Biological Aspects of Neural Nets*

Dr. Iben Browning

Unlike other biological tissues, nerve cells (of neural nets) do not reproduce. They set up a "particular configuration", and stay there.

If reproduction occurs -- as in cancer -- the information content disappears; the person with the cancer loses his memory.

The "particular configuration" is not a chance configuration. A neurosurgeon rarely lost a bet that when he uncovered the brain (i.e., removed the top of the scull preparatory for a removal of epileptic causative tissue), he could stimulate a thumb twitch first. However flexible the brain might be, it starts out with a specific organization "hard wired".

Vertebrate brains are fundamentally similar in structure: a spinal cord and pairs of nerves (12) connected via the medulla (which operates automatic functions), and thence to the central part of the brain: the "white matter", or insulated connective nerves (the hard wiring). [see fig.1]

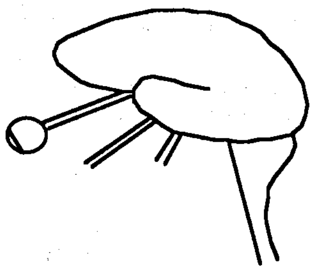

Figure 1

The core of hard-wiring (the brain's "white matter") interconnects the twelve pairs of input nerves, the "gray-matter" cortex, and outputs through the spinal cord.

It's the "gray-matter" that does the learning,abstracting,contemplating,initiating, and monitoring. The "white-matter"-addressed-"gray-matter" learns the "knowledge". The huge "cul-de-sacs" have no direct neurological inputs or outputs. These come in edgewise from the "knowledge" cortex into the "cul-de-sac" prefrontal and temporal lobes where the circulating signals give rise to those attributes most closely associated with intelligence: understanding (in the temporal lobes) and wisdom (in the prefrontal). [see fig.2]

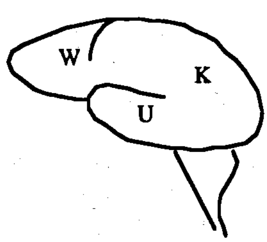

Figure 2

---

* This is a biological talk for computer people

But what gives rise to these uniquely valuable "cul-de-sacs" in the "higher" life forms that is so conspicuously missing in the "lower" life forms such as the frog or rat? These "lower" forms have a cortex that fits smoothly over the brain's inner "white matter".

The distortion is the sealing factor.

Analogously, if the sealing factor on an orange peel were exponential with the radius of the orange, then given a smooth peel on a small orange; a large orange would have a very wrinkled peel because there would be an exponential abundance of peel.

The cortex exists in such abundance that it is so wrinkled that 85% of the entire human cortex of the isolated brain is hidden from view. The "cul-de-sacs" are thus formed, and are there to perform the neuro-circulatory functions of "wisdom" and "understanding".

The brain is composed (in the case of humans) of about 10^{10} neurones, each with about 3200 synaptic connections from 100 other neurones. There are about 100 glial cells per neurone (the glial cells surround neurone cell axones (fibrous extensions) like a wiener fitting around a pencil that is stuck through it from end to end). The fatty glial cells constitute the "white matter" in the mass of nerve fibers that they insulate. The fibers range around one to a few micro-meters in diameter. The neurones are about ten micro-meters in diameter.

With each neurone connecting to and from a hundred other neurones, a system of parallel connections for each bit (perhaps 10^6 neurones per bit), the system memory should approximate [see fig. 3]:

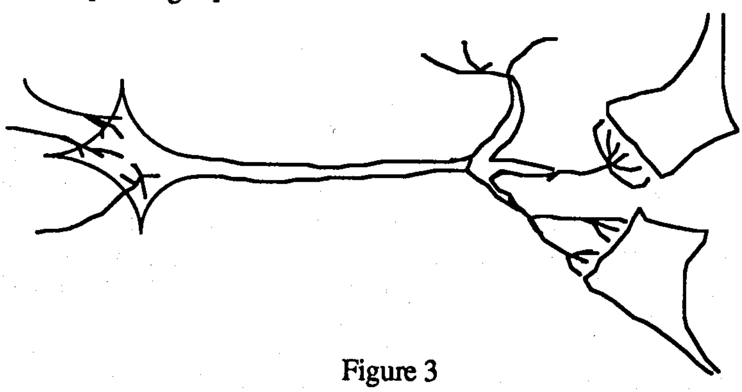

Figure 3

$$\text{Bitcapacity} \cong 10^{10}/10^{6} \times 100! \cong 10^{154}$$

With the rapidly expanding capacity of computers, it is only a matter of time before networks can enter the phase of having more bits of memory than it has components. Once entered, that phase of computer development can extend the memory of neural networks astronomically.

At that phase of network development, it will begin to be practicable to build "cul-de-sacs" which -- with outputs connected to action devices -- can learn wisdom; or with outputs feeding back into knowledge cortex, can learn understanding.