Automated Shoreline Extraction from Optical Images by Image Processing Technics: A Case Study in Lark Island (IRAN)

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Abstract
A shoreline is the boundary between land and ocean masses. Shoreline change is considered to be one of the most dynamic processes in the coastal area. Accurate shoreline detection has great importance as a prior step of land use/land cover monitoring and planning. Traditional shoreline mapping in small areas is carried out using conventional field surveying methods. Due to the subjectivity and substantial effort involved in manual delineation, an automatic delineation method has been long desired. The purpose of this research is to present a methodology to automated shoreline extraction from optical images by image processing technics. The experiments on a case study (Lark Island in Iran) show that our methodology works acceptable.

Keywords: Shoreline Extraction, Lark Island, Optical Images, Image Processing

Introduction
Climatic, geodynamic and anthropogenic driving forces move the shoreline. The amount of this movement is of paramount importance for protection, development and management of the coastal area. The shoreline, occurring between land and sea, is dynamic in nature. It undergoes frequent changes, short term and long term, caused by hydrodynamic changes (e.g., river cycles, sea level rise), geomorphological changes (e.g., barrier island formation, spit development) and other factors (e.g., sudden and rapid seismic and storm events) [1]. A shoreline is defined as the line of contact between land and a water surface [2]. It is important to identify the shoreline. For example, an analysis of shoreline information is required in the design of coastal [3], to calibrate and verify numerical models [4], to assess sea-level rise [5], to develop hazard zones [6, 7], to formulate policies to regulate coastal development [8], and to assist with legal property boundary definition [9] and coastal research and monitoring [10]. Shoreline position measurements for various time periods can be used to derive quantitative estimates of the rate of shoreline change (erosion or accretion). Automated shoreline extraction from digital image data belongs to the boundary detection problem in the field of computer vision and image processing. The purpose of this research is to present a methodology to automated shoreline extraction from optical images by image processing technics. In the next section our methodology and case study is presented.

Methodology Overview

Study Area
This study investigates the coast around Lark, the strategic island of Iran (Fig. 1), which is on the Persian Gulf. Multi-resolution satellite data over the study area have been acquired, and georeferenced with available bench marks.

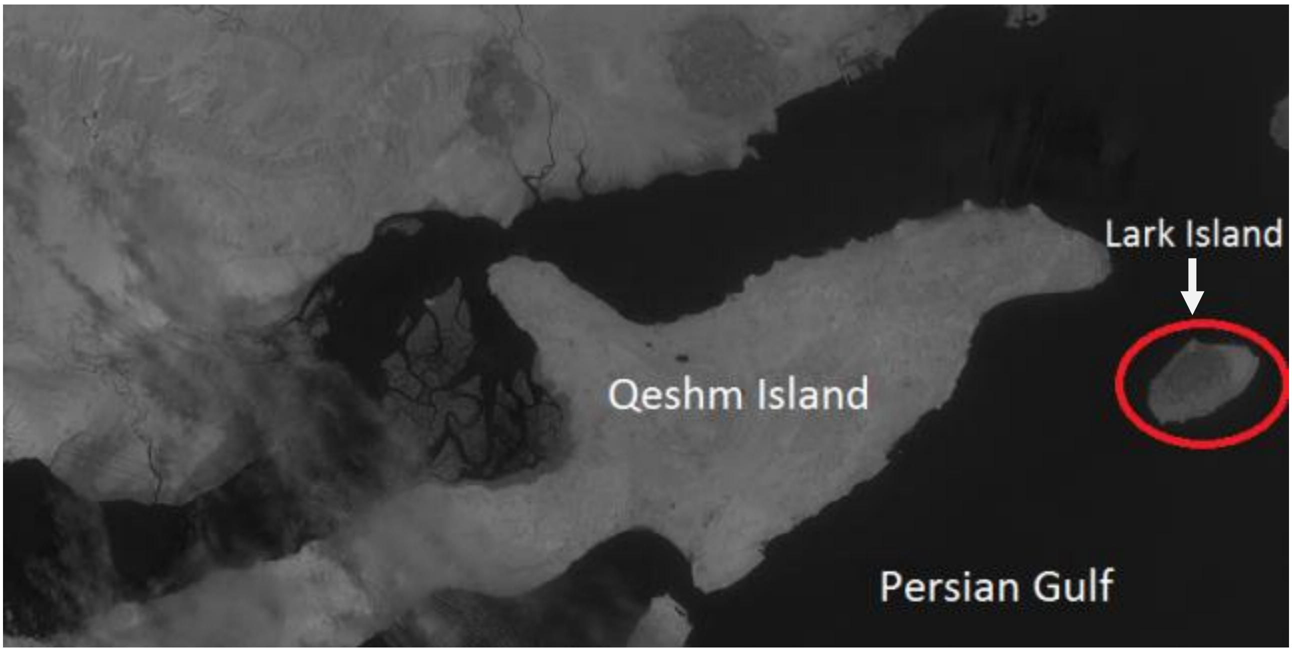


Figure 1: The location of the study area (Lark Island in Persian Gulf)

Shoreline Detection and Digitization

In this research shows how to detect a shoreline using edge detection and basic morphology. An object can be easily detected in an image if the object has sufficient contrast from the background. Below steps must be done to extract shoreline from an optical image:

Step 1: Read Image

Read a gray scale or color image from graphics file.

Step 2: Detect Entire Shoreline

Image segmentation is used for object detection in an image. The object to be segmented differs greatly in contrast from the background image. Changes in contrast can be detected by operators that calculate the gradient of an image. First, we use edge and the Sobel [11, 12] operator to calculate the threshold value. We then tune the threshold value and use edge again to obtain a binary mask that contains the segmented shoreline.

Step 3: Dilate the Image

The binary gradient mask shows lines of high contrast in the image. These lines do not quite delineate the outline of the object of interest. Compared to the original image, we can see gaps in the lines surrounding the object in the gradient mask.

Step 4: Fill Interior Gaps

The dilated gradient mask shows the outline of the shoreline quite nicely, but there are still holes in the interior of the shoreline. To fill these holes we fill image regions and holes.

Step 5: Remove Connected Objects on Border

The cell of interest has been successfully segmented, but it is not the only object that has been found. Any objects that are connected to the border of the image can be removed.

Step 6: Smoothen the Object

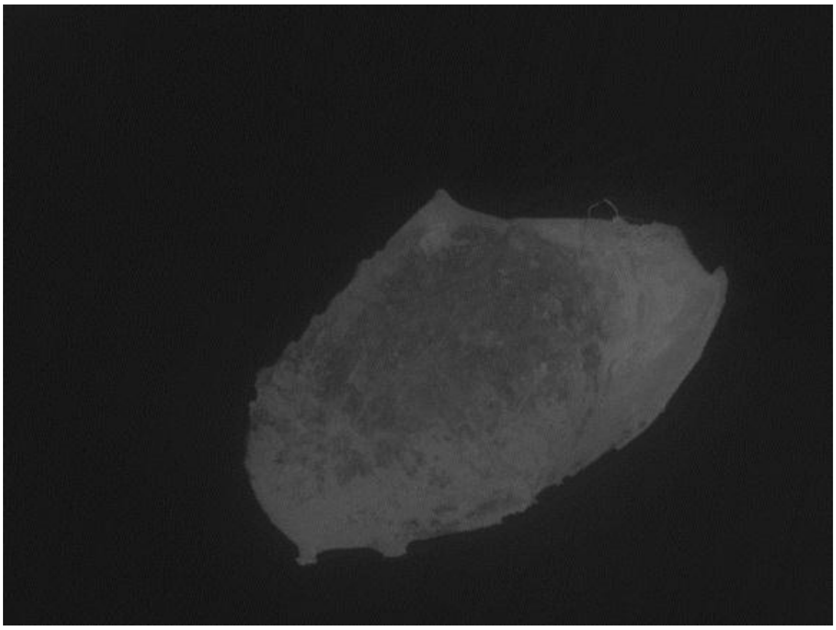
Finally, in order to make the segmented object look natural, we smoothen the object by eroding the image twice with a diamond structuring element.

Step 7: Convert Shoreline Data to Shapefile Format

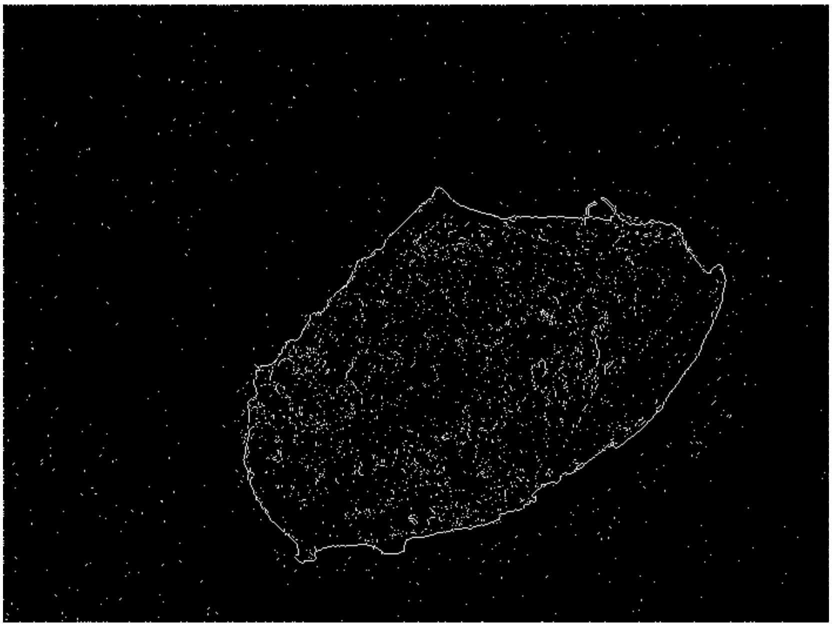
For future use in MATLAB, or for export to a Geographic Information System (GIS), we save the extracted shoreline to a shapefile format.

Results

A brief discussion of the results, presented in Fig. 2. For this purpose we write a MATLAB program base on proposed method to extract shoreline from input image.

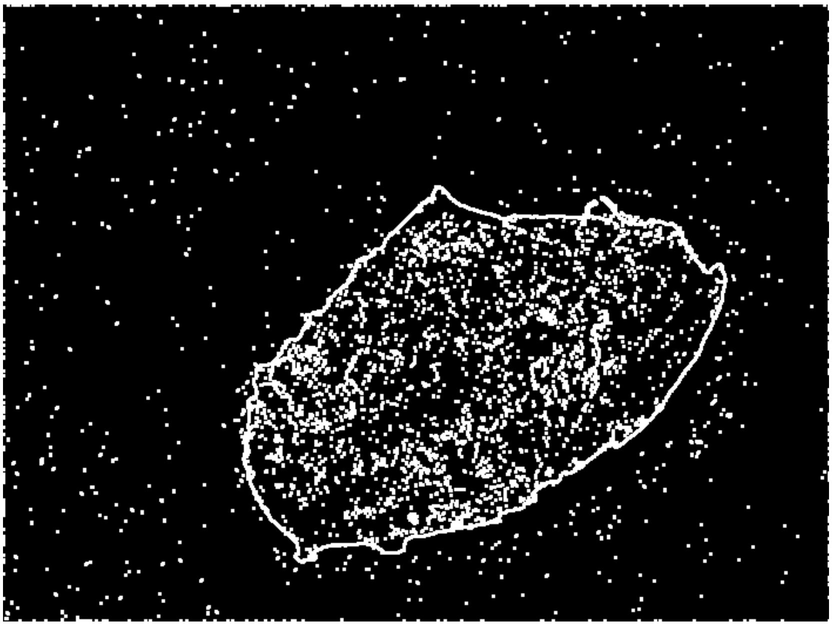


Step 1: Read Image



Step 2: Detect Entire Shoreline

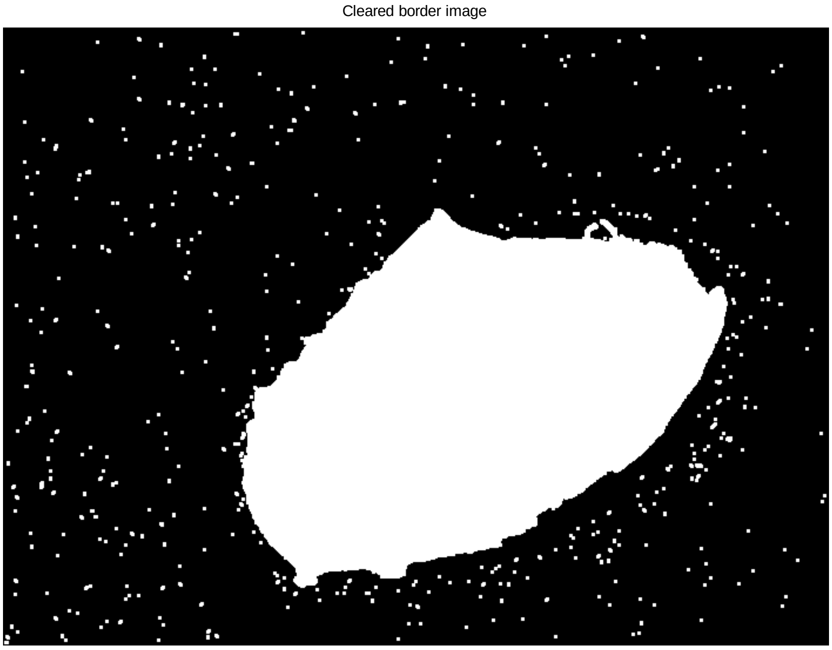
Dilated gradient mask



Step 3: Dilate the Image

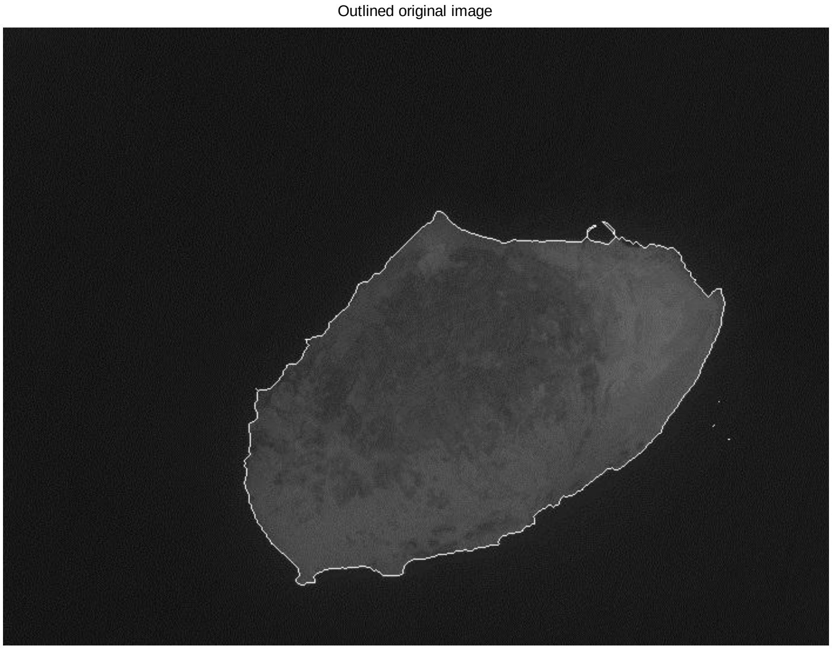
Binary image with filled holes

Step 4: Fill Interior Gaps

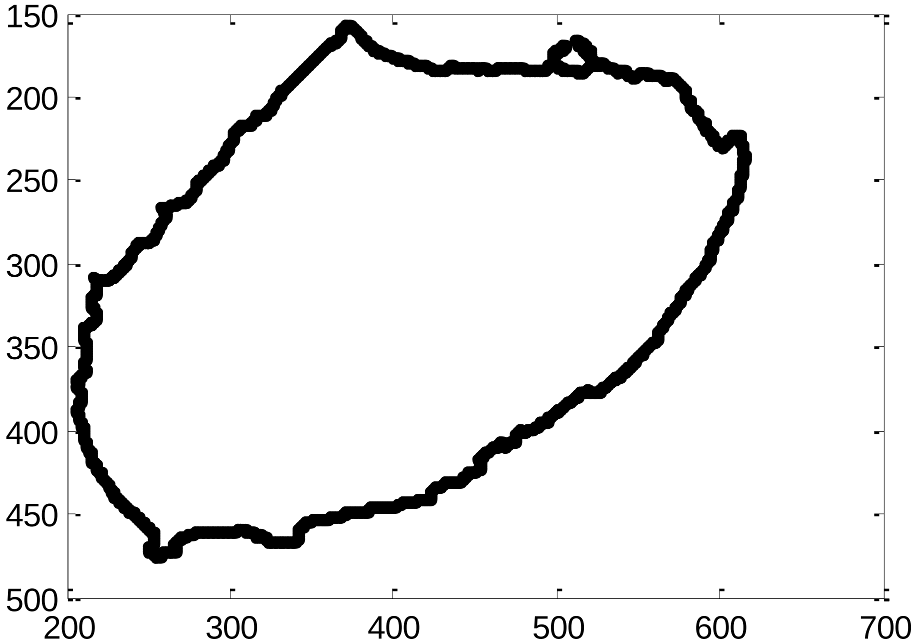


Step 5: Remove Connected Objects on Border

Step 6: Smoothen the Object



Outlined original image



Extracted Shoreline

Figure 2: An example of shoreline extraction from a satellite image of Lark Island

Conclusion

We have developed a method to automatically extract the position of the shoreline from optical images. From the above given analysis and results it is evident that our proposed method performance is satisfactory.

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