

Chapter 3.20

Hybrid System with Artificial Neural Networks and Evolutionary Computation in Civil Engineering

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ABSTRACT

This chapter proposes an application of two techniques of artificial intelligence in a civil engineering area: the artificial neural networks (ANN) and the evolutionary computation (EC). In this chapter, it is shown how these two techniques can work together in order to solve a problem in hydrology. This problem consists on modeling the effect of rain on the runoff flow in a typical urban basin. The ultimate goal is to design a real-time alarm system for floods or subsidence warning in various types of urban basins. A case study is included as an example.

INTRODUCTION

The advances in the field of artificial intelligence keep having strong influence over the civil engineering area. New methods and algorithms are emerging that enable civil engineers to use computing in different ways. One of them is in the area of hydrology.

Hydrology is the science that studies the properties of earth's water movement in relation to land. A river basin is an area drained by rivers and tributaries. Runoff is the amount of rainfall that is carried away from this area by streams and rivers. In the study of an urban basin, the streams and rivers are replaced by a sewage system. An

urban basin is influenced by the water consumption patterns of the inhabitants of a city.

The modeling of runoff flow in a typical urban basin is that part of hydrology which aims to model sewage networks. It aims to predict the risk of rain conditions for the basin and to sound an alarm to protect against flooding or subsidence. The goal of the engineers is to build a completely autonomous and self-adaptive system which makes real-time predictions of changing water levels, complemented with alarms that can alert the authorities to flooding risks.

This chapter proposes the application of two techniques of artificial intelligence in hydrology: artificial neural networks (ANNs) and evolutionary computation (EC). We show how these two techniques can work together to solve a problem, namely for modeling the effect of rain on the runoff flow in a typical urban basin. The ultimate goal of this chapter is to design a real-time alarm system for floods or subsidence warning in various types of urban basins. Results look promising and appear to offer some improvement for analysing river basin systems over some other methods such as unitary hydrographs.

BACKGROUND

Description of the Problem

The problem involves measuring and predicting the rain-based flow of a typical urban basin by means of a sensor located in the city sewer. Two signals are used for modeling: The first one comes from a rain gauge which measures the quantity of rain, and the second one measures the flow level in the sewer. Both the signal corresponding to the flow and the one which corresponds to the pluviometer have been sampled at five-minute intervals.

Then, the *research considers the rainfall* runoff transformation a clear case in which one of the variables (rainfall) is transformed into another one

(flowing discharge through a sewer). The transference function involves different conditions, like street slopes, irregular pavement surfaces, roof types, and so forth. These conditions make it impossible to define an equation capable of modeling the course of a drop of water from the moment it falls to the instant in which it enters the drain network, because the course of water through the network is quite complex.

There are several methods for calculating the rainfall runoff process (Viessmann et al., 1989). Some methods are based on the use of transfer functions, usually called “unit hydrographs,” and are sanctioned by experience. Other methods are based on hydraulic equations whose parameters are fixed by the morphologic characteristics of the study area (cinematic wave). Commercial packs for calculating sewage networks usually provide both “unit hydrographs” and “cinematic wave” modules.

The use of forecast methods not based on physics equations, such as ANN and genetic programming (GP), is becoming widespread in various civil and hydraulic engineering fields. The process we are dealing with is particularly apt for this kind of calculation.

Artificial Neural Networks

An artificial neural network (ANN) (Lippmann, 1987; Haykin, 1999) is an information-processing system that is based on generalizations of human cognition or neural biology and are electronic or computational models based on the neural structure of the brain. The brain basically learns from experience. There are two types of ANN, the first one with only feedforward connections is called feedforward ANN, and the second one with arbitrary connections without any direction, are often called recurrent ANN (RANN). The most common type of ANN consists of different layers, with some neurons on each of them and connected with feedforward connections and trained with the backpropagation algorithm (Johansson et al., 1992).

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