Live Demonstration: An IoT Wearable Device for Real-time Blood Glucose Prediction with Edge AI

Lei Kuang†, Taiyu Zhu†, Kezhi Li†⋆, John Daniels†, Pau Herrero† and Pantelis Georgiou†
† Centre for Bio-inspired Technology, Dept. of Electrical and Electronic Engineering, Imperial College London, UK
⋆ Institute of Health Informatics, University College London, UK
Email: {lei.kuang18, taiyu.zhu17}@imperial.ac.uk

***Abstract*—Blood glucose (BG) prediction is crucial to the successful management of type 1 diabetes (T1D) by allowing for proactive medical interventions and treatment. We present an IoT-enabled wearable device for real-time BG prediction based on continuous glucose monitoring (CGM) and a novel attention-based recurrent neural network (RNN). The complete hardware contains a system on a chip (SoC) that enables BLE connectivity and executes the embedded RNN with edge inference. This device can provide 24-hour predictive glucose alerts, i.e., hypoglycemia, to improve BG control and prevent or mitigate potential complications. Meanwhile, it can be connected to desktop computers and smartphones for the visualization of BG trajectories, data storage, and model update.**

I. Introduction

People living with T1D require long-term management to maintain blood glucose levels in a therapeutically range, where real-time BG prediction is a highly useful tool to reduce the risk of undesired glycemic episodes. Recently, deep learning-based algorithms, especially for RNNs [1], have achieved the state of the art in BG prediction [2], but it is difficult to implement them in actual T1D management systems due to high computational complexity. The implementations on smartphone-based and cloud platforms [3] suffer from short batter life, high cost of end devices, lack of portability, and high latency for decision making. Therefore, a low-cost and power-efficient wearable device to provide reliable monitoring and accurate BG prediction is desirable.

In this demonstration, an IoT-enabled wearable device with an embedded RNN for real-time BG prediction is presented, for which a compact hardware design has been manufactured into a PCB board with a buzzer in a size of 35 mm x 30 mm. The device only consumes an average run-time power of 3.78 mW with an operation period around 13 s. Powered by a coin battery (e.g., CR2032, 240 mAh), it can run for six months, which can cover the lifespan of the front-end sensor and wearable transmitter of CGM.

II. Demonstration Setup

Fig. 1 depicts the proposed wearable device in a T1D management system, which comprises the following components:

- **CGM**: An emulator transmits a BG measurement every five minutes to simulate the CGM signal.
- **Wearable Device**: A Nordic BLE SoC nRF52832 (512 KB FlASH and 64 KB RAM) is employed to receive and store CGM data and support edge computing for the pre-trained RNN. Power gating circuitry is used to maintain low power consumption when the device is idle.
- **Smartphone**: A customized GUI to display historical BG trajectories, current CGM measurements, and predictions.
- **Desktop Computer**: A platform for clinicians to analyze collected BG data, update model, backup data to cloud.

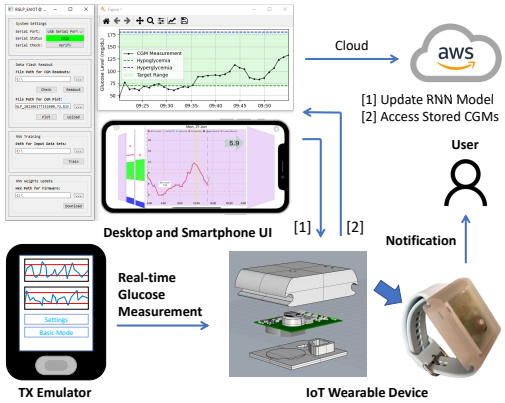

Fig. 1. Overview of the IoT-enabled wearable device in T1D management.

III. Visitor Experience

The demonstration aims to simulate an actual system in T1D management for real-time BG prediction and hypoglycemia warning. The visitor will visualize current CGM measurements, BG predictions and historical trajectories with the smartphone GUI. By adjusting the CGM emulator profile, the user will experience impending hypoglycemic events and receive notifications that generated by buzzing. Using the desktop computer platform, the user can upload data to cloud storage, re-train the RNN, and update model weights.

References

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