Chapter 6
Genetic Programming Applications in Solving Engineering Problems

ABSTRACT

This chapter explains how to use genetic programming to solve various kinds of problems in different engineering fields. Here, three applications, each of which relevant to a distinct engineering field, are explained. First, the chapter starts with the GP application in mechanical engineering. The application analyzes the use of GP in modelling impact toughness of welded joint components. The experimental results of impact toughness represent the input data to build GP models of each welded joint component individually. The second part of the chapter shows how two recent versions of GPdotNET can be satisfactorily used for a binary classification-prediction problem in civil engineering. This application puts forward a new classification-forecasting model, namely binary GP for teleconnection studies between oceanic and heavily local hydrologic variables. Finally, the third application demonstrates how GP could be applied to solve a time series forecasting problem in the field of electrical engineering.

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APPLICATION 1: THE APPLICATION OF GENETIC PROGRAMMING IN MODELLING IMPACT TOUGHNESS OF WELDED JOINT COMPONENTS

Introduction to Impact Toughness Testing

Bend testing with impact force effect on notched specimens can provide an explanation of the behavior of materials under obstructed strain, i.e. the spatial stress state. Determination of work needed for fracture under specified test conditions is commonly used for the current quality control and homogeneity of the material, as well as its processing. This testing procedure can determine the tendency to brittle fracture or a tendency towards increased brittleness during exploitation (Viehring, 2002). The impact energy experimental results obtained by testing the general structural steel S235 JG were used for the application of genetic programming in modeling impact toughness of welded joint components. V-notched specimens were tested at different temperatures on instrumented Charpy pendulum. This examination enabled separation of the total impact energy on the components, crack initiation energy and crack propagation energy. The experimental results of impact toughness represent the input data for the development of mathematical models of each welded joint component. Mathematical models of impact toughness were built using genetic programming, GP. Statistical analysis and comparison for GP models with the correspondent regression models was performed. Mathematical models obtained using GP provide a good basis for a quality and reliable planning of experimental research, with the aim of obtaining the relevant data in the entire process of determining fracture mechanics parameters (Hrnjica, 2014).

Impact testing of specimens of the base material (BM), weld metal (WM) and the heat affected zone (HAZ), was performed according to standard EN 10045-1 (EN-10045-1:1990, 1990) and ASTM E23-02 (ASTM-Standard-E23, 2002), on specimens whose geometry and layout are given in Figure 1, in order to determine the overall impact energy.

During bend impact loading, fracture energy is defined as an integral value. Such defined fracture energy does not allow the separation of the material resistance from the initiation and crack growth. In order to achieve this, impact force and time need to be recorded continuously during the testing, which is enabled with the instrumentation of the pendulum. Scheme of the modern instrumented pendulum is given in Figure 2.

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