Landsat Archive for Monitoring Coastline Changes

Based on some predictions, sea levels may rise by up to 1.5m by the year 2100. Such rises are likely to have severe effects on some coastal regions around the world, including many large cities. Regular monitoring of coastal areas contributes to understanding the current seasonal and long-term effects of changes. Professor John Trinder shares insights into how GNSS equipment, airborne Lidar and UAS-derived imagery have been used to demonstrate periodic changes in the coastline north of Sydney, Australia.

For me, an advantage of working with civil engineers at the University of NSW, Australia, is being able to tap into the outcomes of continued research into sea levels on beaches to the north of Sydney. Staff there have been monitoring the changes in coastlines for about four decades in one of the best datasets worldwide. They have been able to demonstrate the periodic changes in the coastline using the latest technologies, which currently include GNSS equipment, airborne Lidar and UAS-derived imagery.

(By Prof Emer John Trinder, the University of New South Wales, Australia)

The data archive of Landsat Thematic Mapper (TM) satellite images with 30m spatial resolution, such as USGS Landsat TM Global Archive, could provide important data for monitoring the evolution of the coastlines over the past four decades and consequently also the changes due to sea-level rise over that period. SPOT satellite data with 10m spatial resolution might also have been appropriate for this purpose but, apart from SPOT data acquired and held in France, most SPOT data acquired over Australia by local ground stations in the past is no longer available due to the production systems no longer being operational. The best available archival SPOT data is probably only about ten years old, although the first SPOT satellite was launched 30 years ago. This seems to be a tragic loss of archival SPOT satellite data that could have been used for reviewing past and present aspects of the environment, including coastline changes. As a result, the primary archive available for reviewing the positions of coastlines and effects of sea-level rise is Landsat.

Sub-pixel Mapping

Given that the best available data for long-term monitoring of the coastline is likely to be the 30m-resolution Landsat TM, there is a need for innovative image processing based on methods such as sub-pixel mapping to improve the resolution and test the reliability of the coastline extraction in Australia against the past monitoring records. Generally, to realise the classification at sub-pixel level based on the original pixel-level images, two main steps are implemented: soft classification which predicts the percentage of each class inside a pixel, and sub-pixel mapping which determines the distribution of sub-pixel labels. Soft classification, also called sub-pixel classification, allows multiple class membership for each pixel in order to overcome the mixed pixel problem. The estimation of class proportions inside each pixel leads to the generation of multiple fraction/abundance images which are required for the sub-pixel mapping step. To date, considerable research effort has been directed towards the development of sub-pixel mapping techniques.

Our experimentation with the sub-pixel mapping method has been based on a Markov random field developed under the Gaussian class conditional densities assumption, which utilises the local properties of the spatial and spectral information to manage the contributions of spatial and spectral energy. To optimise the MRF energy minimisation, the simulated annealing method has been commonly used by many researchers while the graph-cut optimisation method with comparable accuracy to simulated annealing has been found to be a much faster alternative. Besides, the image edge information can be extracted to enhance the sub-pixel mapping accuracy. Sub-pixel mapping has led to improvements in accuracy of pixel-level classification and will be tested to determine its potential for more accurate coastline monitoring.