Chapter 53
Prediction Changes for Nonstationary Multi-Temporal Satellite Images Using HMM

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ABSTRACT

Due to the growing advances in their temporal, spatial, and spectral resolutions, remotely sensed data continues to provide tools for a wide variety of environmental applications. This chapter presents the benefits and difficulties of Multi-Temporal Satellite Image (MTSI) for land use. Predicting land use changes using remote sensing is an area of interest that has been attracting increasing attention. Land use analysis from high temporal resolution remotely sensed images is important to promote better decisions for sustainable management land cover. The purpose of this book chapter is to review the background of using Hidden Markov Model (HMM) in land use change prediction, to discuss the difference on modeling using stationary as well as non-stationary data and to provide examples of both case studies (e.g. vegetation monitoring, urban growth).

INTRODUCTION

Recent years have seen growing interest in technological evolution of remote sensing sensors and satellites which provides a huge amount of free valuable earth observation data (Lillesand et al., 2014; Reiche et al., 2015). Therefore, a crucial importance is given to develop and to improve innovative tools in order to make the most of its spatio-temporal informational content (Senthilnath et al., 2014; Wondrade, et al., 2014; Badreldin & Goossens, 2014). The accessibility of remotely sensed images and growing advances in their temporal, spatial, and spectral resolutions continues to provide tools for detecting land use changes at different scales. Multi-Temporal Satellite Images (MTSI) analysis from high temporal resolution remotely sensed images is important to promote better decisions for sustainable management

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of land use. The free of cost of long MTSI of, for example, Landsat and MODIS makes the development and analysis of land use techniques a hot topic in the field of remote sensing. Currently, much attention has been given to land use in order to improve our understanding of the causes and consequences of these changes. Notably, to analyze the possible scenarios of land use change in the future.

This chapter answers this issue to benefit from these informations extracted from MTSI to detect land use changes. Land use is a major issue due to its practical uses in various applications, such as: deforestation, damage assessment, disasters monitoring, urban expansion, planning, and land management. Accurate and up-to-date land use data is necessary to understand and assess the change. This issue was addressed in several research papers and tacked from different points of view (Coppin et Bauer, 1996; Veldkam & Lambin, 2001 Coppin, et al., 2004 Badreldin & Goossens, 2014; Halmy et al., 2015). Consequently, two significant challenges stand out. First, methods must allow change detection for nonstationarity in MTSI. Secondly, methods must build a prediction system to predict future state of land use. The aim of land use changes prediction is to predict and analyze the future scenario for land use. Predictive models comprise a variety of methods based on statistics and data mining that analyze current and historical data to make a prediction about future events. Generally, predictive analytics can help experts to understand land use change, to identify unpredicted opportunities and to anticipate changes before they happen. Over the last decades, a variety of methods have been developed for change prediction using remotely sensed images such as neural networks (Li & Yeh, 2002; Basse et al.,, 2014), decision trees (Bui et al., 2015; Bouatay et al., 2014), Markov models (Viovy & Saint, 1994; Salberg, et al., 2011; Shen et al., 2013; Leite et al., 2014), multi-agent systems (Parker et al., 2003; Hosseinali & Alesheikh, 2014), statistical models (Faghih-Imani et al., 2014; Rosà, et al., 2014) and evolution model (Boulangeat et al., 2014 ; Riordan and Rundel, 2014).

The most generic schema of land use prediction (as shown in Figure 1) (Halmy et al., 2015), considers as input a sequence of satellite images, which describe a geographical area (e.g. vegetation, urban) at different times. Comprises broadly speaking:

1. Pre-process images,
2. Extract interest area,
3. Calculate and normalize attributes and
4. Build prediction model.

This chapter addresses the use of Hidden Markov Model (HMM) in prediction of land use change. In fact, HMMs have been widely used in change prediction in MTSI under stationarity hypothesis. Two problems in implementation of predictive analytics give off the following items:

Figure 1. Generic system for land use prediction changes using MTSI