WHITE PAPER: NEURAL NETWORKS

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1. What is a Neural Network?

Artificial neural networks (usually just called neural networks) are interconnected collections of simple, independent processors. While loosely modeled after the brain, the details of neural network design are not guided by biology. Instead, for over 20 years researchers have been experimenting with different types of nodes, different patterns of interconnection and different algorithms for adjusting connections.

Neural networks are called machine learning algorithms because changing these connections (training) causes the network to learn the solution to a problem. This differs from other artificial intelligence technologies, such as expert systems, fuzzy logic or constraint-based reasoning which must be programmed to solve a problem.

Many different neural network models have been explored. These models are described as either unsupervised or supervised. Unsupervised neural networks, such as self organizing feature maps, find relationships between input examples by examining the similarities and differences between the examples. Supervised neural networks, such as backpropagation, are used for pattern recognition or prediction. For supervised neural networks, the input examples must be accompanied by the desired output.

2. Where have Neural Networks been applied?

Problems involving prediction and classification are prime candidates for neural networks. Some sample applications include:

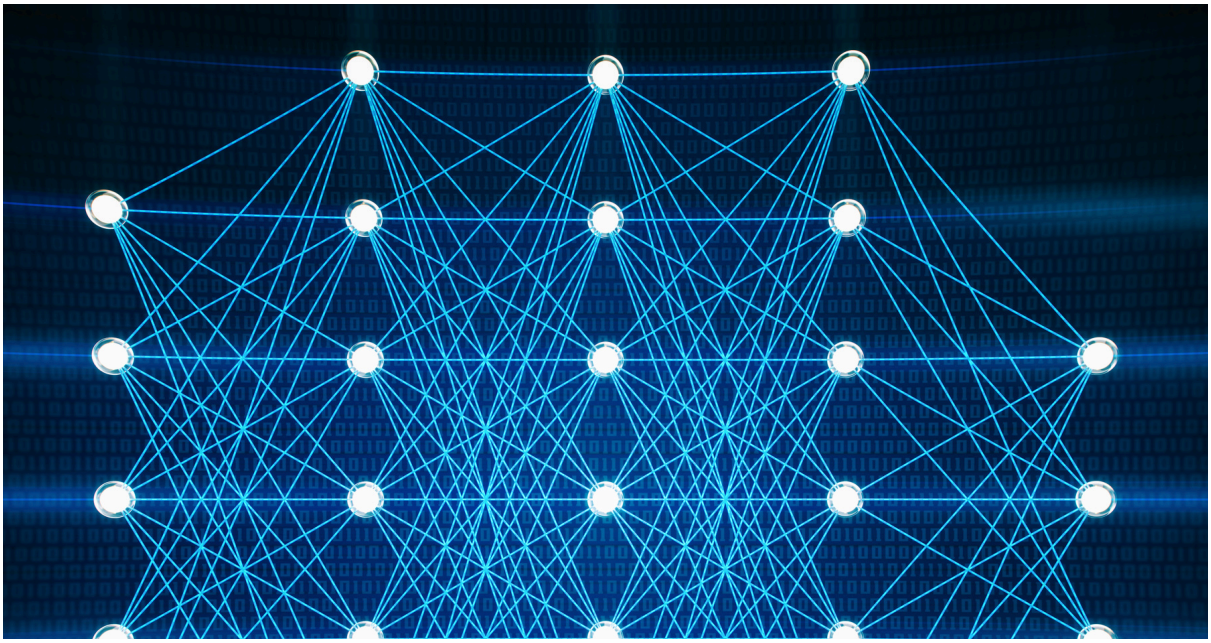
- **Sales Forecasting:** Sales forecasting allows retail and distribution companies to make better inventory and purchasing decisions and to identify opportunities for increased sales. Sales forecasting is very difficult due to the high number of factors affecting sales and the inter-relationships between them. These factors include seasonality, price, advertising, in-store display, and time since last promotion, among many others. Neural networks use historical data to learn the relationship between the factors. The relationships are then used to predict sales levels for various combinations of the factors.
- **Data Mining:** To find valuable patterns in large databases, huge numbers of examples must be analyzed. Neural networks are used to group, or cluster, the examples. A representative sample of each group is used for analysis, and the results of the analysis are applied to the entire group. This saves considerable processing time.
- **Credit Application Approval:** Neural networks are well suited to a number of situations requiring approval decisions, whether for loans, leases, or credit cards. Networks can be trained to simply classify an application as acceptable (a yes or no decision) or to predict a value such as the revenue that will be generated. Networks with multiple outputs can be used to provide a simple reason code along with a credit evaluation, but more detailed explanations are beyond the current limits of neural network technology.

3. When should I use a Neural Network?

A neural network application should be considered when faced with a problem having one or more of the following characteristics:

- The problem is poorly understood, either because of complexity or lack of experience. All that is required to train a neural network is a set of good examples. Conversely, other artificial intelligence technologies, such as expert systems, must be explicitly programmed to solve a problem.
- The problem requires a decision be made even when the input data is incomplete. Because neural networks work in parallel, they will make a decision on whatever input data is given to them.
- The input examples used to train the neural network are “noisy” (the same output value may be associated with different input values.) or incomplete (not all of the input values for the examples are present). Training algorithms for neural networks are designed to be tolerant of incomplete data.

- The problem is very complex with many variables. Most of these problems are non-linear. An example of a non-linear relationship is when variable a changes, variable b also changes, but the change is dependent upon variable c. In sales forecasting the relationship between factors is generally non-linear. Neural networks can model non-linear relationships. Traditional statistical techniques handle non-linear relationships poorly.
- Problems that require quick decision making are also good candidates for neural networks. The internal processing of neural networks is relatively simple, once the network is trained, it runs very quickly.

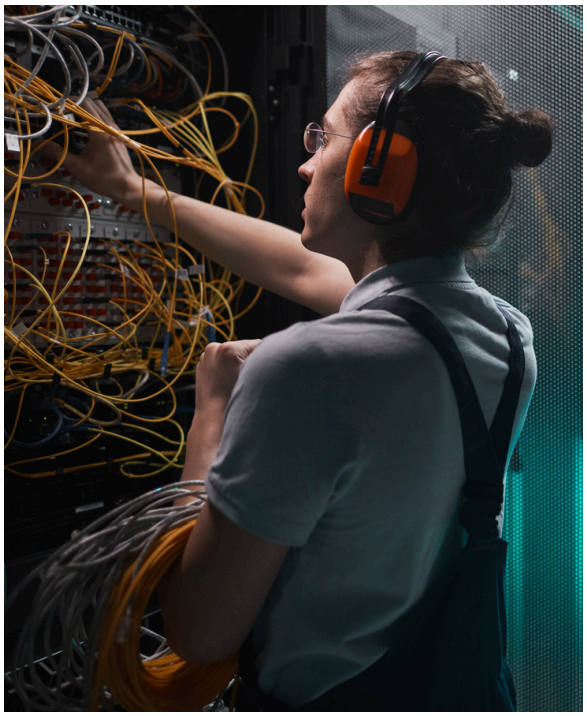


4. How do Neural Networks compare to other Artificial Intelligence techniques?

Some problems, such as loan approval decisions, can be approached as either expert system or neural network applications. In contrast to expert systems, neural networks can be developed where expertise is limited or the experts are unable to explain their reasoning process. Because of their speed, neural networks may be appropriate where rule-based processing is too slow. Developing a neural network, however, requires far more data than building an expert system. In general, the more complex the data and the more accurate the required response, the more data is required. Typical applications require hundreds to thousands of training examples. Neural networks alone are inappropriate in situations requiring detailed explanations of the output; situations where expert systems excel. The technologies do not compete so much as they complement one another. Each technology mimics a different type of human problem-solving behavior. Expert systems embody conscious, methodical reasoning while neural networks represent instantaneous, unconscious pattern recognition.

5. How would I develop a Neural Network application?

Six types of activities take place during neural network development: project definition, knowledge engineering, database creation, network training, network validation and building the user interface. Over the course of the project, the emphasis on each of the activities shifts from the first towards the last, but they do not constitute separate and well defined stages. In our experience, a traditional, waterfall approach to system development is inappropriate when building intelligent applications. Developing an intelligent system is a learning process for all of the project participants. One of the best ways to facilitate and measure that learning is to follow a rapid prototyping approach to systems development. A production neural network is almost always the result of several iterations, each building upon the results of prior iterations.



6. What is the conclusion?

Neural networks represent a proven, widely used technology for complex prediction and classification problems. Neural networks excel in problem domains where there are non-linear relationships, limited expertise, missing or incomplete data and fast processing is required. Many neural network applications have been successfully applied in a number of domains, from retail to insurance.

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