Chapter 11
Medical Applications of Cartesian Genetic Programming

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11.1 Introduction

Evolutionary algorithms have been used in medical applications since they were first developed some 30 years ago. Although often regarded as a theoretical pursuit, research on and development of a wide range of real-world applications of genetic and evolutionary computation (GEC) has long been evident at conferences and in the scientific literature. Medicine and healthcare is no exception and this challenge, and worthy aim, has motivated many to apply GEC to a wide range of clinical problems.

This chapter presents examples of CGP applied to the diagnosis of three medical conditions: breast cancer, Parkinson’s disease and Alzheimer’s disease.

11.2 CGP Applied to the Diagnosis of Breast Cancer

Breast cancer is one of the leading causes of death in women in the western world. In 2007, some 46,000 new cases were detected in the UK alone, and 12,000 women died in 2008 as a result of the disease, making it the most common cancer in women and the second most common cause of death through cancer. The number of breast cancer-related deaths has fallen since screening programmes were introduced in 1988. Nonetheless, it is predicted that one in nine women will develop breast cancer at some point during their life [1]. The detection of breast cancer in the early stages of the disease significantly increases the survival rate of patients. The main method for screening patients is the mammogram, a high-resolution X-ray image of the breast [2]. The process of identifying and evaluating signs of cancer from mammograms is a very difficult and time-consuming task that requires skilled and experienced radiologists. This assessment is also, by its nature, highly subjective and susceptible to error, leading to cancers being missed and patients misdiagnosed. To achieve a more accurate and reliable diagnosis, computer aided detection (CAD)
systems have been investigated which provide an objective, quantitative evaluation. CAD systems have the potential to help in two main ways: (i) the detection of suspicious areas in the mammogram that require further investigation, and (ii) the classification of such areas as cancerous (malignant) or non-cancerous (benign) [3].

Two powerful indicators of cancer that are commonly used in evaluating mammograms are known as masses and microcalcifications. Masses (see Fig. 11.1) are the larger of the two indicators and can be either benign or malignant. Characteristics such as the border and the density of the mass, which is greater for malignant examples, can be used for classification. Traditionally, masses are more difficult to classify than microcalcifications. Microcalcifications are, essentially, small calcium deposits which occur as the result of secretions from ductal structures that have thickened and dried. They can have a great variety of mostly benign causes, but might also be an indication of malignancy. They are fairly common in mammograms and their appearance increases with age, so that they can be found in 8% of mammograms of women in their late 20s and in 86% of mammograms of women in their late 70s [4]. Microcalcifications that indicate malignancy are usually less than 0.5 mm in size and are often grouped into clusters of five or more (see Fig. 11.2). Any calcification larger than 1 mm is almost always benign (see Fig. 11.3) [4].

Fig. 11.1 An example of a speculated mass [5]. Image courtesy of the Radiology Assistant, www.radiologyassistant.nl

Over the past 20 years, there has been much research into the application of CAD to breast cancer, with numerous different approaches being exploited, and many of these involve image analysis of the digitized mammogram. A typical approach is to use a pattern recognition scheme that employs sensing, segmentation, feature extraction, feature selection and classification, to isolate and then characterize a feature of interest [6]. Each stage of this processing is a potentially complex operation requiring much investigation. Evolutionary algorithms and, in particular, genetic algorithms, have previously been used with some success in CAD of breast cancer, but