Collaborative Research Experience for Women 2002 (CREW’02)

Supervised Learning with Potential Functions for Neural Network-Based Object Recognition

Student research team: Anna Fiorentino, senior student in 2002-2003, CSI/CUNY
Helen Zhang, senior student in 2002/2003, CSI/CUNY
Annie Wang, senior student in 2002/2003, CSI/CUNY

Faculty Mentor: Dr. Natacha Gueorguieva, Associate Professor, Department of CS, CSI/CUNY

School: College of Staten Island/City University of New York (CSI/CUNY)
Address: 2800 Victory Blvd, Staten Island, NY 10314

Goals and Purpose of the Project

Multilayer Perceptrons (MLP) and Radial Basis Function (RBF) networks are commonly used to solve classification problems. MLP are feed forward networks with one or more hidden layers of nonlinear perceptron elements. They usually employ sigmoid functions as nonlinearities and a variation of delta training algorithm. RBF networks commonly have one hidden layer, the elements of which compute the values of radial basis functions. These nonlinearities are normally Gaussian functions with local influence around their centers. The RBF neural networks compared to MLPs have an advantage that their training is much less computationally intensive. Normally one-tenth of the time that is needed for the training of a MLP network, is needed for the training of a RBF network. Also the RBF networks have the best approximation ability.

RBF networks create a global approximation to a target function as a linear combination of the local nonlinearities in the hidden layer. It is difficult to find good parameters for the basis function centers and their variances, while the number of centers is small. In order to fill out a high dimensional hidden space many basis function centers are needed and this number grows exponentially with the dimension of the hidden space. A large number of basis functions leads to a large number of needed training examples. Finding a suitable network size and fitting parameters still remains an open problem.

The goal of this project is to develop supervised learning algorithms for feed forward and RBF neural networks and a novel method for data clustering which performs classification based on a set of potential fields synthesized over the domain of input space by a number of potential function units.

This project represents on-going research conducted by the faculty-applicant. Preliminary results were published and presented at the 13th International Symposium on Computer and Information Sciences ISCIS’98 [5]. Substantial theoretical findings have been submitted to ANNIE’02 “Smart Engineering System Design: Neural Networks, Fuzzy logic, Evolutionary Programming, Data Mining, and Complex Systems“ refereed conference honored with Best Paper Award in Theoretical Developments in Computational Intelligence category (http://web.umr.edu/~annie/bpa02.htm). This proposal was a continuation and was built upon the developed theoretical basis.

Process Steps Used in Completing the Research

1. Seven seminars have been organized during Fall’02. During the first four seminars the PI presented the potential functions and their application in solving pattern recognition problems; how to construct multivariate functions based on orthonormal polynomials; basic principles in development of supervised learning with radial-basis functions using potential functions. During the last three seminars, student-participants discussed some approaches in building neural networks, proposed their own ideas and presented the basic steps in neural network design. More details can be found on the project web site given below.

http://www.cs.csi.cuny.edu/~natacha/Projects/Pfnn/seminars.htm
2. Three formal seminars and several informal meetings took place during the Spring’03. Their purpose was to share the achieved results, to discuss the content of the papers submitted to two conferences and the prepared presentations, to update the web site.

3. A final meeting was scheduled on May 27 to discuss the final reports and update the project web site.

Conclusions and Results Achieved

The student-participants

- Made a research of the current state of the art of the problem domain and extended their knowledge in design of neural networks.
- Mastered their knowledge in C++/Java programming language, Data Structure, Object-Oriented Programming, Linear Algebra and Matlab programming package.
- Designed the basic topologies of the feed forward and RBF neural networks as well as learning algorithms for supervised learning with potential functions.
- Proposed experiments with novel approaches, which can be a basis for a future research and investigated the dependence of the proposed method and algorithms on different parameters and apply different strategies to several data sets.
- Wrote four papers and presented them on traditional CSI/CUNY Undergraduate Research Conference on April, 10, 2003 and American Society for Engineering Education (ASEE) Mid-Atlantic Region Conference on April 11 – 12, 2003.
- Created and maintained a project web site.

Publications


Project web site: 
http://www.cs.csi.cuny.edu/~natacha/Projects/ProjectGrant.htm
http://www.cs.csi.cuny.edu/~natacha/Projects/Pfnn/index.htm