ARTMAP ARTIFICIAL NEURAL NETWORKS WITH FUZZY LOGIC. THEIR APPLICATION TO STUDY THE WAVE CONDITIONS AT SINES PORT, PORTUGAL

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1. Introduction

Coastal zones are very attractive regions for human settlement. Associated to man's occupation of these areas is the attempt to minimize the natural hazards, with structures being designed to ensure quality of life and safety to neighboring populations. Dornelles (2007) showed that protection structures such as dikes, dams, polders, jetties, breakwaters, spurs, etc., are always designed for a particular return period of wave or flood events, and for situations beyond the projected period, losses are amplified because in the "protected" areas the occupation is intensified due to the false perception that sea waves or flooding will never reach that region.

So, the knowledge of the local wave climate is essential for a more supported coastal management. In order to meet these needs it is important to uprightly simulate real cases for the planning of current or emergency situations. Numerical hindcast and wave propagation models represent a powerful tool to address problems in coastal engineering and in environmental studies, such as water management. They give an important contribution in this context, due to their quickness, flexibility, and wide application range. Although these characteristics allow the easy simulation of several scenarios, the models are computationally demanding and have their own limitations because they cannot simulate all physical phenomena present in the complex process of generation, propagation and dissipation of waves from offshore to the coastline. Physical modeling can analyze these phenomena, but it is expensive, time consuming, requires very specific infrastructure and equipment and a high experience by those performing the tests and analyzing their results. Therefore, it has been demonstrated (Londhe and Deo, 2004) that techniques based on Artificial Neural Networks have been taken up with great approval by their users. These network tools have proven very useful in the practice of engineering, but still have limitations mainly related to the lack of generalization. Thus, this paper presents the application of ARTMAP Artificial Neural Networks, with Fuzzy Logic techniques, to try to excel the complexity of wave prediction models.

2. ART Artificial Neural Networks

Several types of ANNs have been proposed for different kinds of application. A quite popular ANN in the field of pattern recognition is a multi-layer network using the back-propagation learning algorithm. But, once trained, if a new example is presented, on its own, to the network, previous information may be lost in the process. Carpenter et al (1987) showed that the ART (Adaptive Resonance Theory) networks seem to satisfactorily meet these requirements. FAM (Fuzzy ARTMAP) model development, illustrated in Figure 1, allowed adaptation of ARTMAP network for using analog patterns both of input and output. The Fuzzy ARTMAP network is a generalization of the binary ARTMAP network. It is capable of incremental supervised learning, updating itself during operation without "forgetting" what has learned previously.

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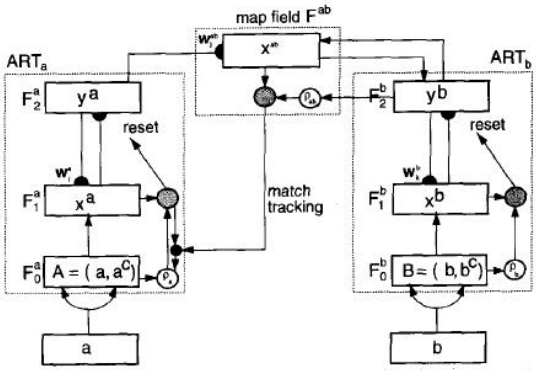

Figure 1. Adapted model of Fuzzy ARTMAP (CARPENTER et al., 1992).

3. Study Area and Methodology

The Port of Sines is located on the Southeast of Europe, on the west coast of Portugal, 58 nautical miles south from Lisbon, on the cross of the main international maritime routes – East-West and North-South (Figure 2). The offshore wave height and period from the wave buoy were used as input values, whereas the output values were the wave height and period, respectively, determined at the coast by using the SWAN model. The network was trained with a data period of one year (2010), approximately 3,000 values. Subsequently, a test was performed for a few random months included in the spring, summer, autumn and winter.

Figure 2. Port of Sines.

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