



College of Engineering, Mathematics and Physical Sciences

**INTELLIGENT COMPUTATIONAL SOLUTIONS
FOR CONSTITUTIVE MODELLING OF MATERIALS
IN FINITE ELEMENT ANALYSIS**

Submitted by

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ABSTRACT

Over the past decades simulation techniques, and in particular finite element method, have been used successfully to predict the response of systems across a whole range of industries including aerospace, automotive, chemical processes, geotechnical engineering and many others. In these numerical analyses, the behaviour of the actual material is approximated with that of an idealised material that deforms in accordance with some constitutive relationships. Therefore, the choice of an appropriate constitutive model that adequately describes the behaviour of the material plays an important role in the accuracy and reliability of the numerical predictions. During the past decades several constitutive models have been developed for various materials.

In recent years, by rapid and effective developments in computational software and hardware, alternative computer aided pattern recognition techniques have been introduced to constitutive modelling of materials. The main idea behind pattern recognition systems such as neural network, fuzzy logic or genetic programming is that they learn adaptively from experience and extract various discriminants, each appropriate for its purpose.

In this thesis a novel approach is presented and employed to develop constitutive models for materials in general and soils in particular based on evolutionary polynomial regression (EPR). EPR is a hybrid data mining technique that searches for symbolic structures (representing the behaviour of a system) using genetic algorithm and estimates the constant values by the least squares method. Stress-strain data from experiments are employed to train and develop EPR-based material models. The developed models are compared with some of the existing conventional constitutive material models and its advantages are highlighted. It is also shown that the developed EPR-based material models can be incorporated in finite element (FE) analysis. Different examples are used to verify the developed EPR-based FE model. The results of the EPR-FEM are compared with those of a standard FEM where conventional constitutive models are used to model the material behaviour. These results show that EPR-FEM can be successfully employed to analyse different structural and geotechnical engineering problems.

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