Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 98 (2016) 228 – 235

Procedia Computer Science

The 6th International Conference on Current and Future Trends of Information and Communication Technologies in Healthcare (ICTH 2016)

On-Line Blood Glucose Level Calculation

Tomas Koutny[a]*, Michal Krcma[b], Josef Kohout[a], Petr Jezek[a], Jana Varnuskova[a], Petr Vcelak[a], Jan Strnadek[a]

[a]*The Department of Computer Science and Engineering and/or with the NTIS - New Technologies for the Information Society, University of West Bohemia, Technicka 8, 306 14 Plzen, Czech Republic*
[b]*The 1st Department of Clinic Medicine, Teaching Hospital and Medical School in Pilsen, Charles University in Prague, Alej Svobody 80, 323 00 Plzen, Czech Republic*

Abstract

Diabetes is a silent disease. It is the 8th most common cause of death that does not hurt until it is too late and the disease has developed. Technology plays a vital role in managing diabetes and educating patients about importance of the treatment. The patient must be able to manage his blood glucose level. However, blood glucose level is measured sporadically as it causes important discomfort to the patient. Measuring glucose level in subcutaneous tissue is minimally invasive technique and thus considerably comfortable, but this level may be different from blood glucose level. We implemented a recently proposed method of blood glucose level calculation from the continuously measured subcutaneous tissue glucose level. Then, we developed a web portal that makes this method accessible to any doctor's office and any diabetic patient. To the best of our knowledge, we are the very first web portal that does this. In this paper, we describe the portal.

Peer-review under responsibility of the Program Chairs

Keywords: continuous glucose monitoring; blood glucose; glucose modelling; on-line calculation; web portal

1. Introduction

Diabetes is a widespread civilization disease. Specifically, it is a heterogeneous group of diseases, which are characterized by elevated blood glucose level. Elevated blood glucose level chronically damages internal organs, and

* Corresponding author. Tel.: 0-420-377-632-437; fax: 0-420-377-632-401.
E-mail address: txkoutny@kiv.zcu.cz

Peer-review under responsibility of the Program Chairs
doi:10.1016/j.procs.2016.09.037

eventually may lead to death. Diabetes is the 8th most common cause of death according to WHO fact sheet N°310. In addition, diabetes is a silent disease that does not hurt nor manifests itself until it is too late and the disease has developed. Approximately, 20% of diabetic patients need to dose insulin to manage their blood glucose level. Especially, type-1 diabetic patients would die shortly without it. In such a patient, autoimmune reaction has destroyed beta-cells of pancreas, which produce insulin.

Glucose is primary source of energy for cells of living animals. Glucose and lipids are energy stores for the body. Fructose, glucose and galactose are final products of carbohydrate digestion, whereas glucose has circa 80% share of these. Once absorbed from the intestinal tract, liver rapidly converts fructose and galactose into glucose[1]. Liver cells store excessive glucose as a glycogen. Glycogen is a multi-branched polysaccharide of glucose. It serves as a secondary, long-term energy storage. When blood glucose level is low, liver breaks glycogen down into glucose. Then, glucose gets from liver cells into blood. Most cells are capable of storing at least some glycogen. Most notably, glycogen is stored in liver cells (5-8% of their weight) and muscle cells (1-3% of weight)[1]. However, brain cannot synthetize nor store glucose for more than a few minutes supply. It is dependent on continuous supply of glucose from blood[2]. Therefore, we are concerned about the blood glucose level. Simply speaking, we cannot care about the patient in the long-run, if we cannot prevent an acute risk of death, e.g., due to hypo- or hyperglycemic shock, or a clinically silent diabetic autonomic neuropathy.

There are two major ways to treat type-1 diabetic patients. The first one is a transplantation of beta cells, which is still without a widespread clinical use. The second way is to use technology to dose insulin artificially. Each insulin dose must correspond with current blood glucose level. Otherwise it could kill the patient. Nevertheless, the patients are reluctant to frequently monitor their blood glucose levels as this requires an unpleasant finger stick to draw a drop of blood[3,4]. A motivated patient draws approximately five blood drops a day[5]. A common patient, however, draws only two or three drops of blood a day[6]. Therefore, another technology emerged to allow the patient to monitor glucose level continuously: continuous glucose monitoring system (CGMS).

CGMS comprises a sensor installed in abdominal subcutaneous tissue and a receiver that collects glucose levels, which the sensor measures. It is a minimally invasive technique. It has the requested temporal resolution to substitute blood glucose level measuring, but still lacks of precision and accuracy[7]. While CGMS solves the problem of sporadic blood glucose level measurements, it does not replace them. Inpatient and outpatient studies rely on blood glucose levels[4]. Frequent and accurate reference blood glucose level is key for modeling and computing outcome metrics in clinical trials but difficult, invasive, and costly to collect[7]. Therefore, we are motivated to calculate continuous blood glucose level from CGMS measured glucose levels.

We have already developed a model of glucose dynamics that requires only minimal input data[5-13]. Then, we faced another, innovative issue that we address in this paper - how do we get this model from academy to physicians and diabetics? How do we make the model available in doctor's office? We chose to develop a web portal, where the physician and patient can upload glucose levels of subcutaneous tissue and the portal will calculate a continuous curve of blood glucose level. Then, everyone can access the portal independently on a particular system of continuous glucose monitoring.

In addition, let us stress the potential to educate the patient about importance of continuous glucose monitoring. By showing blood and interstitial fluid glucose levels together, the patient will see how amount of food and its composition, duration and intensity of physical activity, insulin dosage and delay of insulin actions affect his glucose levels. To live a relatively normal life with diabetes, it requires a will to do so and a minimal degree of intelligence to handle all these factors. Anything that helps the patient to manage his blood glucose level easier also prolongs his life. Such a thing is to give the patient a portal to study his glucose levels in the comfort of home, to realize all the complex feedback that affects quality of his life.

2. Related Work

Recently, many software solutions were released to assist diabetic patients with the treatment of their chronic illness. The common idea is to collect as much information as possible about patient's immediate health condition. Typically, it includes current blood glucose level, exercise track, diet, etc. Based on these information, it could automatically alert the patient if the current condition gets worse; e.g., hypoglycemia or hyperglycemia. Then, a