Lightweight Hyperdimensional Computing (HDC) Algorithm for Microcontrollers

Aammya Sapra, Duanhui Li, Jennifer Tanurdjaja, Jezebel Yangari
Advisors: Tajana Rosing, Xiaofan Yu

Methodology

Problem Statement

The aim of this project is to create a lightweight HDC encoding method that can be implemented on variety of low powered devices (i.e. microcontrollers like ESP8266 and Arduino Uno).

We implemented two hyperdimensional computing encoding methods, Random Projection and ID Level, in C. Our lightweight implementation was able to run on microcontrollers (ESP8266 boards and Arduino Unos), in comparison to previous Python implementations that support microprocessors at best.

Motivation

Edge computing is the collection and processing of data collected by edge devices (e.g. sensors) in a local network instead of the cloud.

Edge computing reduces network pressure and increases security, but there is a lack of a universal algorithm that can be implemented across edge devices of varying hardware/software limitations.

Previous works have implemented edge computing algorithms on microprocessors but not microcontrollers due to hardware limitations.

Hyperdimensional computing (HDC) is a promising learning paradigm for implementing a lightweight algorithm across varying edge devices. HDC casts the input data into large binary vectors (10,000+ bits), called hyper vectors, and performs arithmetic operations on the hyper vectors to classify the data.

Testing and Results

To test the encoding, we select tensors from the ISOLET dataset:

- Select two tensors from the same class
- Select one tensor from a different class
- Increase generated hyper vector dimension
- Use encoding to generate hyper vectors for the tensors
- Compare the three hyper vectors to one another

These encoding methods map the input data to a high dimensional space as a hyper vector, where more similar data inputs are nearer to one another.

Hardware Difference between Microcontroller and MicroProcessor

(Sanchez-Iborra and Skarmeta, 2020.)

This is a comparison of energy consumption of the two encoding methods on different devices.

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Energy Consumption = Execution Time of Encode × Power Consumption of Device