Chapter XXX
Machine Learning for Designing an Automated Medical Diagnostic System

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ABSTRACT

This chapter describes the application of machine learning techniques to solve biomedical problems in a variety of clinical domains. First, the concept of development and the main elements of a basic machine learning system for medical diagnostics are presented. This is followed by an introduction to the design of a diagnostic model for the identification of balance impairments in the elderly using human gait pattern, as well as a diagnostic model for predicating sleep apnoea syndrome from electrocardiogram recordings. Examples are presented using support vector machines (a machine learning technique) to build a reliable model that utilizes key indices of physiological measurements (gait/electrocardiography [ECG] signals). A number of recommendations have been proposed for choosing the right classifier model in designing a successful medical diagnostic system. The chapter concludes with a discussion of the importance of signal processing techniques and other future trends in enhancing the performance of a diagnostic system.

INTRODUCTION

Machine learning is the study of algorithms and techniques that allow computers to "learn." It refers to an intelligent system that makes decision based on the autonomous acquisition and integration of knowledge from accumulated experience contained in successfully solved cases, analytical observation, and other means. A machine learning system uses many different mathematical methods for exploiting the computational power of a computer. In many professional fields, good tests and measurements may be available, but methods of applying this information to solve a problem may be poorly understood. Physicians, for instance, are always searching for the best possible measures to

make a particular diagnosis at a very early stage. From a medical diagnostic system design perspective, there are several reasons why there has been a considerable interest in machine learning systems. The argument in favour of learning systems is that they have the potential to discover new relationships among concepts and hypotheses by examining the record of successfully solved cases. In biology and medicine, where expertise in understanding the complex physiological functions is limited, these learning systems may aggregate knowledge that has yet to be formalized. In this chapter, we confine our attention to the most prominent and basic learning task, that is, *classification*.

As illustrated in Figure 1, the fundamental goal of the machine learning system is to extract the generalized decision rules from sample data that will be applicable to new data. Then the learning system can be viewed as a classifier that produces a decision for new data to be classified. A typical learning system is designed to work with a classifier model such as a neural network, support vector machines, or a discriminant function. Learning helps to choose or adapt parameters within the model structure that work best on the samples at hand. For example, in medical diagnosis, the physician has observations and test results, and the objective is to pick the correct diagnosis. The objective of the machine learning algorithm is to customize the classifier structure to the specific diagnosis by finding a general way of relating any particular pattern of symptoms to one of the specified diseases or conditions.

Machine learning systems have found many valuable applications in early diagnosis of diseases so that appropriate intervention can be exercised to achieve better outcomes (Begg & Palaniswami, 2006a; Ifeachor, Sperduti, & Starita, 1998; Teodorrescu, Kandel, & Jain, 1998). As biomedical diagnostic systems are becoming more specialized and complex, they adapt to new methods, instrumentation, and assay technologies that were originally developed for other applications; for example, defense, energy, and aerospace have found applications in the medical industry/environment. In this chapter, we will focus on two applications of machine learning approach in designing: (1) a diagnostic system for balance impairments based on human gait signals and (2) a diagnostic system for sleep apnoea syndrome based on electrocardiography (ECG) signals. Needless to say, such systems do not mean to replace the physician from being the decision maker but, rather, they attempt to enhance the physician's abilities to reach a correct decision.

Figure 1. A General overview of a machine learning system for classification
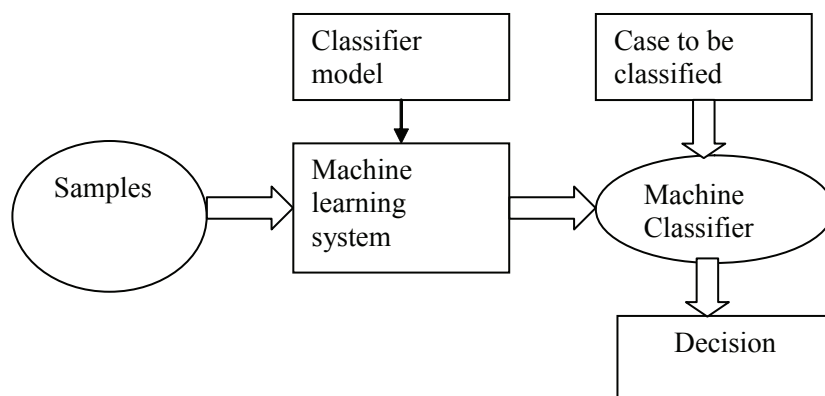
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