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

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Our research focused on different neural network architectures based on potential functions and their implementation in solving classification problems. We focused on the design of the basic topologies of the feed forward and RBF neural networks and building criteria for determination of the number of hidden layers and number of hidden units. We compared their performance and derived conclusions about their advantages, disadvantages and suggested ways for their improvement.

My particular research focused on the architectures and algorithms used by multilayer neural networks. The performance of a Multilayer Feedforward Potential Function Network is based on the potential functions used to recognize patterns in the input domain. The feed forward network does not focus on a winning neuron approach instead it uses the linear boundaries of the input space and uses nonlinear potential functions to extrapolate the teaching patterns. The network incurs multiple layers as well as two learning phases. The potential function units presented in the Multilayer Feedforward network are Gaussian. The Gaussian function is a good potential function because of its ease and regulation of the number of parameters. The three layers, the input, hidden and output layers allow the network to correctly classify patterns by clustering and function approximation. The performance of the network in pattern recognition is accurate but can be improved upon. Some drawbacks to the network are maintained in its inability to correctly generate the appropriate number of potential function units. This results in redundancy of Gaussian units or minimal units. As with any multilayer network, an algorithm that can determine the adequate number of hidden layers for performance will improve the networks ability.

Our development of the improved algorithm includes extrapolating the layers of the Feedforward Network while introducing the potential functions of the Radial Basis Functions. This allows flexibility of the parameters and number of hidden layers without the redundancy of the previous Gaussian units. There seems to be a consensus that Radial Basis Functions employed with Multilayer Feedforward Networks are a better approach to classifying and clustering objects. This statement leaves room for exploration. Therefore, I intend to continue research at the graduate level in neural networking and potential functions. I would like to make some general observations for the applications of this new algorithm.

As a result of this project, the following two research papers have been accepted, presented and published:


It was a privilege to have participated in this collaborative research project. In the Fall’03 I will be attending New Jersey Institute of Technology where I have been awarded a scholarship into their Computational Biology M.S. program.

Project web site: http://www.cs.csi.cuny.edu/~natacha/Projects/ProjectGrant.htm
http://www.cs.csi.cuny.edu/~natacha/Projects/Pfnn/index.htm
Supervised Learning with Potential Functions for Neural Network-Based Object Recognition

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Supervised learning techniques are widely used in object recognition rooted in neural networks. We try to develop the theory and applications for different neural network architectures based on potential functions and their implementation in solve classification problems. It is our prospect that applying potential function approach will lead to a precise classification when performing object recognition.

In our research, we use potential function method to approach the determination of decision functions, which produce the partition boundaries in the pattern space to split patterns of one class from another. The analytical design of automatic pattern classification systems consists primarily in the determination of the decision functions.

Our development of generating the learning algorithm essentially encloses three phases -- the initializations phase, the learning phase, and the dynamic learning phase -- with structural changes by using the potential functions between cluster centers and samples as the learning criterion. Our results show many advantages of using potential function approach. One of the great advantages the potential function has is that it facilitates matching of non-overlapping sets. By applying this method, it results in higher order decision boundaries while the other method, for example, the Euclidean distance method, generates piecewise linear boundaries between classes. Therefore, our research demonstrates that the potential functions method has more consistent similarity distribution between samples in the same class, and has smoother and more natural decision boundaries between classes.

As a result of this project, the following two research papers have been accepted, presented and published:


As an undergraduate student, I gained a significant opportunity to present my research at these conferences. Also, as a female Computer Science student, one of the many challenges for me is that I am surrounded by a male environment. However, I learned that it is essential to let the results of my hard work speak for my potentials. It is my pleasure that I can be included as one of the CREW student research members. Involving in this project, it enhances my programming proficiencies as well as analytical thoughts. Presenting these projects at these conferences, it improved my presentation skills as well as communication skills. Thus, I realize that learning takes place both inside and outside of the classroom.

In conclusion, I appreciate this great opportunity that CREW provided to me. I intend to continue my education and obtain MS degree in the future.

Project web site: http://www.cs.csi.cuny.edu/~natacha/Projects/ProjectGrant.htm
http://www.cs.csi.cuny.edu/~natacha/Projects/Pfn/index.htm
Supervised Learning with Potential Functions for Neural Network-Based Object Recognition

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Neural networks have been extensively used in the area of pattern classification due to their parallel computation and learning capabilities. Algorithms are proposed for trainable pattern classifiers to recognize different classes of objects based on the construction of the potential functions. The performance of a given algorithm is not only dependent on the type of data being analyzed, but is also strongly influenced by the chosen measure of pattern similarity and the method used for identifying clusters in the data.

In our research, we use a supervised learning algorithm to recognize different classes of objects. The way of grouping samples into clusters dominates the learning speed and effect. Most of the learning methods use Euclidean distance as the similarity criterion to cluster samples. However, we use a method using potential function. Each sample accumulates different amount of potential generated by cluster centers from different classes.

As result of our research, using the method of potential functions to two pattern classes so the learning results can be shown in graphic form. The distance learning gives more cluster centers than potential learning. When the density of different classes is the same, the results are not much different from each other. When the different classes have distinct density, the results are different from each other. The learning processes use potential function with threshold. Any sample, which falls into this region, will not be classified. The higher the threshold value, the broader the separation region. The potential method has more natural decision boundaries between classes than those obtained by using the Euclidean distance. Except, in most cases, the number of cluster centers obtained by potential method is smaller. Therefore, using the potential function as the learning criterion produces a good clustering which results in a good representation for classes in the feature plane.

Publications:


Through this research, I’ve realized the importance of working as a team. We separated one big difficult project into small pieces. We could work on our own as well exchange our ideas and learned from each other. I knew I cannot only use resources from database, Internet, but also can use my crew as my unlimited resources. Moreover, I integrated the knowledge, which I learned from classes, with research practice in order to enrich my professional experiences. After these conferences, I have more confidence about my oral skill. On the other hand, I’ve learned how to arrange my tense schedule between the research and classes, thereby, I can work well in my future working areas. Ultimately, I want to say thank to the fund for providing this significant opportunity that I can enhance my knowledge.

**Project web site:** [http://www.cs.csi.cuny.edu/~natacha/Projects/ProjectGrant.htm](http://www.cs.csi.cuny.edu/~natacha/Projects/ProjectGrant.htm)

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