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Context-aware system for glycemic control in diabetic patients using neural networks

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Abstract: Diabetic patients are quite hesitant in engaging in normal physiological activities due to difficulties associated with diabetes management. Over the last few decades, there have been advancements in the computational power of embedded systems and glucose sensing technologies. These advancements have attracted the attention of researchers around the globe developing automatic insulin delivery systems. In this paper, a method of closed-loop control of diabetes based on neural networks is proposed. These neural networks are used for making predictions based on the clinical data of a patient. A neural network feedback controller is also designed to provide a glycemic response by regulating the insulin infusion rate. An activity recognition model based on convolutional neural networks is also proposed for predicting the patient's current physical activity. Predictions from this model are transformed into a six-level code and are fed as input to the neural network glucose prediction model. Experimental results of the proposed system show good performance in keeping blood glucose levels in the nondiabetic range.

Key words: Neural networks, diabetes, closed-loop control, insulin, convolutional neural networks

1. Introduction

Type 1 diabetes, also called diabetes mellitus, is a condition in which the body fails to keep the blood glucose levels within the euglycemic range. Blood glucose (BG) increases (hyperglycemia) for a longer duration of time can increase the risk of kidney failure, heart attack, blindness, etc. In normal or healthy individuals these levels are maintained within normal limits (<154 mg/dL) [1] by insulin secretions from the pancreas. Type 1 diabetes (T1D) usually develops in children and adults due to the destruction of beta cells resulting in insulin deficiency [2, 3]. People with type 1 diabetes require lifelong insulin injections to prevent hyperglycemia for survival. Type 2 diabetes is characterized by hyperglycemia due to insulin resistance, which is believed to occur due to increased weight, stress, and lack of exercise [4, 5]. The most frequently used methods for T1D management are multiple daily injections and insulin delivery via an insulin pump [6–8]. In the last few decades, both glucose sensing capabilities and insulin delivery methods have greatly improved. These technological advancements, along with advancement in computer control systems, have led to the development of a closed-loop insulin delivery system also called an artificial pancreas [9–12]. An artificial pancreas is a system consisting of a continuous glucose monitor (CGM), insulin pump, and control algorithm as shown in Figure 1.

In the literature, many control algorithms have been proposed for the closed-loop control of diabetes [9, 13]. The authors in [14] developed a closed-loop control system that uses continuous glucose measurements and a pump that can deliver both insulin and glucagon. A computer algorithm decides the amount of insulin or glucagon to be delivered based on the blood glucose measurements of a patient. The 27-h experiment conducted

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