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COASTLINE AUTOMATED DETECTION AND MULTI-RESOLUTION EVALUATION USING SATELLITE IMAGES

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INTRODUCTION

Detail topographic maps, aerial photographs and, recently, satellite images are the main data used to extract indicators that are important for monitoring the coastline evolution along coastal segments. In the last years, the geographic information acquisition systems are experimenting a deep change, making available more and more accurate data in digital format. This fact allows for the development of automated systems in order to extract certain elements, such as coastlines. Examples of these types of acquisition data are high resolution imagery (QuickBird, Ikonos,...) and Lidar.

However, these new data sources are expensive, short time series are available and only some geographic areas are covered. On the other side, more traditional medium resolution satellite images (Landsat, SPOT,...) have a worldwide coverage as a regular basis and long time series of them are available.

Many studies of coastal evolution carried out in different types of beaches show that the shore location in a given moment is a low reliable data in order to establish long term trends, since its variability is high. This is due to the changes of the beach shape, as well as to the location of the sea level. Analysing the results obtained in several systematic measurements concerning inter-annual changes in beaches from very different geographic areas (Morton y Speed ,1998; Zhang et al., 2002; Pajak y Leatherman , 2002; Ruggiero et al., 2003; Pardo et al., 2007), a common conclusion is that changes detected using a short set of aerial photographs must be taken carefully. O'Connell (2005) insists that, many times, the seasonal variability of the reference element used to draw the coastline is unknown, and it can be the main source of error detecting coastline changes. Pardo *et al.* (2007), point that, in microtidal areas, the error sources can come from the changes in the beach shape that have a seasonal component, but also from more random variations of the sea level due to meteorological factors.

Therefore, in order to know the middle and long term evolution of the coastline, it is important to create a database large enough to register intra-annual oscilations, and long enough to detect the global trend in a reliable manner. This may be feasible by means of periodic satellite imagery, but using images with coarser pixel size, such as the ones provided by medium resolution sensors.

The main objectives of this work are:

- To develop an image processing **methodolgy for automatic coastline extraction** in microtidal beaches

- To evaluate the use of simulated **medium resolution satellite images** as an alternative to high resolution images

METHODS

The proposed method for automatic extraction of the coastline is based on multispectral mid-resolution satellite imagery, and can be synthetised in a few steps. First, an approximated coastline is defined based on a binarisation of the second principal component obtained from multispectral data (Figure 1).

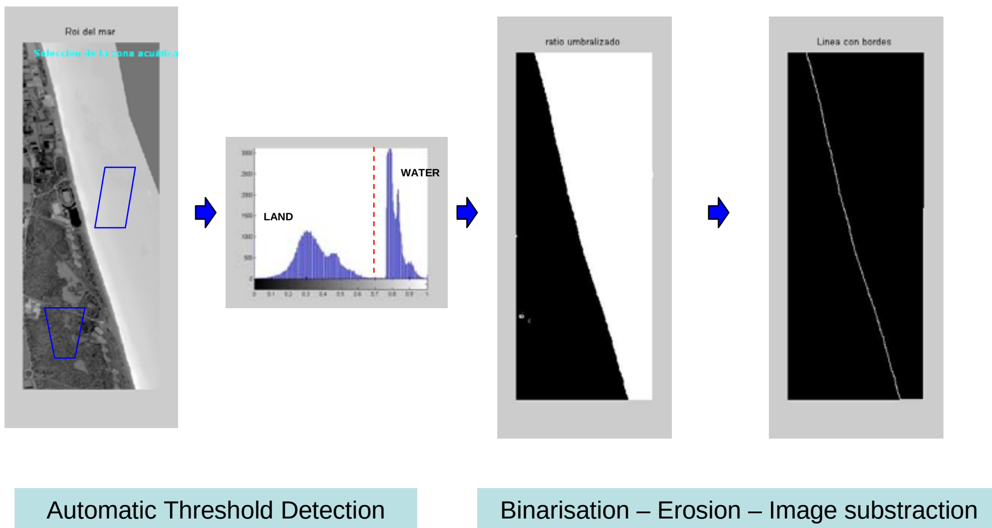

Figure 1. Detection of the inicial approximate coastline (pixel level).

Along this line, representing a rough interface between land and water, a larger neighbourhood is analysed, searching a fifth order continuous polinomic function that localy fits the image around every single interface point. Then, the maximum curvature points are detected, which define the final coastline at a subpixel level (Figure 2).

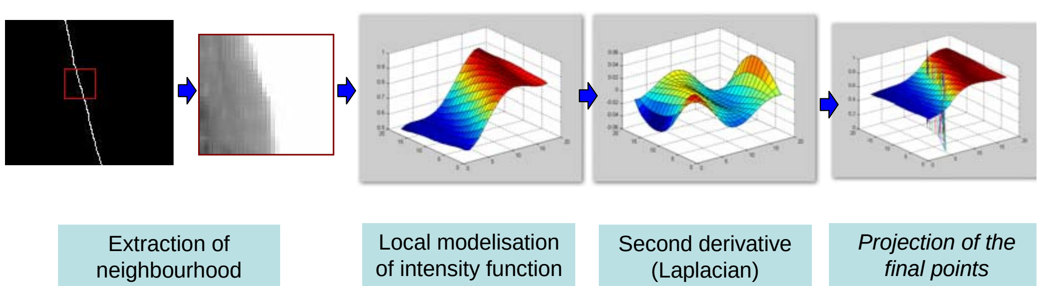

Figure 2. 3D Modelization of coastline and detection at subpixel level.

The reference line is obtained combining an automated classification process of the fused multispectral QuickBird image with image interpretation (Figure 3).

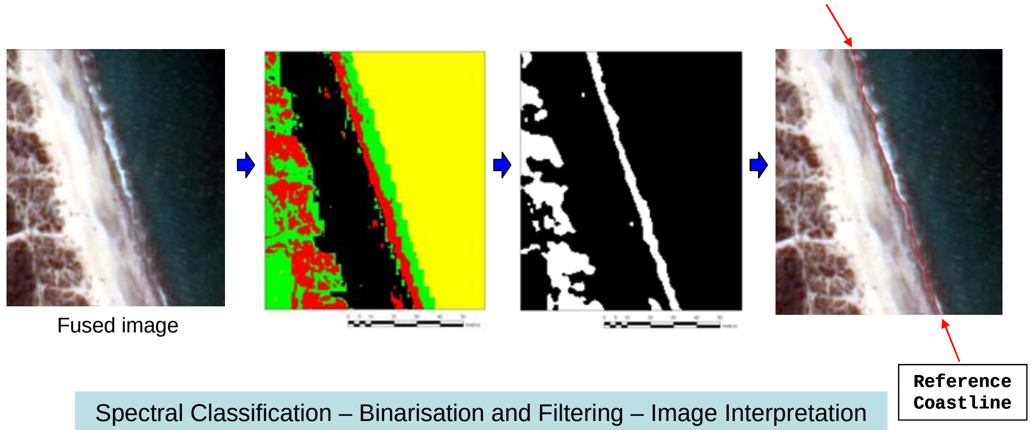

Figure 3. Methodology followed for the definition of the reference line.

The potential of this method has been evaluated over a QuickBird satellite image, using a 3 km beach segment located along the coast of El Saler beach (Valencia). A reference coastline has been obtained by supervised classification of the panchromatic and multispectral fused image (0.6 m of spatial resolution), defining the wet interface between land and water as a class in the process. The original multispectral image (2.4 m of spatial resolution) has been resampled to four new lower resolutions: 4.8 m, 6.9 m, 14.4 m, and 19.2 m. The automatic algorithm has been applied over these spatially degraded images, extracting five different coastlines, that have been compared to the reference line by analysing their respective differences.

RESULTS

Figure 4 shows an example of a detail image, including superimposed the reference line (in black) and the different coastlines detected by the proposed algorithm at different resoultions (in color).

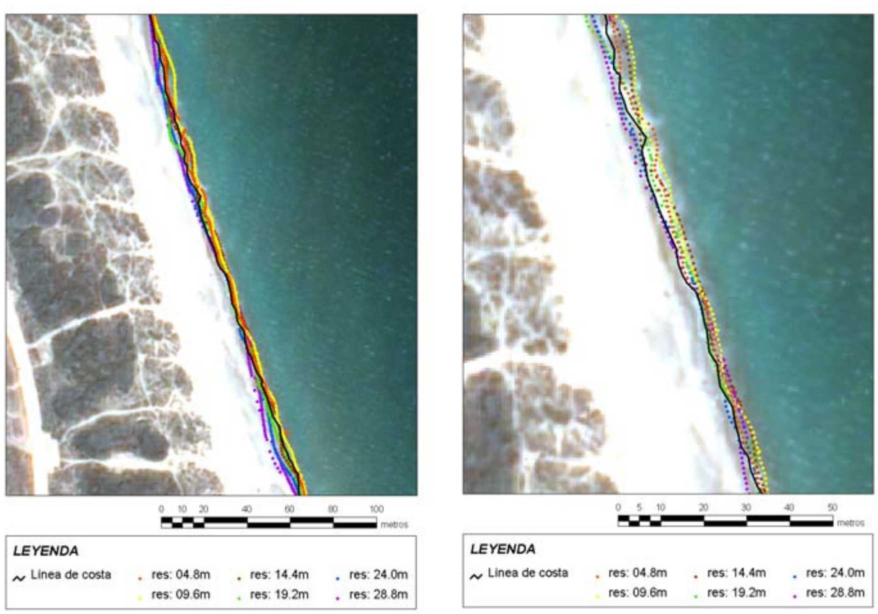

Figure 4. Examples of the detected coastlines at different resolutions.

The results show an increase of the error as the resolution of the image decreases but, in general, pixel sizes of 28 m provide a mean error of approximate 4 m. However, using images acquired in storm conditions, the mean error is almost 7 m. (Figure 5).

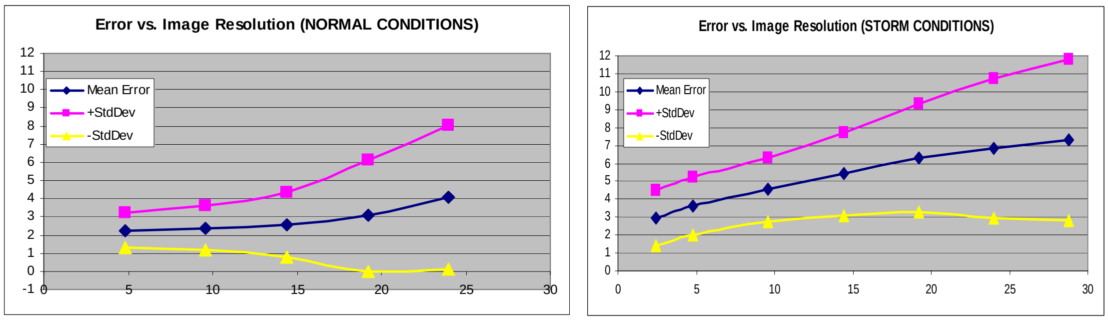

Figure 5. Error in automatic coastline detection (m) vs. spatial resolution of the data (m)

The results obtained evidence a systematic positional error of the estimated coastline (towards the sea), which is more relevant when using small pixel sizes. However, this systematic error suggests to the possibility to increase the accuracy of the results by a careful revision of the algorithm.
The results obtained are encouraging, showing the possibility to create a system that automatically extract the coastline using mid resolution satellite images as input, such as Landsat TM, Spot, etc. These images are less expensive than high resolution ones, and they are available many years ago, allowing the study of coasts from larger series of time.

CONCLUSIONS
An automatic method for coastline detection at subpixel level is presented and evaluated using satellite images at different spatial resolution. The results show that medium resolution images (20 – 30 m/pixel) provide sufficient positional accuracy for certain applications of monitoring global coastline dynamics.

The use of medium resolution images adds two principal advantages: (1) The availability of historic series (Landsat TM is operational from the beginning of the 1980 decade); and (2) they have a reduced cost compared to high resolution images However, the algorithm is not definitive and should be revised in order to improve the systematic error projected towards the sea. Finally, this methodology has a high potential for coastal change monitoring applications, as described above.

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