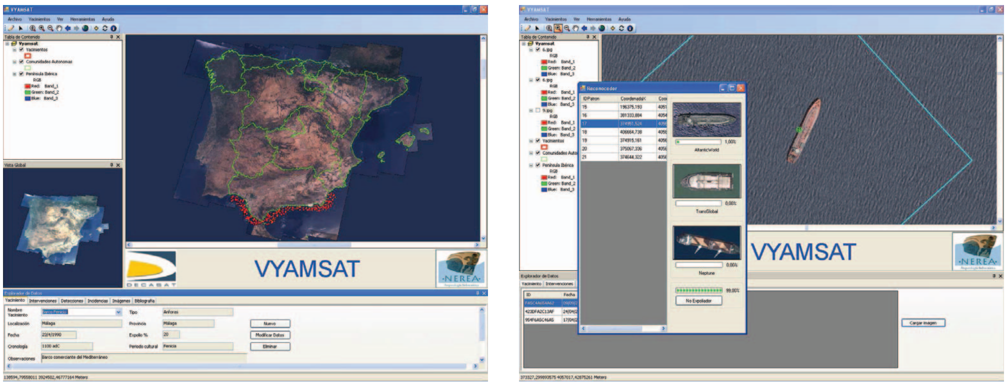
1. INTRODUCTION

During the XVI and XVII centuries, hundred of galleons transported tons of gold, jewelries, and archeological pieces from the new discovered American continent to Spain. A significant number of these ships were wrecked, due to different causes like storms, human errors, or naval battles, filling the bottom of the sea with inestimable wealths. The Spanish state has realized the need to protect this heritage from the plundering activities of some companies. One of such attempts is the *Vyamsat* project, which was conceived with two main objectives: (i) To catalogue and register areas in the sea where a sunken treasure is supposed to be located, and (ii) To automatically monitor the steady presence of ships in these areas and assess the risk of wealth plundering according the type of the ship.

In this paper we present a GIS-based software called Vyamsat-soft that provides a long-term solution to the aforementioned goals. It integrates in a unique application the management and visualization of interest regions, i.e. those that are believe to contain sunken treasures, and algorithms to automatically detect and identify ships from Quickbird colour images (see figure 1). For the former the software relies on ArcGis/ArcObject technology while for the latter, a Bayessian classifier based on image extracted features is considered. This paper only addresses the second of these problems, that is, the ship classification and identification module of the Vyamsat software.



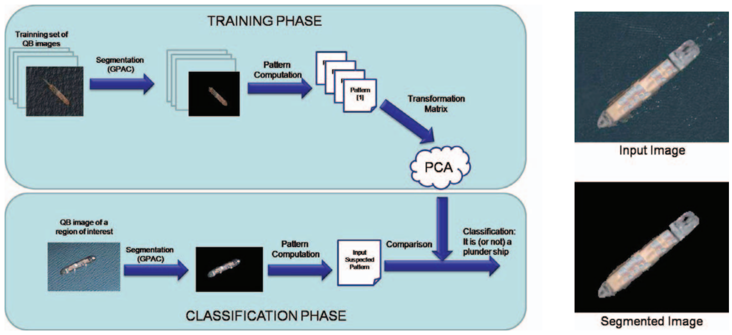
a) b)

Fig. 1. Snapshots from the Vyamsat-soft application. a) Main screen of the application showing (in red) the regions that contain sunken treasures along the coast of the south of Spain. In the bottom window, the user can manage (create, modify, or delete) regions of interest and check the log of ships that has traversed each area. b) Identification of a ship inside an interest region. The ship is recognized and compared to those stored in the database of plunder ships for assessing the plundering risk level.

2. THE VYAMSAT-SOFT APPLICATION

One of the main purposes of the Vyamsat-soft application is to automatically alert to risk of plundering sunken treasures. Since such plundering activities requires a considerable period of time to be committed, the application is expected to be fed with images taken with a periodicity of days or even weeks, possibly provided by different satellites.

Next, the developed algorithm for ship detection and recognition is presented.



a) b)

Fig. 2. Stages of the ship identification process. a) A scheme of the full process, divided in two stages as explained in the text. b) Example of the segmentation process.

3. AUTOMATIC SHIP DETECTION AND RECOGNITION

The process for ship recognition is divided in two phases (see figure 2-a). First, in a training stage, a pattern that represents each sample ship image is computed from a collection of satellite or aerial ship images. Patterns account for information about colour, shape and size. Concretely, each pattern is described by a 10x1 feature vector that contains the segmented ship's size and its three first Hu moments calculated upon the three bands of the image [1]. In the second stage the input image is first segmented and compared to the training images, using a Bayessian classifier, which provides a degree of similarity. In both phases we rely on the segmentation algorithm GPAC [2] that extracts the background, i.e. the sea, and returns the foreground, if any, i.e. the image of a ship as shown in figure 2-b.

The identification algorithm employed in our work is based on a Bayessian classifier. The computed patterns for the training ship's images are used to construct a transformation matrix that reduces the original 10-dimensional feature's space into a 2-dimensional one using PCA [3]. In this reduced space, ship's patterns belonging to the same type (i.e. class) are represented by taking their average, μ, and covariance matrix, Σ, as prototypal characteristics. In the recognition phase, the pattern of segmented images taken from the regions of interest are transformed into such a reduced space. The likelihood of the resultant pattern, s_i, to belong to a certain class, C_r, is computed as:

$$likelihood(s_i, C_r) = \frac{1}{(2\pi)^{n_r/2} \left|\Sigma_r\right|^{1/2}} e^{1/2(s_i-\mu_r)^T \Sigma_r^{-1}(s_i-\mu_r)} \tag{1}$$

where μ_r and Σ_r are the average and covariance matrix of the class r respectively.

4. CONCLUSIONS

In this paper we have introduced the Vyamsat-soft application, a GIS-based software that monitors maritime areas of valuable interest. Our focuss has been on one of its components, which is in charge of the automatic identification of ships that are likely to be on plundering activities on a protected maritime site. This ship recognition module has been successfully implemented and tested using Quickbird images from the Spanish coasts.

5. REFERENCES

[1] Hu M.K., "Visual pattern recognition by moment invariants," *IRE Trans. Info. Theory*, vol. 8, pp. 179–187, 1962.

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