Chapter 13
Shoreline Mapping and Coastal Change Studies Using Remote Sensing Imagery and LIDAR Data

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This chapter introduces algorithms and methods for numerically extracting shorelines from the remote sensing imagery and LIDAR elevation data. These methods aim to minimize human operator’s intervention and editing efforts and to maximize the delineation accuracy. The shoreline extraction method designed for processing remote sensing imagery consists of three groups of algorithms: preprocessing, segmentation and classification, and post-processing. This method is applicable to both satellite images and digital aerial photographs, and the shoreline can be extracted from the imagery at a pixel level accuracy. Further, two methods are presented to process LIDAR data for automated shoreline delineation. The first method is composed of three processing steps: contouring, line selection with a length threshold, and line smoothing and generalization. The second one is based on the segmentation of the LIDAR DEM. These methods have been employed to process multi-temporal digital orthorectified aerial photographs, Landsat imagery, and airborne LIDAR data in the upper Texas Gulf coast. The shorelines delineated from the time series of remote sensing images and LIDAR DEMs are compared in GIS environment for coastal change studies.

13.1 Introduction

Shoreline information is important to navigation charting, marine boundary determination, and many coastal zone management activities, such as monitoring shoreline changes and delineating the inter-tidal zone, wetlands, and other coastal habitats. Land planners have relied on up-to-date shoreline information for establishing building setback lines, managing recreational resorts, inventorying the wetland and agricultural land resources, and delineating flood and hurricane hazard zones (Zeidler 1997). Engineers have employed shoreline and beach morphology information for designing coastal defense and shipping structures (Szmytkiewicz et al. 2000). Geomorphologists have long recognized the usefulness of shoreline information for...
studying coastal erosion and accretion and estimating sediment transport and budgets (Shepard and Wanless 1971, Leatherman and Douglas 2003). As pointed out by many coastal scientists (e.g. Morton 1991, Leatherman and Douglas 2003), tracking and investigating shoreline and coastal changes calls for rapid, highly accurate methods that minimize the mapping error and processing time and provide frequent and timely measurements.

Traditionally, shorelines on the nautical charts and topographic maps were compiled through ground surveys and visual interpretation of aerial photographs. In the ground surveys, the direction and distance of shoreline features were observed and determined in person on the beach with the plane table and rod, and the shorelines were drew through the series of measured points on the shore. In the 1920s, the aerial photogrammetric survey method replaced the older plane table survey method and became the primary shoreline mapping technique. Using aerial photography mapping method, shoreline interpretation and compilation was brought from the field into the office, saving time and cost. At present, shorelines on the majority of maps are still determined through interpretation of the stereo-photogrammetric models of aerial photographs (Graham et al., 2003). In recent decades, new approaches have been developed for coastal and shoreline mapping. Those include the use of high-resolution satellite imagery (Li et al. 2003), all-terrain kinematic GPS vehicles (Morton 1997), and airborne LIDAR technology (Gibeaut et al. 2000, Robertson et al. 2004).

The fundamental problem in using remote sensing images for shoreline mapping is that the wet/dry beach (high-water) lines delineated from the imagery is affected by water level at the time the images were acquired. Remote sensing images are rarely taken at precise mean high water with no wave action throughout the survey. Therefore, the high water line derived from the remote sensing imagery is not exact intersection where a body of water at the precise desired tidal datum elevation and the shore meet. The seasonal tidal variation and storm surges often create different water levels. Water levels have their greater effects on the high water line for wide low-gradient beaches than for narrow, steep beaches. Some mapped shoreline changes could be merely a manifestation of the differences in water levels rather than actual coastal erosion or accretion. With the recorded tide stages, we can adjust and normalize the image derived shorelines to a common tidal elevation for comparison. However, the tide adjustment and normalization process is often difficult and inaccurate.

With the advent of airborne LIDAR technology, the coast zone and shoreline may be mapped more accurately and cost-effectively. Shorelines extracted from LIDAR data have unprecedented accuracy and can establish a baseline for change analysis. If the LIDAR data are collected at the time of low water level, it is possible to derive shoreline indicators using various tidal datums. Therefore, the airborne LIDAR data over coastal zones may offer a means to link and assimilate different shorelines obtained from divergent approaches such as the NOAA T-sheets, kinematic GPS, and aerial photographs, and satellite imagery.

While new remote sensing data have been increasingly becoming available, derivation of shorelines from remote sensing data still is challenging. Manual