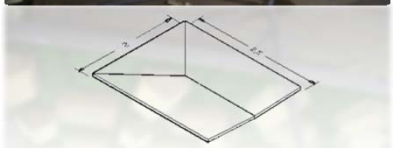
PREINCO. Genetic Programming for the water flow and solids transport prediction.

Introduction

In many fields of Civil Engineering the most common way of designing models and structures is application of the laws of physics; experimentation, trial resulting data for their study and validation of the results are the following steps. However, the AI advances have had strong influence on different areas of Civil Engineering, as engineers can use these techniques in several ways and in very different problems. The present work shows the application of Genetic Programming to Hydrology, and more specifically to the modelling of water flow, generated after a rain event, in a given basin.



Once the water flow prediction has been obtained, the following step is the prediction of the solids transport and its quantity through the river basin. These predictions are very important in the field of Civil Engineering because they serve to predict flooding and the times that exist since a spilling is produced until a fixed concentration reaches to a downstream point (for example, a town with inhabitants).

One of the most important processes in Hydrology is the so-named “Rainfall-Runoff transformation process”, meaning the process in which the rain fallen over an area concentrates and runoff-flows over the surface. In the field of Civil Engineering there are currently several methods based on mathematical equations for modelling the rainfall-runoff process; some of them are the Hydraulic Equations and the Unit Hydrographs. Actually, there is not any method that allows obtaining with reliable results the solids quantity that is transported through the river water flow in case of predicting the pollutant transport when a spilling is produced.

Problem description

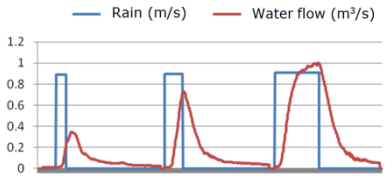
In the Centre of Technological Innovations in Construction and Civil Engineering of A Coruña (CITEEC) there is a physique model (to scale) of a basin to be able to study the behavior of the rain fallen transformation and its water flow that was generated as well as the solids transport in the water flow.

This model to scale simulates a basin where rain events can be produced and the water flow that is generated is measured. It can be also added a solid quantity in suspension to the model and it can be studied its transport in the water flow that has been generated. With the obtained data, and using the GP, we can obtain a mathematical expression that predicts the behavior.

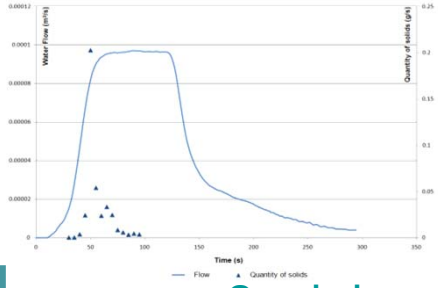
GP Configuration

	Water flow prediction	Solids transport prediction
Population size	1000	1000
Crossover rate	90%	85%
Mutation rate	5%	10%
Selection algorithm	tournament	tournament
Parsimony level	0.0001	0.000001
Variables	P(t), P(t-1), P(t-2), P(t-3), P(t-4), P(t-5), P(t-6)	Q(n)
Constants	10 random values between -3 and 3	10 random values between -1 and 1
Operators	+, -, *	+, -, *, /

Water flow generated by rain



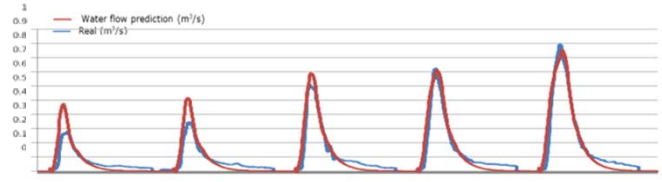
Parameter	Value
Flow input:	0.082 l/s
Duration:	92.15 seconds
Rainfall:	235 mm/h
Sediment concentration:	0.02 g/cm²
Sediment type:	White sand



Results

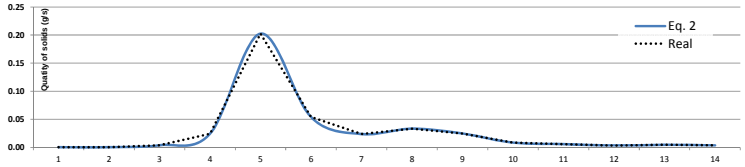
Water flow prediction

$$Q(t) = 0.0251 * P(t) - 0.083 * P(t-1) + 0.1 * P(t-2) - 0.068 * P(t-3) + 0.0651 * P(t-4) - 0.054 * P(t-5) + 0.0051 * P(t-6) + 2.818 * Q(t-1) - 2.662 * Q(t-2) + 0.784 * Q(t-3) + 0.105 * Q(t-4)$$



Solids transport prediction

$$Y(t) = \frac{Q(t) - (Y(t-2) * Y(t-1))}{Y(t-5)} * [Q(t) - Y(t-1) * Y(t-2) - Y(t-2)^2 - 0.0119 * Y(t-1)] - [(Q(t) - Y(t-5) - Y(t-2) * Y(t-1) - 0.8228 * Y(t-2) + Y(t-1)^2) * (Y(t-3) + Y(t-1) + 0.0119)]$$



Conclusions

The results achieved by GP when modelling the runoff flow of an artificial basin by using a mathematical expression shows that they have a satisfactory performance.

Once the water flow prediction is achieved, and it is known the quantity of spilled pollutant in such water flow, it is also possible to model and predict the pollutant transport through the basin.

The modelling of the solids transport process through a mathematical expression obtained using Genetic Programming produces very good results. This means a new advance in the field of Civil Engineering because, until now it did not exist any model or system that allow obtaining this type of results in terms of a mathematical equation and in a satisfactory way.

Acknowledgment

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