BIOS AND THE USE OF TELECOMMUNICATIONS

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INTRODUCTION

The unprecedented progress in all fields during the past 30 to 40 years has surpassed all previous successes of mankind. Almost all technical/scientific fields have reached the limit of natural laws. The majority of macroscopic phenomena have been analyzed, well understood and put at the service of man. A substantial amount of progress into the understanding of the microcosmos has also been achieved.

Progress in the field of telecommunications which deals with the study and implementation of generation, processing, storage and transmission of information -- whether it be voice or any type of information signal or data -- has reached the point where computers are able to recognize and synthesize a natural voice, and transmission systems can transmit information at the speed of light. All was unthinkable only a few years ago. However, in order to continue to satisfy the needs of modern society with its ever-increasing standards of living, the requirements on all subfields of telecommunications are greater than that which technological progress is presently envisaged to provide.

Hopefully, elements of biological systems which exhibit telecommunications characteristics, are providing new models for the macroscopic telecommunications field. New understanding has been obtained and new rules have been devised using these models. The storage and information processing capability of the human brain, and the transmission of information between centers of information generation within living organisms, are examples of new dimensions available to the field of telecommunications. The field of biology in general presents the next frontier, which undoubtedly will serve as a reservoir for new ideas. These will range from semiconductor memory chips, whose structure mimics that of the nerve cells, or neurons, to the understanding of how a wasp, with only a few neurons in its brain, unerringly locates the single species of spider its young will feed on or how the information required to sprout and grow a plant is packaged inside a pea.

Science is at a unique point in history. The silicon that chips are made of is the first medium that allows biological-style information processing to be imitated accurately and inexpensively in hardware. Scientists have already built memory chips that imitate the information processing capability of sensory organs, such as the human eye. Furthermore, in the future, it is envisaged that chips could actually be composed of biological molecules.

The purpose of this paper is to present a simplified model of the human communication system in general, and then discuss areas in which the biological models involved offer a new dimension for innovation.

We shall see that the Human Communication System can be modelled by a hierarchical system. A close scrutiny of which offers new ideas and models to be applied in other fields.

HUMAN COMMUNICATION MODEL

For a better understanding of any complex function, it has been found that it becomes an easy task when factored into simpler ones. Similarly, the Human Communication System can be recognized in the following components. The "cognitive" component, which follows a logical structure constructed along the patterns of rational language and cognitive communication, relies on definition of words, phrases and sentences. The "emotional" component, which carries feeling-messages, may include facial gestures, voice tone, word choice and other signs of communication.

Another component in the Human Communication System is "memory" and its shared manifestation, "culture". We exchange cultural messages by the way we stand, speak, react, etc.. Finally, the last component is "mission" which describes the goals and objectives of an individual. Typically, the mission system consists of the values and rules that arise from restraints and demands of the world outside the individual.

The levels of communication parallel the levels of human information processing. They have an order, in the sense that certain functions use those at lower levels to accomplish their work. For example, cognition uses memory to recognize ideas or create new ones. Cognition could not work without memory. Cognition uses feeling. Otherwise it could not recognize the appropriate idea. Communication then refers to the dialogue between these levels of our information processing hierarchy in each of us.

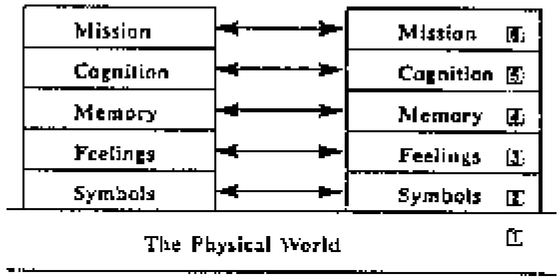

Figure 1: The channels of human communication

Figure 1 shows communication protocols between two people, modelled as a set of functions each uses to process information. The utility of this model is that it separates concerns of different types into compartments where each may be addressed somewhat separately. The advantages of layered communication systems greatly outweigh the disadvantages, e.g., the design is simpler. Each layer's design may be changed without changing that of other layers. Mistakes and malfunctions of one layer may be diagnosed and corrected more easily when the system functions and is understood in separate parts. Finally, each supporting layer should support the mission, and this is not an easy task to grasp. When each stands separately from the others, understanding becomes possible, but confusing when all communication causes and effects seem entangled with each other.

In order to obtain an appreciation for the capacity of such a system, we should analyze the control of the system which is the human brain. It has been found that there are approximately 1013 neurons in the human brain, each of which connects to 1,000 others. This corresponds to around 1012 bytes of information. This storage space is indeed vast compared to the amount we store in computer systems and libraries. An investigation of how the stored information is processed has enabled breakthroughs to be made in many fields.

NEUROCOMPUTING

Nearly all automated information processing at present is based upon the algorithmic approach for implementation. For complex functions the algorithmic approach is very cumbersome, inefficient, time-consuming and even worse, cannot be developed for certain tasks. As an alternative form of information processing, Neurocomputing is quickly developing and some neural networks are already on the market. Neural networks are better for some things than conventional computers. They do well, for instance, at solving complex pattern recognition problems implicit in understanding continuous speech, identifying handwritten characters and determining that a target seen from different angles is in fact one and the same object. In all these cases, large sets of examples of tasks being carried out can be generated and each task involves associating the objects in one set with the objects in another. Instead of being given a step-by-step procedure for carrying out the desired transformation, the neural network itself generates its own internal rules governing the association, and defines those rules by comparing its results to the examples. As can be seen in Figure 2, a neural network consists of a collection of processing elements. Each processingelement has many input signals but only a single output signal. The output signal fans out along many pathways to provide input signals to other processing elements. Each processing element is independent and works independently of the processing going on inside its neighbors. It normally possesses its own small local memory, which stores the values of some previous computations along with the adaptive coefficients basic to neural-network learning. The processing that each element does is determined by a transfer function - a mathematical formula that defines the element's output signal as a function of whatever input signals have just arrived, and the adaptive coefficients present in the local memory. Depending on the design of the neural network, the processing elements either operate continuously or are updated episodically. A scheduling function determines in which way, and how often, each processing element is to apply its transfer function. Each processing element is completely self-sufficient and works in total disregard of the processing taking place inside its neighbors. In any neural network a great deal of independent parallel computation is usually under way. At the same time, all the processing elements intimately affect the behavior of the entire network, since each element's output becomes the input to many others. The topology of the connections among processing elements influences what information processing functions a neural network can carry out. It determines what data each processing element receives, and therefore, the information on which it can act. By and large, every connection entering a processing element has an adaptive coefficient called a "weight". This weight is stored in the local memory of the processing element and is generally used to amplify, attenuate, and possibly change the sign of the signal in the incoming connection. Often, the transfer function sums this, and other weighted input signals, to determine the value of the processing element's next output signal. Thus, the weights determine the strength of the connections from neighboring processing elements.

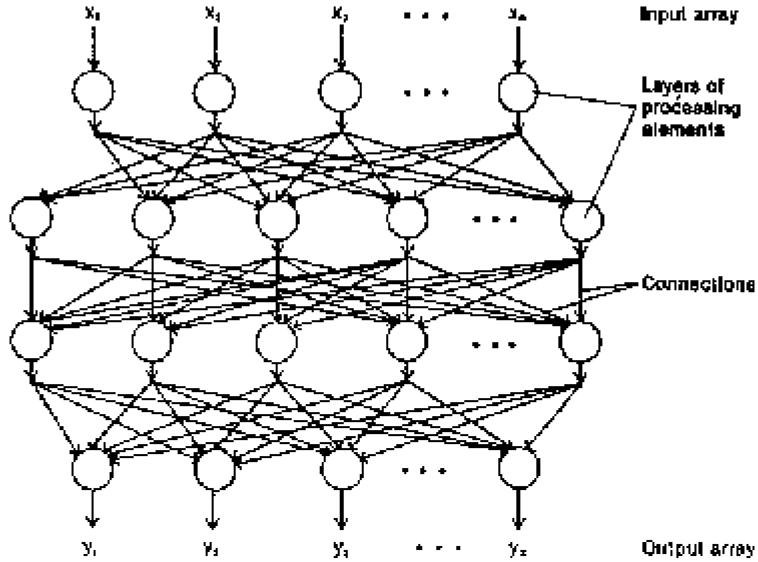

Figure 2:
Conceptually, a neural network consists of many processing elements (circles), each connected to many others. An input array, or sequence of numbers, is entered into the network. Each processing element in the first layer takes a component of the input array, operates on it in parallel with the other processing elements in the layer according to the transfer function, and delivers a single output to processing elements in a layer below. The result is an output array representing some characteristic associated with the input. Since inputs and adaptive coeficients (weights) can change over time, the network adapts and learns.

On the practical side, researchers have designed and are fabricating laboratory models of computer chips that can learn. These chips use very large-scale integration technology and apply the principles and algorithms of neural networks to mimic what scientists believe to be the way the human mind works. Such a chip will be required, for instance, for a telecommunications system that can be trained to recognize natural, spoken language, or perform other kinds of signal processing. It might also be used in new kinds of switches that can categorize traffic situations and learn to adjust to complex demands.

The neurons of the brain are represented on this learning chip by amplifiers, and the synapses (links) are represented by variable resistors. Each resistor is controlled by a processor. During the learning process, each of these processors measures the level and type of activity that is taking place in the neurons connected by the synapses it controls. This measurement is used to increase or decrease the strength of each connection in a manner specified by the algorithm known as a "boltzmann" machine that is used to design the chip. The particular chip is using electronic noise to cause adjustment of the synapse weights. As the noise is reduced, the network settles to the state that produces the desired output. This represents as much as a million-fold increase in processing speed for this algorithm.

Neural networks have been used successfully in pattern and image recognition, fuzzy knowledge processing, bank loan processing, human speech recognition, airline flight scheduling and robotics to name a few. This presents a new hope in handling problems where the algorithmic approach has proven inefficient.

VOICE RECOGNITION SYSTEMS

The technology that enables computers to understand verbal commands, known commonly as a voice recognition system is finally leaving the research stage and becoming a useful tool for many businesses. Breakthroughs include the perfection of a recognition process in which a person's speech is broken down into phonemes, the individual building blocks of syllables and words. Voice recognition systems derived from this research take spoken voice input and translate it to some form of character code output and text. Text to voice, and voice to text systems are becoming invaluable tools in modern telecommunication systems.

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Peter Stavroulakis obtained a Ph.D. in Electrical Engineering from New York University. He has worked at Bell Laboratories on new telecommunications services. He spent three years at Oakland University and two years at the University of Athens. He has been managing director of ATT International (Greece) Ltd., and is presently marketing the entire NYNEX product/services portfolio in Europe. He serves on the Board of Editors of the Journal of the Society for Machine Intelligence. He has prepared and edited two special issues in the Benchmark Book series and co-edited a special issue of the Journal of the Franklin Institute. His publications include a book on satellite intersystem interference and numerous technical papers and journals.