CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Grant Sheen

Project Number
S1516

Project Title
Wireless Brainwave Classification for Alzheimer's Patients via Efficient Neural Network Computation

Abstract

Objectives/Goals
In order to break the communication barrier between Alzheimer's patients and their caretakers, there is an inevitable need to create a thought recognition software to classify the brainwaves of Alzheimer's patients recorded by a portable and wearable wireless device. The unique characteristics of wireless brainwave data (limited amount and low resolution) pose a significant challenge to standard neural networks, which require abundant data. I developed an efficient neural network model and a new training algorithm to attain high classification accuracies of wireless brainwave data, which standard neural networks fail to do.

Methods/Materials
The brainwaves were recorded with a 14-electrode wireless headset called EPOC+ by Emotiv (the data were obtained from the UC Irvine MIND Institute and were de-identified). To overcome the challenge of limited data, I constructed a dimensionally reduced neural network model trained by my Alternating Minimization (AM) algorithm. During training, I computed the unknown parameters of the neural network by minimizing a non-smooth and non-convex objective (cross entropy) function one variable at a time while fixing the rest, until convergence of the objective values. I discovered that the objective function in each variable is piecewise convex, so the global minimum can be computed with bisection. The overall iterative AM algorithm is descending and convergent, free of the step size (learning) parameter in the standard gradient descent method. After training, the testing data is fed into the neural network and the class probabilities are calculated for prediction of thoughts.

Results
After 7 months of research and development, my algorithm classified 4 daily thoughts of an Alzheimer's patient at a 90% accuracy. This indicates that my software can be used to restore the communication capabilities of Alzheimer's patients.

Conclusions/Discussion
My neural network model provides an effective solution to the communication issue between Alzheimer's patients and their caretakers. My algorithm works with a wireless headset, allowing thought recognition to be run anywhere in real time. I was the first person to design a dimensionally reduced neural network for brainwave data, develop an Alternating Minimization algorithm for neural network training, and derive analytical formulas for curved decision boundaries.

Summary Statement
I developed an efficient neural network model and a new training algorithm for wireless brainwave classification of Alzheimer's patients.

Help Received
I designed the neural network model and developed a new training algorithm myself. I received help from Professor Knut Solna of the Mathematics Department at UC Irvine in understanding background material.