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PRESENTATION

Anyone who has selected a career in a subject matter that assumes a strong research component likely acknowledges an ethical responsibility to advance the knowledge of that discipline to some higher level. This is the essence of research: to add to the knowledge base of humanity. Some research is quite esoteric and may be considered little more than a creative footnote while another might be worthy of Nobel recognition. Many, unfortunately, live their careers in the area of the former though we believe our research is worthy of greater acknowledgment.

When I was originally approached to write an introduction to this book I assume it would be much of the above former case but, to my amazement and pleasure, the topics addressed in this book immediately caught my attention not only because of the scientific merit, but also because the areas of application were novel and exciting. As a Systems Scientist my background is, by definition, multi-dimensional and multi-domain. Systems Scientists seek to identify the underlying structure of complexities and apply those insights to the investigations of other complex problems in other possibly entirely different disciplines. You will be equally impressed, I am convinced, as you peruse this book as to its innovative and contributive nature to the areas of general systems, philosophy, archaeology, geography, anthropology, art history, linguistics and even literature!

The one common thread weaving this fabric of excitement together with science is the domain of Artificial Adaptive Systems (AAS). For the reader who is already adept with the concepts of AAS there should be little difficulty in understanding the material but for everyone else, I will offer here a brief and conceptual presentation of AAS with only enough detail so one can delve into the chapters as long as one assumes the mathematics to be accurate. I shall begin with a discussion of Artificial Intelligence.

The raw material of science, it can be argued, is the *datum*. A single *datum* can be observed, measured, sensed, implied, or by other means acquire an understanding of an event by way of a number. A number may represent the degree of brightness, the quantity of growth, the number of items, a feeling or attitude, etc. but it is the number applied to that single event that is the essence of scientific research. We measure, quantify, qualify, and so on to better understand the event in question. But a single *datum* is typically not useful. Statistics tells us that we need much more data, at least 32 data points, before we can use the language of science: mathematics. So we collect as much data as reasonably possible. This task might be formidable given some scientific obscurity, but the world now creates billions of transactions each day amounting to about a doubling of the world's data every two years or so. This has resulted in the development of a concept and its consequent tools for the analysis of big data and is a source of much research but the subjects here are the result of limited amounts of data, such as what one might collect in excavating some archaeological site or from some medical measurements concerning some disease whose scope is extremely limited.

Here it is important to extract as much knowledge as possible from the limited data, and it is not altogether unexpected to discover that traditional statistics does not have the strength to extract much information. This is not to be an indictment of statistics but rather, the acceptance that the field of mathematics was created at a time that preceded computer technology so there are understandable and logical limitations to what can be extracted from a given quantity of data using these traditional pencil and paper tools. There are rules, axioms, theorems, etc. that one is required to follow if one wishes to properly use statistics. But even if all the rules are properly followed it can be argued that there remains information contained in the data that is beyond the purview of statistics to extract. It was not until the mid-1940's that the notion of using a computational model based on biological concepts came into existence with Turing's B-type machine. Alan Turing considered an infant's cerebral cortex to being akin to an unorganized machine which would, over time, become organized. He sought to emulate this concept and suggested an A-type machine, essentially composed of randomly connected networks capable of some very simple activities, and a B-type machine that expanded the A-type machine such that it contained a kind of connection modifier.

This was to be the origin of Artificial Intelligence, eventually a system of input nodes each representing a variable, output nodes representing the recognition of a pattern or outcome, and a set of hidden nodes that linked the input nodes with the output nodes. These hidden nodes are assigned initial weights that together capture the knowledge contained in the input variables. This is accomplished by the iterative modification of these weights until some measure of error is reduced to an acceptable level. The final values of the weights at the conclusion of the algorithms are deemed to contain the knowledge of the system, and it might take a prepared mind to creatively understanding the meaning.

Neural Networks (NN) are not without their risks. Each NN must be trained to extract the meaningful data that becomes these weights and if it is done correctly we can say that we have a model for understanding the structure of the system under investigation. This is accomplished by training the system. The NN must learn all that is necessary to clearly establish the patterns in the data, but no more than enough. If too much leaning occurs then the data that defines the structure of the system also contains "noise" data that is not a part of the system structure. When this happens the NN may lead to wild predictions far beyond what is actually happening in the data. On the other hand the NN may not learn enough to be able to predict the optimal system structure. There is a point at which the ideal learning has taken place and there are algorithms designed specifically to know when enough is enough. Therefore, a method must be determined by which it is possible to know when the amount of training is optimal, and that requires some way to make the NN adapt itself. These algorithms are adaptive and the result is an Adaptive Neural Network (ANN). The mathematics can be a challenge to understand but, if one is willing to commit the time and energy to the task, it can be mastered.

There is substantial literature available in the field of Neural Networks and Adaptive Neural Networks as the field of Artificial Intelligence has been experiencing a resurgence since it fell out of favor in the 1970's. The promise of AI was never realized and there were many other newer opportunities available to the scientific community into which they could direct their energies. That promise of "intelligence", however, is now being realized but in ways that are not necessarily making the evening news. There have been many meaningful advancements made in the area of medical diagnostics, but these methods are not understood or worse, unknown, by too many of the medical community and unfortunately they, as a group, seem happy maintaining their comfortable *status quo*. Similarly, advances have been made in law enforcement but there is seemingly little interest expressed.

This book seeks to make a difference. It will appeal to the scientist, of course, but also the practitioner seeking to find a unique way to solve a complicated problem, the graduate student seeking direction in the pursuit of a research topic, and definitely there is much for the arm chair academic. The corporate executive who possesses an open and prepared mind will also find much here that can be applied to garner competitive advantage, for the scientific applications describe unique visions and those who are strategic visionaries will also be quick to understand the potential for success.

I recall something of a *mantra*: all the simple problems have already been solved! There was a time when being adept at regression provided insight into the future. In this current age regression and its various modifications is as commonplace as the mean. The science of neural technologies has permitted us to learn more of the future by listening more closely to the past. There exists more information in historical data than we have extracted using the methods of the past. In another few years I will probably be making this assertion again, but with another yet-to-be-discovered set of analytical methods. But at this current time, what is presented here is the cutting edge of neural technologies and ripe for use in virtually every knowledge domain.

Like most researchers, I consider myself to possess a certain required level of scientific curiosity that was piqued during my reading of these manuscript-chapters. There is much originality in the approach taken to historical, archeological and anthropological research using Adaptive Neural Network technologies. This is an exciting time for those researchers in this remarkable field, and it is equally exciting for those who will take these advances and move them to the next level. I shall enjoy my time reading about them in the forthcoming years.

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