LAND SUBSIDENCE MONITORING AND FLOODING SIMULATION USING MULTI-TEMPORAL DIGITAL ELEVATION MODELS

Pai-Hui Hsu

Assistant Professor, Department of Civil Engineering, National Taiwan University
No. 1, Sec. 4, Roosevelt Rd., Taipei,10617, TAIWAN,R.O.C.
TEL: +886-2-33664260,FAX: +886-2-23631558
Email: hsuph@ntu.edu.tw

1. INTRODUCTION

Because of the over capacity use of the ground water within the lowlands, the land subsidence along the southwestern coast of Taiwan is a serious problem [1]. For example, the overall amount of subsidence in Yunlin area in the past 30 years reaches about 2 meters, and the total affected area of subsidence is about 516 km2. Land subsidence has increased the vulnerability in this area, and a large portion of which lies below the mean sea level. The consequence is the arising of the flood hazard during the periods of typhoon and heavy rainfall, and property damages and life losses could be caused by the poor drainage. Therefore, how to monitor the land subsidence effectively will be an important study issue for well planning and construction of the proper drainage to minimize the flood hazard impacts.

Traditional methods to monitor land subsidence are usually based on height observations using direct leveling or GPS surveying [2]. Such the ground-based methods have high precise results of height measurements, however only a little point-observations of height in small area are obtained. For the land subsidence monitoring in large area, the interpolations from point-observations cannot appeal the overall trend and variations caused by subsidence. On the other hand, the DEM (Digital Elevation Model) obtained by the photogrammetry and remote sensing technologies provides more extensive height information on regular grids than ground-based methods. In terms of efficiency, ground-based method is more labor intensive and therefore is only suitable for modeling a small area, when high accuracy is required. On the other hand, most of the processes in photogrammetric or remote sensing technique have already been automated nowadays. Therefore, data acquisition is more efficient. Indeed, compared to the points-observations of heights, the DEM with regular grid is more suitable to present the phenomena on the medium- and large-size terrain, especially favorable for the monitoring of land subsidence.

2. METHODOLOGIES

There are many geomatics technologies, which can be used to acquire DEM data [3]. In term of the accuracy of measurement, a centimeter-level can be reached by photogrammetry and LiDAR (Light Detection and Ranging) technologies. InSAR (Interferometric Synthetic Aperture Radar) is another good technique for deformation measurement and with it an accuracy of 1 cm can be reached [4]. One purpose of this study is to test the performance and effective of the multi-source DEM data sets for land subsidence analysis. Firstly, three different kinds of DEM data sets respectively acquired from photogrammetry, LiDAR and InSAR are collected, than the comparison of the quality, resolution and accuracy of the multi-source DEMs are demonstrated. The quality and accuracy assessment of DEM data will be helpful for the analysis of land subsidence. In addition, multi-temporal DEM data sets covering the same test area (Yunlin county, Taiwan) are also collected for the change detection of land subsidence.

In this study, the analysis of the land subsidence is performed respectively along the vertical and horizontal directions. For the former, the difference between multi-temporal and multi-source DEMs is calculated to analyze the subsidence rate, the time variances of the subsidence, and the change detection between different DEMs. However, it will be difficult to perform the analysis of land subsidence when using the different DEM data sets with different resolution and accuracy. Therefore the least squares collocation (LSC), which is a kind of generalized statistic adjustment methods[5], is proposed to adjust the lowprecise DEM data to high-precise leveling observations. In addition, the statistics hypothesis test is applied to verify the significant of the land subsidence. For the latter, some geomorphometric terrain parameters, such as the slope, aspect, break lines and roads features etc., are extracted from the multi-temporal DEM data sets. Then the change of these features locations can be analyzed along the horizontal direction. Finally, many kinds of 3D geo-information including the multi-temporal DEMs, the types of land use/land cove, and 3D building models in the study area were collected, then the SOBEK model which is a powerful 1D and 2D instrument for flood forecasting and simulation is used for the inundation simulation[6].

3. RESULTS AND CONCLUSIONS

The experiment results of this study showed that the extensive DEM data exactly provides more complete and reliable height information for land subsidence than traditional ground-based methods. The least squares collocation (LSC) we proposed in this study can exactly reduce the system errors of DEMs data and reveal more detail variances of land subsidence in local areas. The change detention of multi-temporal and multi-source DEM also reveals the important trend and variances of the land subsidence and flood prediction. Once land subsidence is identified and mapped, subsidence-monitoring programs can be implemented and scientific studies can be launched to improve our understanding of the subsidence processes. A combination of scientific understanding and careful management can minimize the subsidence that results from developing our land and water resources, and then reduce the impact of flood hazards. The results of this study can serve as guidelines for design and planning of the infrastructures for the prevention of flooding hazards. In future, automated tracking of extracted features is needed for more efficient measurement of change of land subsidence, and the results will be used to forecast and simulate the land subsidence. In addition, the visualization of the DEMs and measurements of subsidence will be developed for planning and decision making to reduce the impact of flood impacts.

4. REFERENCES

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