Optimizing Glycemic Control in Type 1 Diabetic Patients Using a Deep Learning-Based Artificial Pancreas With a Secure Glucagon and Insulin Delivery System

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While type 1 diabetes (T1D) affects millions worldwide, some individuals may experience rapid fluctuations in their blood sugar levels. These fluctuations can negatively impact an individual’s quality of life and can be dangerous at night, when blood sugar levels may reach dangerously low levels and lead to "Death in Bed" syndrome, which accounts for an estimated 6% of deaths in people with T1D under 40. While challenges relating to hyperglycemia (high blood sugar) have been addressed through insulin pumps, there has been less success with hypoglycemia (low blood sugar) and glucagon administration. To address this gap, an artificial pancreas with a novel insulin and glucagon pump was developed. A Long Short-Term Memory (LSTM) network was trained on the OhioT1DM dataset, which includes Continuous Glucose Monitor (CGM) readings, meal-carb data, and insulin-bolus data. The two-layer LSTM, developed in Python, accurately forecasts blood sugar levels with a root mean squared error of 1.233. An algorithm then utilizes the predictions to calculate optimal insulin and glucagon doses using metabolization formulas. To prevent unauthorized access, data is transmitted through a cloud-based MQ Telemetry Transport server, encrypted with the industry-level Advanced Encryption Standard, and authenticated using HMAC-SHA256. A prototype was constructed with an Arduino Nano, which accurately releases doses. A personalized mobile app enables users to input meal and insulin bolus data while offering additional analytics. By addressing both hypo- and hyperglycemia, this medical device can be a transformative tool for individuals with diabetes, enabling them to live healthier and more fulfilling lives.

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