Chapter 69
Predicting Hypoglycemia in Diabetic Patients Using Time–Sensitive Artificial Neural Networks

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ABSTRACT

Type-One Diabetes Mellitus (T1DM) is a chronic disease characterized by the elevation of glucose levels within patient's blood. It can lead to serious complications including kidney and heart diseases, stroke, and blindness. The proper treatment of diabetes, on the other hand, can lead to a normal longevity. Yet such a treatment requires tight glycemic control which increases the risk of developing hypoglycemia; a sudden drop in patients' blood glucose levels that could lead to coma and possibly death. Continuous Glucose Monitoring (CGM) devices placed on a patient body, measure glucose levels every few minutes. These devices can also detect hypoglycemia. Yet detecting hypoglycemia sometimes is too late for a patient to take proper action, so a better approach is to predict the hypoglycemic events ahead of time and alarm the patient to such occurrences. In this research, the authors develop a system that involves a special type of Artificial Neural Networks (ANN), the Time-Sensitive ANN (TS-ANN), to predict hypoglycemia events ahead of time and within a prediction horizon of thirty minutes. This period should be long enough to enable diabetic patients to avoid hypoglycemia by taking a proper action. A TS-ANN based system that is able to predict hypoglycemia events have been developed and tested with high accuracy results (average specificity of 98.2%, average accuracy of 97.6% and average sensitivity of 80.19% with a maximum value reaching 93%).

1. INTRODUCTION

Type-One Diabetes Mellitus (T1DM) is a chronic disease characterized by the elevation of glucose levels within patient's blood. Controlling the blood glucose level in diabetic patients and keeping it within the normal range is the biggest challenge facing physicians nowadays (Wach, Trajanoski, Kotanko, & Skrabal, 1995). The improper control of diabetes can lead to many serious complications, including blindness, renal failure and foot disorders to name a few (BOUNDLESS, 2014; Gibbons, & Shaw, 2012). Neverthe-less, tighter glycemic control increases the risk of patients experiencing acute hypoglycemia (Bergenstal et al., 2010). Hypoglycemia is a condition that occurs when blood glucose drops dangerously low. This leads to starving the brain -from glucose- which may result in coma and possibly death (Cryer, 2007). Diabetes Control and Complications Trial (DCCT) concluded in (Diabetes Control and Complications Trial Research Group, 1993) that the occurrence of hypoglycemia is three times higher in intensively treated group of diabetic patients over those of the group receiving standard treatment (Dassau, et al., 2010). For intensive treatment of diabetes, Continuous Glucose Monitoring (CGM) devices are used. These devices are placed on patient body and measure glucose levels every few minutes. The develop-ment of CGM devices is considered a breakthrough in diabetes treatment and management field, due to the wealth of useful information they supply to the diabetic patients and their doctors (Georga, Fotiadis, & Protopappas, 2011).

During the last decade there has been an explosion of interest in medical machine learning, due to the trillions of data elements collected from patients and stored in databases, yet not being effectively utilized (Canlas, 2009). Moreover, machine learning techniques proved their effectiveness in many fields including medicine (Barakat, & Bradley, 2010; Canlas, 2009; Patil & Kumaraswamy, 2009). The study presented in this paper aims at developing a machine learning based system suitable for predicting future occurrence of hypoglycemic events within a prediction horizon of thirty minutes. The prediction is carried out using the recent history of CGM subcutaneous glucose measurements, simulated rate of appearance of glucose in plasma following a meal intake, and simulated plasma insulin after administer-ing subcutaneously infused insulin. Our study, presented in this paper, follows the case study technique, namely, the study starts with collecting data from Type-1 diabetic patients, analyzing the data, and then generating the results (highly accurate prediction of future hypoglycemic events).

In this paper, section II reviews recent research on glucose and hypoglycemia predictions in Type-1 diabetic patients. Section III, on the other hand, presents some background information about machine-learning and in specific Artificial Neural Networks and their use as predictors. Section IV describes our proposed prediction system. Section V discusses the results obtained from applying such a model to a group of type-1 diabetic patients, and finally, section VI presents some concluding remarks.

2. STATE OF THE ART IN GLOCUSE AND HYPOGLYCEMIA PREDICTION

During the last decade, plenty of research efforts went into developing machine learning algorithms suit-able for predicting events in the healthcare field. Two types of research can be identified, namely, blood glucose predication and hypoglycemic events predication. Both of these research types are presented next.

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