Rushil Thakker

Blue Springs, MO

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Junior

Computer Engineering; Electrical Engineering

Faculty Mentor: Dr. Syed Kamrul Islam, Electrical Engineering & Computer Science

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Energy Efficient Machine-Learning Model Embedded on FPGA for Identification of Sleep Apnea Among Adults

Rushil Thakker, Omiya Hassan, Syed Kamrul Islam

Sleep Apnea is a type of breathing disorder caused by multiple extended pauses in breathing during sleep. This can lead to a decrease in the blood oxygen saturation level which can cause many long-term health issues such as high blood pressure or a weakened immune system. Currently, sleep apnea is diagnosed by using polysomnography (PSG) or other at-home monitors. PSG is the gold standard for detecting sleep apnea, however, it requires an expensive overnight stay monitored by sleep experts. The at-home monitoring methodologies are portable and cheaper compared to the PSG but provide less accurate results while still requiring sleep experts to analyze the results. In this project, we propose a solution by constructing a machine learning model which is inspired by a biomedical system design that can automatically detect sleep apnea with a high degree of precision. This will improve early detection of apnea and allow for constant monitoring in cases where apnea may prove fatal. A digital hardware design of this feedforward neural network is embedded on a field programmable gate-array (FPGA) to detect sleep apnea. The proposed system prototype is designed on an FPGA which analyzes data from two inputs: an ECG sensor and a pulse oximeter providing information on blood oxygen saturation level. These inputs are fed into the network by using the switches on the FPGA and the output of the network is shown on the FPGA's display. The network shows an accuracy of about 88% when detecting sleep apnea and has a power consumption of roughly 52 watts. Future applications of this research include integration into a system-on-a-chip (SOC) platform to create sleep apnea identification devices such as a smart beside apnea monitoring device.