Chapter 28
Application of Artificial Neural Computation in Topex Waveform Data:
A Case Study on Water Ratio Regression

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ABSTRACT

Using the TOPEX radar altimeter for land cover studies has been of great interest due to the TOPEX near global coverage and its consistent availability of waveform data for about one and a half decades from 1992 to 2005. However, the complexity of the TOPEX Sensor Data Records (SDRs) makes the recognition of the radar echoes particularly difficult. In this article, artificial neural computation as one of the most powerful algorithms in pattern recognition is investigated for water ratio assessment over Lake of the Woods area using TOPEX reflected radar signals. Results demonstrate that neural networks have the capability in identifying water proportion from the TOPEX radar information, controlling the predicted errors in a reasonable range.

INTRODUCTION

Cognitive informatics (CI), a multidisciplinary study combining both modern pattern recognition technologies and biological neuropsychology theories to simulate the brain functions in information processing has significantly improved the learning capability of human being (Wang, 2003). As one of the kernel methods in CI, artificial neural computation has been successfully performed to solve many complicated information learning problems (Shi and Shi, 2003; Cai and Shi, 2003; Yaremchuk and Dawson, 2008, *etc*.). Moreover,

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neural networks has been widely applied in signal processing and recognition (Kinsner, *et al*., 2003; Pernkopf *et al*., 2009, *etc*.). Our study focuses on information learning process of the TOPEX radar signals by artificial neural computation approaches, which shows importance of CI technologies in practice for different scientific studies.

The TOPEX Radar Altimeter Satellite was launched in October 1992 by National Aeronautics and Space Administration (NASA) and French Space Agency Centre National d'Etudes Spatials (CNES). The platform of the TOPEX allows a better monitoring of ocean dynamics by providing more accurate sea level estimate with the Root Mean Square Error (RMSE) about 2.7 cm (Zieger, et al., 1991; Fu & Cazenave Eds., 2001). The satellite carries dual bands, C-band (5.3 GHz) and Ku-band (13.6 GHz) and is operated on the orbit at 1334±60 km with an inclination within 62° to 67°. The principle of the TOPEX Altimeter is to determine the range R from the sensor to the sea surface based on the overall travel time of microwave pulses with known magnitude transmitted from the sensor towards the sea surface and then reflected back to the sensor.

Although Topex Radar Altimeter was initially designed for study of Sea Surface Height (SSH), the massive data with wide coverage from latitude 66 S to 66 N and the short repeat cycle of 10 days for about 15 years can provide substantial useful information to other studies. For example, recent studies (Birkett, 1998; Birkett, 2000; Campos et al., 2001; Jekeli & Dumrongchai, 2003) have successfully demonstrated promising potentiality of the TOPEX Altimeter in detecting water level fluctuation of inland lakes and wetlands. Besides water areas, research highlighted that The TOPEX Altimeter could also be applied to examine land surfaces. For instance, Papa et al. (Papa, 2002) used the TOPEX Altimeter σ^0 (backscattering coefficient) data and successfully estimated depth of snow pack over the Northern Great Plains of the United States; Papa et al. (2003) produced the first continental σ^0 maps from the TOPEX Altimeter and discovered interesting patterns of σ^0 values corresponding major land cover types globally. In addition, the TOPEX Altimeter can also provide great insight to rain rate estimate (Varma, et al., 1999). Hence, there are great incentives to explore capabilities of the TOPEX Altimeter further, especially in the aspect of imaging ground surfaces such as land cover. One of the most important hydrological applications in such areas is to estimate water proportion within the TOPEX footprints over land surfaces. If feasible, TOPEX data can be widely applied and extended into many other research fields such as inland lake hydrology, land change estimation, flood assessment, and etc.

However, it becomes particularly difficult to conduct water ratio estimation using data from the TOPEX Altimeter. The major factors that complicate the process include: (1), the single value of σ^0 of each ground footprint from the TOPEX Altimeter is not sufficient to identify different land cover types; (2), due to the fact that returned radar waveforms contain tremendously mixed information the data are too complex to be readily utilized as imagery data; (3), different radar reflectivity for variant land cover types and interaction of signals with terrain relieves and roughness interfere echoes received by the sensor, which, however, is not problematic for oceans as water is the only and an excellent reflector and waves on sea surfaces are assumed to follow Gaussian distributions (Fu and Cazenave Eds., 2001). Therefore, theoretical models are intractable for land surfaces. Furthermore, sizes of ground footprints of the TOPEX Altimeter are variable and depend on terrain.

Instead of relying upon theoretical models for water ratio derivation, this article examines modern pattern recognition algorithms for solution. Modern pattern recognition approaches are often powerful in discovering meaningful patterns from massive and complex dataset. In fact, machine learning algorithms such as Neural Networks have been successfully used as classification and

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