Designing a Reinforcement Learning Controller for Insulin Delivery in an Artificial Pancreas

Raj, Mark (School: duPont Manual High School)

With the growing prevalence of Type 1 Diabetes (T1D), the complete loss of insulin production among children and adults, the artificial pancreas is becoming increasingly necessary to combat long-term health implications due to extended periods of hyperglycemia. An artificial pancreas—which consists of a constant glucose monitor and an insulin pump controlled by an algorithm that responds to spikes in blood glucose—functions completely hands-free. The key component needed for this device to become an effective treatment option is a sophisticated control algorithm for insulin dosing. With current devices suffering from antiquated PID algorithms, the engineering goal focused on using reinforcement learning (RL), a subset of artificial intelligence (AI), to effectively administer a continuous and responsive dosage of insulin to patients that can be adapted across a varied population. An RL algorithm attempts to maximize "reward" through exploration of the environment and exploitation of learned policies. Beginning with glucose-insulin simulations and data from clinical diabetes patients in critical care, the most sensitive parameters for glucose levels were determined to optimize the final AI controller. A cohort of 23 virtual patients was crafted for in-silico validation of the controller, which was designed in MATLAB®. For all patients, the controller maintained a healthy glucose range of 90-130 dg/mL—demonstrating its effectiveness and adaptability—and "learned" how to administer both basal and bolus doses of insulin. This research is a successful proof-of-concept of an advanced AI approach to the artificial pancreas and currently no marketed device can administer bolus insulin doses in response to meal intake, which would improve the quality of life for T1D patients.

Awards Won:

Third Award of $1,000