Chapter 14
Online Prediction of Blood Glucose Levels using Genetic Algorithm

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ABSTRACT

Diabetes mellitus is one of the most common chronic diseases. The number of cases of diabetes in the world is likely to increase more than two fold in the next 30 years: from 115 million in 2000 to 284 million in 2030. This chapter is concerned with helping diabetic patients to manage themselves by developing a computer system that predicts their Blood Glucose Level (BGL) after 30 minutes on the basis of their current levels, so that they can administer insulin. This will enable the diabetic patient to continue living a normal daily life, as much as is possible. The prediction of BGLs based on the current levels BGLs become feasible through the advent of Continuous Glucose Monitoring (CGM) systems, which are able to sample patients' BGLs, typically 5 minutes, and computer systems that can process and analyse these samples. The approach taken in this chapter uses machine-learning techniques, specifically Genetic Algorithms (GA), to learn BGL patterns over an hour and the resulting value 30 minutes later, without questioning the patients about their food intake and activities. The GAs were invested using the raw BGLs as input and metadata derived from a Diabetic Dynamic Model of BGLs supplemented by the changes in patients' BGLs over the previous hour. The results obtained in a preliminary study including 4 virtual patients taken from the AIDA diabetes simulation software and 3 volunteers using the DexCom SEVEN system, show that the metadata approach gives more accurate predictions. Online learning, whereby new BGL patterns were incorporated into the prediction system as they were encountered, improved the results further.

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INTRODUCTION

One of the most common medical chronic diseases is diabetes mellitus, and in 2000, the World Health Organization, stated that there were at least 171 million people worldwide suffering from diabetes, and that the number was increasing rapidly, and expected to almost double by 2030 (World Health Organization, n.d.). Diabetes is a chronic disease that occurs either when the pancreas does not provide enough insulin or leads to an uncontrolled increase in blood glucose (Type I), or the body cannot effectively use the insulin it produces, typically because of excess body weight or physical inactivity (Type II).

Diabetic patients are predisposed to many complications associated with their disease and these may results in hospitalisation, permanent disabilities, and death. These complications may be classified as acute (quick manifestation and correctable) or chronic (taking years or decades to develop). Acute complications include hypoglycemia, hyperglycemia, and diabetic ketoacidosis (DKA), while macrovascular (atherosclerosis) and microvascular (nephropathy, neuropathy, and retinopathy) diseases are the most common chronic complications.

People with diabetes have an important role in their own medical care, and self-glucose monitoring is an opportunity for people with diabetes to take control of their health and wellbeing. At present, most diabetics monitor their BGLs by sampling a drop of capillary blood, typically from the fingertip, and measuring its BGL with a blood glucose meter (Rossetti, 2008). The stages are shown in Figure 1. First, a lancet is used to prick a finger (2), drawing forth a small droplet of blood (3). The blood is then added to a strip which is either separate or built in to the glucose monitor (4), and finally the glucose monitor then gives a reading of the concentration of glucose in the blood (5).

Recently, several sensors have been developed which allow continuous glucose monitoring (CGM) for several days. These systems are noninvasive or minimally invasive, and in many cases are portable and so can allow their use in patient daily life. Although the clinical validation of some of the CGM devices is still under way, there is a general agreement that in the near future these devices will enable the tuning of appropriate changes in the daily management of diabetes in order to achieve better metabolic control (Medtronic diabetes and health care providers company, 2012) (Dexcom medical device company, 2012) (Abbott Diabetes Care Company, n.d.). A summary of the features of the four CGM systems that are FDA approved is given in Table 1. The BGL is usually shown on a display, and in one case (Dexcom SEVEN System) the BGL data can be downloaded to a PC for computer analysis.

Figure 1. Self BGL monitoring system