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Project

The simulation of human intelligence by machines is known as Artificial Intelligence (AI). One capability expected from an intelligent machine is *learning* ability. In *supervised* learning[1], the machine is given plenty of data, previously labeled by humans, to learn from and improve its ability to recognize unseen data. Inspired by human brain, artificial neural network (ANN) is an structure used in the training process.

Figure 1 shows the structure of an artificial neural network. It consists of an input layer, one or more hidden layers, and an output layer. The layers consist of neurons which receive inputs from other neurons. The inputs to a neuron may activate it and when activated, it casts outputs which may activate other neurons as well. *Training* is the processing of adjusting the weights. In *feedforward* neural networks, neuron connections do not form a loop and information flows only in one direction (i.e. from input layer to output layer).

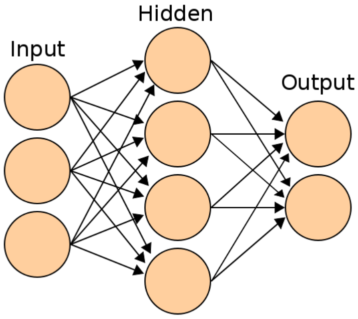

FIGURE 1. The structure of an artificial neural network.

Genann is a minimal feedforward neural network implementation in C programming language. It uses *backpropagation* training while alternative training methods such as *hill climbing* may be employed. In this protect, you are required to speed up the training process of a neural network. The project consists of two phases and in each phase you have instructions to follow. You report must contain the deliverable of each item.

PHASE ONE

Review. Read the source code of the library and briefly explain its important sections in your report.

Demo. Download Semeion Handwriting Digit dataset from UCI Machine Learning Repository. In the dataset, each row is a handwritten digit (i.e. [0-9]), in the form of a 16 × 16 pixels black and white image, hence 0s and 1s. The 10 digits at the end of line denote the written number as follows:

0: 1 0 0 0 0 0 0 0 0 0
1: 0 1 0 0 0 0 0 0 0 0
2: 0 0 1 0 0 0 0 0 0 0
3: 0 0 0 1 0 0 0 0 0 0
4: 0 0 0 0 1 0 0 0 0 0
...
9: 0 0 0 0 0 0 0 0 0 1

Use the *genann* library to train a neural network with one hidden layer. The input and output layers have 256 and 10 neurons, respectively. You may consider 28 neurons for the hidden layer. Use 70% if the data for training and 30% to test the accuracy of your trained model. Report accuracy and execution time for different number of *iterations* and *learning rates*. You should be able to achieve an excellent accuracy.

[1] In *unsupervised* learning the machine itself has to find patterns in data.

$$\text{Accuracy} = \frac{\text{Number of correct predictions}}{\text{Total number of predictions}}$$

- In the next steps, you may use other datasets.

Analyze. Profile the library with Intel Parallel Studio and report the hotspots. Propose your decomposition and mapping scheme to parallelize the code.

Implement. Implement your parallel approach and fix errors. Use Intel Parallel Studio to find race conditions, false sharings, unbalance load on threads, etc. Provide data on each step. Show the correctness of your implementation, provide the source code, and report the speed up for various problem sizes and number of threads.

Evaluation. Your implementation will be tested and evaluated with an arbitrary dataset on a multicore machine.

Phase two

Implement an accelerated version of the library that is faster than the parallel backpropagation version in the previous phase. To this end, you can change the training algorithm, approach, or execution device.

Report. Source code, method, correctness check, results, etc.

Evaluation. On the presentation day, you will compete with your classmates where the implementations will be ranked based on their correctness and performance on a given dateset and GPU-equipped multicore system. The implementations will be graded accordingly. Works with remarkable achievements will be rewarded with extra points.