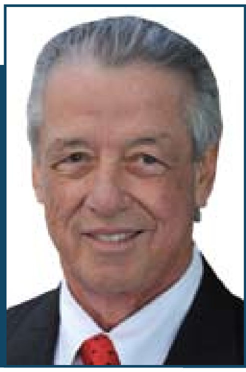

Future Trends - By Roger Gudobba

On Intelligence – Part 2

The brain's architecture has a great deal to tell us about how the brain really works and why it is fundamentally different from a computer.

Continuing from our discussion last month, neural networks have been around since the late 1960s. Neural networks were a genuine improvement over the AI approach because their architecture is based, though very loosely, on real nervous systems. Brains are made of neurons; therefore, the brain is a neural network.

While neural nets grabbed the limelight, a small splinter group of neural network theorists built networks that didn't focus on behavior. Called auto-associative memories, they were also built out of simple "neurons" that were connected to each other and fired when they reached a certain threshold. When a pattern of activity was imposed on the artificial neurons, they formed a memory of this pattern. The most important property is that you don't have to have the entire pattern you want in order to retrieve it. Second, unlike most other neural networks, an auto-associate memory can be designed to store sequences of patterns. This feature is accomplished by adding a time delay to the feedback. With this delay, you can present an auto-associative memory with a sequence of patterns and it can remember the sequence. This is how people learn practically everything, as a sequence of patterns. Jeff proposes that the brain uses circuits similar to an auto-associative memory to do so.

A basic **computer operation** is five million times faster than the **basic operation** in your brain.

But neural networks and the Artificial Intelligence (AI) movement were competitors, for both the dollars and the mind share of the agencies that fund research. AI actively squelched neural network research.

During the computer age, the brain has been viewed as a particular type of machine, the programmable computer. There is a largely ignored problem with this brain-as-computer analogy. Neurons are quite slow compared to transistors in a computer. A basic computer operation is five million times faster than the basic operation in your brain. The most fundamental problem with most neural networks is a trait they share with AI programs. Both are fatally burdened by their focus on behavior.

Jeff Hawkins believed that any theory or model of the brain should account for the physical architecture of the brain. This was essential to understanding the brain and how it relates to intelligence. The other key points were the inclusion of time in brain functions and the importance of feedback. The vast majority of AI, neural network, and cognitive scientists ignored time and feedback.

Let's start with the architecture. Jeff felt we should focus on the neocortex or its shorter moniker, the cortex. Every part of the brain has its own community of scientists who study it and the suggestion that we can get to the bottom of intelligence by understanding just the neocortex is sure to raise a few howls of objection from communities of offended researchers. Granted the brain consists of many parts and most of them are critical to being human. Jeff's counter argument is that he is not interested in building humans. He wants to understand intelligence and build intelligent machines. To build machines that are undoubtedly intelligent, but not exactly like humans, we need to understand the part of the brain that is strictly related to intelligence.

Almost everything we think of as intelligence- perception, language, imagination, mathematics, art, music and planning occurs in the neocortex. When you think about it, we teach our children that humans have five senses: sight, hearing, touch, smell and taste. We really have more. Vision is more like three: motion, color and luminance. Touch has pressure, temperature, pain and vibration. They all enter our brain as streams of spatial patterns. Brains are pattern machines. The idea that patterns from different senses are equivalent inside your brain is quite surprising, and although well understood, it still isn't widely appreciated. This is the model of the neocortex. Take six business or playing cards and stack them. The six cards are about 2 millimeters thick. Functionally they are arranged in a branching hierarchy. It has nothing to do with their physical arrangement. What makes one region higher or lower is how they are connected. Lower regions feed information up by way of a certain neural pattern while higher areas send feedback to the lower regions using a different connection pattern. Once you understand how interconnected the senses are, you are drawn to conclude the entire neocortex, all the sensory and association areas, act as one.

> The brain **doesn't "compute"** the answers to problems; **it retrieves** the answers from memory.

There are four attributes of neocortical memory that at fundamentally different from computer memory:

<<< the neocortex stores sequences of patterns

<<< The neocortex recalls patterns auto-associatively

<<< The neocortex stores patterns in an invariant form

<<< The neocortex stores patterns in a hierarchy

An adult human neocortex has an incredibly large memory capacity. We can only remember a few things at any time and can only do so in a sequence of associations. Here is a fun exercise. Try to recall details from your past, details of where you lived, places you visited, and people you knew. You can always uncover memories of things you haven't thought of in many years. Most of the information is sitting there idly waiting for the appropriate cues to invoke it. An auto-associative memory system is one that can recall complete patterns when only given partial or distorted inputs. This can work for both spatial and temporal patterns. Artificial auto-associative memories fail to recognize patterns if they are moved, rotated, rescaled or transformed in any of a thousand other ways, whereas our brains handle these variations with ease. The third major attribute of neocortical memory is how it forms what are called invariant representations. We use the term invariant representation to refer to the brain's internal representation. Memory storage, memory recall, and memory recognition occur at the level of invariant forms. These are necessary ingredients to predict the future based on memories of the past. Making predictions is the essence of intelligence. There is no equivalent concept in computers.

When Jeff thinks about building intelligent machines, he wonders, why stick to the familiar senses. As long as we can decipher the neocortical algorithm and come up with a science of patterns, we can apply it to any system that we want to make intelligent. One of the great features of a neocortical inspired circuitry is that we won't need to be especially clever in programming it. Therefore, there is no reason for intelligent machines of the future to have the same senses or capabilities as we humans. The cortical algorithm can be deployed in novel ways, with novel senses, in a machined cortical sheet so that genuine, flexible intelligence emerges outside of biological brains.

Jeff wanted to understand how the brain worked in order to build more intelligent machines. The corollary to the mortgage industry technologists is to take the time to think about the challenges we face. We are at a critical point and need to be able to visualize different ways to solve our problems. Not just because they may be different but because they may be an improvement over the current way we approach our business.

Next month we will conclude this series and discuss how Jeff envisions the future of intelligent machines.

Credit: A lot of this material is taken verbatim from the book. This is not an attempt at plagiarism but rather a tribute to the author for this monumental work.

I felt any attempt to restate this would diminish the integrity of his work. I strongly encourage everyone to read this amazing book. ❖

Roger Gudobba has over 25 years of mortgage experience. He is CEO at PROGRESS in Lending and Chief Strategy Officer at technology vendor Compliance Systems. Roger is an advocate of data standardization and a more data-driven approach to mortgage. Roger can be reached via e-mail at rgudobba@compliancesystems.com.