**History**

The history of artificial neural networks is filled with colourful, creative individuals from a variety of fields, many of whom struggled for decades to develop concepts that we now take for granted. This history has been documented by various authors. One particularly interesting book is Neurocomputing: Foundations of Research by John Anderson and Edward Rosenfeld. They have collected and edited a set of some 43 papers of special historical interest. Each paper is preceded by an introduction that puts the paper in historical perspective.

Histories of some of the main neural network contributors are included at the beginning of various chapters throughout this text and will not be repeated here. However, it seems appropriate to give a brief overview, a sample of the major developments.

At least two ingredients are necessary for the advancement of a technology: concept and implementation. First, one must have a concept; a way of thinking about a topic, some view of it that gives a clarity not there before. This may involve a simple idea, or it may be more specific and include a mathematical description. To illustrate this point, consider the history of the heart. It was thought to be, at various times, the centre of the soul or a source of heat. In the 17th century medical practitioners finally began to view the heart as a pump, and they designed experiments to study its pumping action. These experiments revolutionized our view of the circulatory system. Without the pump concept, an understanding of the heart was out of grasp.

Concepts and their accompanying mathematics are not sufficient for a technology to mature unless there is some way to implement the system. For instance, the mathematics necessary for the reconstruction of images from computer-aided tomography (CAT) scans was known many years before the availability of high-speed computers and efficient algorithms finally made it practical to implement a useful CAT system.

The history of neural networks has progressed through both conceptual innovations and implementation developments. These advancements, however, seem to have occurred in fits and starts rather than by steady evolution.

Some of the background work for the field of neural networks occurred in the late 19th and early 20th centuries. This consisted primarily of interdisciplinary work in physics, psychology and neurophysiology by such scientists as Hermann von Helmholtz, Ernst Mach and Ivan Pavlov. This early work emphasized general theories of learning, vision, conditioning, etc., and did not include specific mathematical models of neuron operation.

The modern view of neural networks began in the 1940s with the work of Warren McCulloch and Walter Pitts [McPi43], who showed that networks of artificial neurons could, in principle, compute any arithmetic or logical function. Their work is often acknowledged as the origin of the neural network field.

McCulloch and Pitts were followed by Donald Hebb [Hebb49], who proposed that classical conditioning (as discovered by Pavlov) is present because of the properties of individual neurons. He proposed a mechanism for learning in biological neurons.

The first practical application of artificial neural networks came in the late 1950s, with the invention of the perceptron network and associated learning rule by Frank Rosenblatt [Rose58]. Rosenblatt and his colleagues built a perceptron network and demonstrated its ability to perform pattern recognition. This early success generated a great deal of interest in neural network research. Unfortunately, it was later shown that the basic perceptron network could solve only a limited class of problems. (See Chapter 4 for more on Rosenblatt and the perceptron learning rule.)

At about the same time, Bernard Widrow and Ted Hoff [WiHo60] introduced a new learning algorithm and used it to train adaptive linear neural networks, which were similar in structure and capability to Rosenblatt’s perceptron. The Widrow-Hoff learning rule is still in use today. (See Chapter 10 for more on Widrow-Hoff learning.)

Unfortunately, both Rosenblatt’s and Widrow’s networks suffered from the same inherent limitations, which were widely publicized in a book by Marvin Minsky and Seymour Papert [MiPa69]. Rosenblatt and Widrow were aware of these limitations and proposed new networks that would overcome them. However, they were not able to successfully modify their learning algorithms to train the more complex networks.

Many people, influenced by Minsky and Papert, believed that further research on neural networks was a dead end. This combined with the fact that there were no powerful digital computers on which to experiment, caused many researchers to leave the field. For a decade neural network research was largely suspended.

Some important work, however, did continue during the 1970s. In 1972 Teuvo Kohonen [Koho72] and James Anderson [Ande72] independently and separately developed new neural networks that could act as memories. (See Chapter 15 and Chapter 16 for more on Kohonen networks.) Stephen Grossberg [Gros76] was also very active during this period in the investigation of self-organizing networks.

Interest in neural networks had faltered during the late 1960s because of the lack of new ideas and powerful computers with which to experiment. During the 1980s both of these impediments were overcome, and research in neural networks increased dramatically. New personal computers and 1 Introduction 1-4 workstations, which rapidly grew in capability, became widely available. In addition, important new concepts were introduced.

Two new concepts were most responsible for the rebirth of neural networks. The first was the use of statistical mechanics to explain the operation of a certain class of recurrent network, which could be used as an associative memory. This was described in a seminal paper by physicist John Hopfield [Hopf82].

The second key development of the 1980s was the backpropagation algorithm for training multilayer perceptron networks, which was discovered independently by several different researchers. The most influential publication of the backpropagation algorithm was by David Rumelhart and James McClelland [RuMc86]. This algorithm was the answer to the criticisms Minsky and Papert had made in the 1960s.

These new developments reinvigorated the field of neural networks. Since the 1980s, thousands of papers have been written, neural networks have found countless applications, and the field has been buzzing with new theoretical and practical work.

The brief historical account given above is not intended to identify all of the major contributors, but is simply to give the reader some feel for how knowledge in the neural network field has progressed. As one might note, the progress has not always been “slow but sure.” There have been periods of dramatic progress and periods when relatively little has been accomplished.

Many of the advances in neural networks have had to do with new concepts, such as innovative architectures and training rules. Just as important has been the availability of powerful new computers on which to test these new concepts.

Well, so much for the history of neural networks to this date. The real question is, “What will happen in the future?” Neural networks have clearly taken a permanent place as important mathematical/engineering tools. They don’t provide solutions to every problem, but they are essential tools to be used in appropriate situations. In addition, remember that we still know very little about how the brain works. The most important advances in neural networks almost certainly lie in the future.

**Application**

List of some of those applications follows.

Aerospace:

High performance aircraft autopilots, flight path simulations, aircraft control systems, autopilot enhancements, aircraft component simulations, aircraft component fault detectors.

Automotive:

Automobile automatic guidance systems, fuel injector control, automatic braking systems, misfire detection, virtual emission sensors, warranty activity analysers

Banking :

Check and other document readers, credit application evaluators, cash forecasting, firm classification, exchange rate forecasting, predicting loan recovery rates, measuring credit risk

Defence

Weapon steering, target tracking, object discrimination, facial recognition, new kinds of sensors, sonar, radar and image signal processing including data compression, feature extraction and noise suppression, signal/image identification

Electronics

Code sequence prediction, integrated circuit chip layout, process control, chip failure analysis, machine vision, voice synthesis, nonlinear modelling

Entertainment

Animation, special effects, market forecasting

Financial

Real estate appraisal, loan advisor, mortgage screening, corporate bond rating, credit line use analysis, portfolio trading program, corporate financial analysis, currency price prediction

Insurance

Policy application evaluation, product optimization

Manufacturing

Manufacturing process control, product design and analysis, process and machine diagnosis, real-time particle identification, visual quality inspection systems, beer testing, welding quality analysis, paper quality prediction, computer chip quality analysis, analysis of grinding operations, chemical product design analysis, machine maintenance analysis, project bidding, planning and management, dynamic modelling of chemical process systems .

Medical

Breast cancer cell analysis, EEG and ECG analysis, prosthesis design, optimization of transplant times, hospital expense reduction, hospital quality improvement, emergency room test advisement

Oil and Gas

Exploration, smart sensors, reservoir modelling, well treatment decisions, seismic interpretation

Robotics

Trajectory control, forklift robot, manipulator controllers, vision systems, autonomous vehicles

Speech

Speech recognition, speech compression, vowel classification, text to speech synthesis

Securities

Market analysis, automatic bond rating, stock trading advisory systems

Telecommunications

Image and data compression, automated information services, real-time translation of spoken language, customer payment processing systems

Transportation

Truck brake diagnosis systems, vehicle scheduling, routing