Chapter 8

An Approach to Improve Bayesian Inference in Assessment of Coast Evolution

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ABSTRACT

The chapter reports the state of the art in the modeling of coastal environments by the method of event bush. This method appears to be an efficient alternative to highly subjective conceptualizations used in the databases that provide data for probabilistic assessment of evolution of the coast. The event bushes themselves may be used for Bayesian computation, but there emerge complications that pose intriguing theoretical tasks. Still, their application requires deep conceptual rethinking of the field of knowledge including both the terminology and concepts traditionally accepted in it.

INTRODUCTION AND MOTIVATION

Shoreline evolution in the coastal zone has received much attention due to the increasing presence of numerous assets of social and economic nature in these areas and because of uncertainties about the actual consequences of future sea level rise. Many factors are involved in causing shoreline changes in the coastal zone: waves, currents, winds, sea level changes. All these may mobilize available sediments leading to morphological changes in the coastal zone. Because of the complex interactions between all factors involved in shoreline mobility at various time and space scales, finding out the relative importance of each process in causing sediment and shoreline mobility is still a challenge.

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This issue can be approached quantitatively – e.g., by developing indices that aim to aggregate factors such as sea level rise, coastal elevation, historical shoreline movement, geology, geomorphology, wave height, tide range, beach slope, vegetation, and coastal defenses (e.g., Gornitz et al., 1994; Shaw et al., 1998; Coelho et al., 2006). However, evaluation of the relative importance of each factor is still a challenge. To meet it, the Bayesian approach was applied in the coastal studies (Hapke and Plant, 2010; Gutierrez et al., 2011; Plant and Holland, 2011).

In particular, Gutierrez et al. (2011) proposed investigating this issue through the exploration of large coastal databases. They modeled the relations between shoreline mobility and the factors causing it in a Bayesian Belief Network (BBN; Jensen, 2001). In their study, sea level was found the most important cause for shoreline evolution at the eastern coast of the USA. A similar study was undertaken in Europe (Yates and Le Cozannet, 2012), using the Eurosion dataset (Eurosion, 2004). In that study, the most important parameter to explain the shoreline migration was coastal geomorphology. Le Cozannet et al. (2012) investigated the causes of this discrepancy and found that the values of relative importance of the indices largely depend on the conceptualization (data model) accepted in a dataset used to compute the indices.

The problem was aggravated by the fact that these coastal databases had been developed for other purposes. Thus, in Europe, the Eurosion (2004) dataset was collected throughout European Union member state institutions in charge of shoreline surveys in order to provide authorities with homogeneous statistics and GIS data on the coastal zone of Europe. The data model of the GIS dataset was the same as in the previous ‘Corine Coastal Erosion’ dataset, which was released in 1990. Incidentally, this database became the only European scale-complete dataset available for applying the data exploration method developed by Gutierrez et al. (2011) in Europe.

However, to improve the situation, one should abstract from indices and look at the relationships between real “actors” of the coastal environments – sea, coastal sediments and rocks, coastal landforms, winds, and others. The data model should desirably be a conceptual, or qualitative, model of a natural system (e.g., coast). Then, if at least basic relationships in this system are understood in a more or less uniform way by different scientists building the databases, the data models they use would not be contradicting. Nonetheless, in regard of the coast, this reasonable point immediately brings another hindrance that has got no methodological solution so far, to the authors’ knowledge. Existing methods of building data models, essentially the ER (entity-relationship) diagrams of Pin and Chen (1971), express the relationships between static objects, and so does the whole database theory (Codd, 1970). Description of processes can be made only indirectly and implicitly, via an ensemble of properties related to each other and to time, and inevitably leads to ambiguity. Still, coastal systems are highly dynamic, and this urges us to look for another tool to formally and qualitatively express the processes operating in the coastal zone.

This task seems to fall in the scope of a method of knowledge engineering proposed specially to describe changing geoenvironments, the event bush (Pshenichny and Kanzheleva, 2011).

Behncke and Pshenichny (2009) suggested that the event bush could serve as an intermediary method between expert elicitation and event description based on Bayesian networks. Here, we present the first application of the event bush formalism for modeling the coast behavior. Using this preliminary result, we question if the event bush can help improving data model of coastal databases.