Summary:

This research explores using small spiking neural networks (SNNs) to control insulin delivery for people with Type 1 diabetes, aiming to develop a low-power, embedded artificial pancreas system. The networks decide how much insulin to give every 3 minutes based on continuous glucose monitor (CGM) data. SNNs are a new wave of computing in the post Moore's law era, representing computations as biological networks of neurons and synapses that store information in the weights and delays between connections. These networks can be trained to perform all kinds of tasks, with this work specifically exploring a reinforcement learning control task.

Key points:

The researchers trained many SNNs using evolutionary optimization and reinforcement learning. They decided to use previous research to guide their decisions around network hyperparameters, leaving more time for exploration of application specific details.

The insulin doses controlled by the networks could only change in fixed steps of 0.15 Units per output spike, which limited fine control. This sometimes caused the network to give too much insulin ("overbolus") or made it hard to maintain a steady basal insulin level, especially for younger patients.

Blood glucose data from both adults and children showed that the networks were generally effective at keeping blood sugar in the healthy range (called the "euglycemic" range), but children's glucose levels were more variable.

The CGM sensor data is noisy and sometimes inaccurate. The networks were able to handle this noise fairly well without overreacting too much and causing dangerous blood sugar drops.

Compared to other reinforcement learning methods tested on similar diabetes simulations, the small spiking neural networks performed as well or better, while being much smaller and simpler. This makes them ideal for use on tiny, low-power devices. This is likely due to the fact that SNNs can store much more information that a traditional "neuron" in an ANN. SNNs are able to store both a weight and a delay value, allowing the networks to take advantage of the temporal dimension in their computation, a fact that lead to the success of these networks.

The researchers deployed the best adult network on a Raspberry Pi Pico microcontroller and measured its power use. The network processed a full day's worth of glucose readings very quickly and used very little energy overall—about 267 joules per day. This suggests such a system could run efficiently on a small embedded device.

The small size (only 5 neurons and 5 connections) also makes the network easier to understand and analyze compared to large neural networks.

Conclusion:

Tiny spiking neural networks can effectively control insulin dosing in real time, and they are efficient enough to run on low-power embedded hardware. This supports the idea that such networks could be used to build a neuromorphic artificial pancreas—an implantable or wearable device that automatically regulates blood sugar for people with diabetes.