Possibilities of Human Memory Simulation for Brain Based Learning Applications

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Abstract: - In this paper the possibilities of modeling and simulation for human memory based on his working categories is presented. At the beginning the working principle and structure of the neuron and neuronal networks according to the simplified model accepted by neurosciences are developed. The differed kinds of memory like “sensorial memory”, “associative memory”, “recall memory”, “associative memory”, “forgetting memory” etc. are modeled and simulated using McCulloch-Pitts neuronal networks and logic neuronal networks on Simulink platform. The simulation results are satisfactory for several types of memory models and open new perspectives for Brain Based Learning and e-Learning applications.

Key-Words: - human memories, works principle, simulation, logic networks, applications, Brain-Based-Learning, e-Learning.

1 Introduction

The researches in the neurosciences area have clarified many issues related of the human brain activity, remains but many unknowns than are still waiting to be studied. One of the problems that have fascinated centuries among on researchers was the human memory activity.

Although there are still many items to mention, it is considered fully accepted the model of human memory proposed lately. In this model we will continue to showcase the features of human memory, two simulation models based on artificial neural networks which open some perspectives of use the principle Brain Based Learning, by e-learning technology.

The memory is a function representing the ability of human body to store and display information acquired from real world. But human memory is not like as a computer because nowhere in the human body exit a have memory function organ.

The innumerable mechanisms have been proposed for memory, but none has achieved widespread acceptance. There is no mechanism for memory in basic system of survival. Also, there is no special provision for memory as being the organic system advanced. It seems that scientists and philosophers have sought the memory in the wrong place.

All sense organs and other parts of the body transmit or receive stimuli. The stimuli reaching at brain and pass through the nerve fibers along the spinal cord until the brain areas. The path connecting between the organs sense and cortex is achieved through, and are called "nerve channels" or "pathway" [2].

The nerve fibers are formed of the basic functional units, called "neurons" that are excitable nerve cells and constitutes the basic functional unit of the nervous system. Neurons receive signals transmitted bioelectrical signals which are also called the nerve impulses or "the paternal impulses". The total number of neurons in the human brain is estimated at 100 billion (10^{11}).

The neuron is consists of a body called the soma and two types of extensions: axon is only that conducts the electrical impulses to the dendrites, which are up to 7000 per neuron.

Axon has a diameter between 1 and 15 microns, the length varies from one millimeter to over a meter and is extremely rich in micro-tubes. However at the axon can see more connection or terminal segments necessary connections between the dendrites of another neuron, this is called synapses. Each branch ends in a swelling that is the button synaptic terminal or the node and is composed by neuro filament, micro tubes and micro vesicle.

ISBN: 978-1-61804-172-2

In most cases, the axon transmission of the neuron is connected to the dendrites for send information to other neurons. Another neurons are connected the axon to axon, dendrite to dendrite or axon to the cell body. Most connections transferring electrical signal, but has been transferred and chemical molecules called neurotransmitters. They form synapses [8].

These 4 elements: the neuron, synapses, neurotransmitters and electrical impulses are based in the thinking process of human and form the neural networks in the brain. The complex thinking process of human brain is based only on these 4 elements, but complexity is not in these elements that are simple, but in development of complex interconnections between these elements called "neural networks", are more advanced and sophisticated. All neurons operate by changing the voltage. In the rest they have a rated voltage of 70 millivolts. The receipt of neurotransmitter molecules exciter produce increased to the tension and receiving of inhibitory neurotransmitters produce decrease tension. This means that you earn a high voltage for a short period of time, which is transmitted along the axon, and then returns to normal resting voltage. Although neurons receive different excitation voltages, the discharge voltage of the pulse is the same for all. In the absence of an external signal the neurons discharge normally one constant value impulse. This rate varies for different types of neurons, the (7-15) Hz. Upon receipt of the paternal impulses the rate of discharge up to 100 Hz.

In fig. is presented schematically a neuron and a neural network [7].

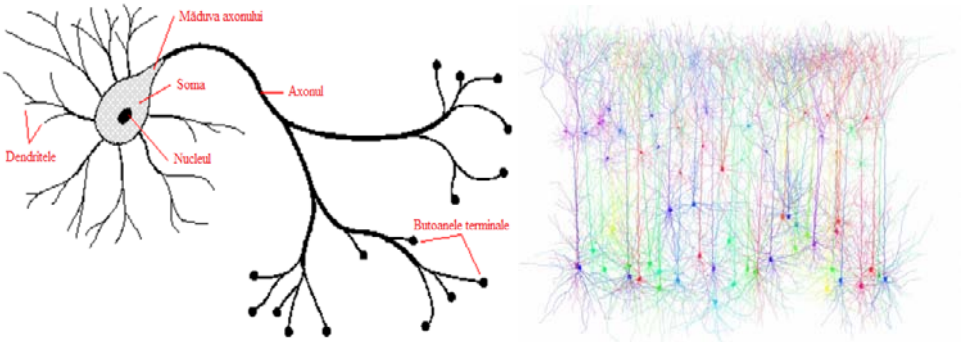


Fig. 1 The neuron and the neural network

The nature has designed an elegant way to accelerate the signal propagation in the human brains. Each passage of a signal through a synapse causes a discharge of neurotransmitter molecules preparing the synapses for the next use. If are used frequently, the synapses are extensively connected. Incoming sensory information signal is making by "paternal impulses" and are retained only as long as the synapses in the neural network are connected. When the connection is lost a new sensory signal must reform to the network. This happens as the detection of stimuli for the first time, nothing is gained from experience. So maintenance of the neural network is done by strengthening the synapses and this is the element key in the mechanism of memory and learning.

The memory is the mechanism to bring awareness of present to what has been detected in the past. The human bodies have distributed the memory along connecting channels of the neurons and neural networks. The mechanism of human memory must be understood by appealing to the way in which the acquisition and processing of information in the real world by human senses. Memory is formed by neurons connecting through synapses and this is done the human senses by transmission of the paternal impulses through the pathway, that by neurotransmitter realize the connection between neurons and neural networks.

The memory an event of real world is physically equivalent to the neural network which was formed when paternal impulses were generated at event detection by senses.

The types of memory

The definition of memory as a mechanism for training that belongs to the past for neural networks by paternal impulses defines an event and the mechanism bringing content in network allows us to distinguish different types of memory [5].

In case of human memory involved the following: strengthening the network, during network maintenance, recognition, memory association, recycling and oblivion.

- The consolidation of memory is made through receiving paternal impulses set after which it performs the synapses. Consolidation can be done by recycling the input from the output of a signal network that is equivalent to repeating information in mind.

ISBN: 978-1-61804-172-2

- If the memory is not consolidated its duration is about 0.5 s and is called "short time memory". If it is consolidated for longer, minutes or hours and is called "intermediate memory". If consolidated is strong or emotional event is strongly or belongs survival instinct the time duration can be up to several months, years or for life and is called "long-term memory". A short time memory unconsolidated is loses the synapses will be "forgotten".
- A consolidate memory which forms the same set of pulses paternal or simulations, represent "the recognition memory".
- A memory formed of pulses paternal some of which are similar to others and have previously formed a network called "associative memory". Those two networks have a common part.
- After the way activities which involved in formation to the memory, we have "declarative memory" which is based on descriptions in words, the events "facts and concepts or procedural memory" formed through activities, exercises, habits creating abilities.
- The declarative memory can be "episodic" or "semantic".

In this fig. 2 is presented the types of memory.

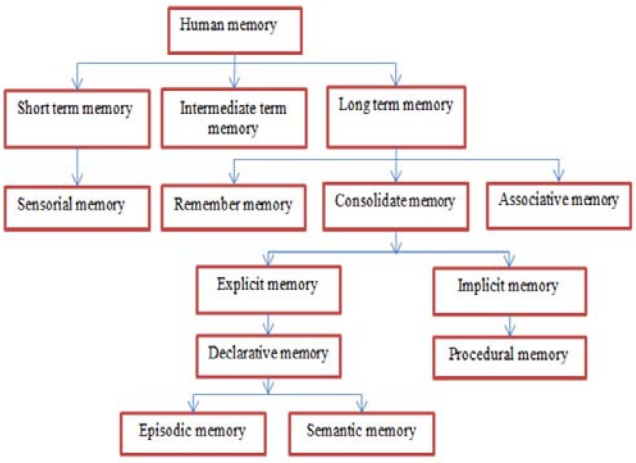


Fig. 2 The memories

The brain has no way to know the origin of internal sensory pathways or a memories generated, they are handled in the same way as those formed by detection of external stimuli.

The learning is formation a memory. Learning is the first detection of a set of stimuli. Most times repetition is necessary for the strengthening synapses from sensory way newly formed.

If it happens that a sensory signal into a previously formed sensory path is equivalent to a sensory signal from the past, it will strengthen synapses of sensory way. This reform to the memory by redetection a set of stimuli is the "recognition memory."

All memories are formed by redetect the sensory signals that strengthen the synapses in sensory way of cortex. This think is made in three ways:

- The sensory signal is formed by redetection an stimuli representing the real objects.
- The sensory signal is formed by detection of similar stimuli in a communication otherwise.
- The recirculation signals produce simultaneously pulses paternal.

This mechanism shows that a memory is not stored somewhere in the brain and then is recalled by consciousness. What is stored in the brain is a sensory way improved, strengthened and consolidated.

All the stimuli detected at the same time, form one homogeneous impulse model called "the complex pulse pattern." This complex sensory impulse is carried by the route assigned to the strongest impulse pattern reaching the set of neurons in the cortex where synapses were previously consolidated.

Suppose that detected a set of stimuli, representing a man and a dog which walk together. After is detect your walking several times is consolidate the strengthened sensory way. Suppose now that the dog is walking alone and impulse pattern detected is large and forms part of the complex pulse pattern. This set of pulses will bring the image of man and dog in mind. So the picture dog brings to the image of man in mind, even though it was not detected at this time. This is "associative memory".

The pattern sensor made be image an object that exists in nature or could be an imaginary object, such as an idea, a philosophy, a habit or a series of movements. Any sensor or set of paternal sensors can be associated with label recognition for generator object of stimuli.

The associating a sensorial model with a label form and all other associations, association which are already received and formed with others dialed in communications and association which may be forgotten by disuse.

It is much easier to put labels and these associations greatly facilitate human thought and communication mechanism, both verbal and nonverbal.

ISBN: 978-1-61804-172-2

2 Modeling and simulation of the memory with neural networks

Modeling and simulation of the memory can be done in two ways: the first is used by neural networks McCulloch-Pitts or the artificial logical networks. Denoting with y, u_i, w_i, θ, respective the output, the inputs and switching step function (Heaviside) to obtain the mathematical model of the neuron: $y = \theta[\sum_{i=1}^{n} w_i u_i]; w_i \in R; y, u_i \in \{0,1\}$.

In another ordering keep in mind that the neuron has the output linear and the products w_i, u_i can be encoded in linear, who allows working with logic signals and the switching function is of type logical changeover.

In this case a logic neuron with two-input that belonging rows and columns will logical function:

$$y_i^k = \bar{u}_i \cdot v_{i-1}^{k-1} + u_i \cdot w_{i-1}^{k-1};$$
$$i \in \{1, 2 \dots n\}; k \in \{1, 2\}.$$

In this case the weights w_i appear like the logical sizes of selection v_{i-1}^{k-1}, w_{i-1}^{k-1}. This tree forms an arborescent logical neural network controllable.

Where the v_{i-1}^{k-1}, w_{i-1}^{k-1} is connected with previous outputs y_{i-1}^k resulting a arborescent logical neural network controllable [3].

In fig. 3 is presented first the two inputs McCulloch-Pitts and second the same by logical neuronal networks. Then build the encoder of the logical function "equivalence" $y = u_1 \cdot u_2 + \bar{u}_1 \cdot \bar{u}_2$ in two ways.

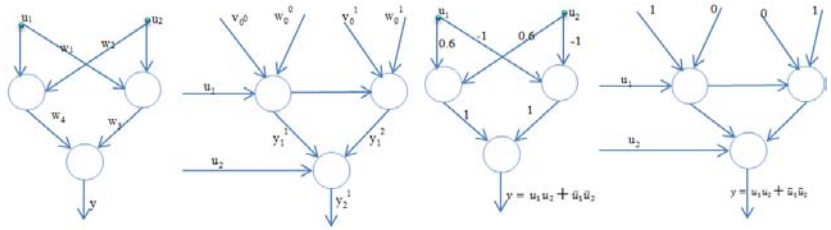


Fig. 3 Two type of neurons and neural networks, McCulloch-Pitts and logical

In fig. 4 is modeled an event which represents the paternal complex set of impulses. Two events A and B are detected simultaneously, forming first sensory memory short term AB. This event is retained, and for event B is created a positive emotion, which is to formulate a long-term recirculation memory. Event B produce a associative memory which triggers the sensory memory BA, forming the "memory", but the event A has not produced the "remember" of memory then "is forgotten" [4] [9].

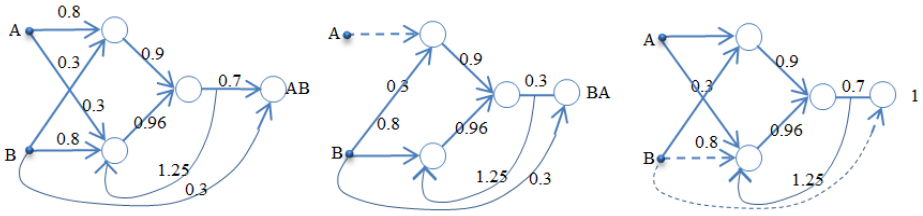


Fig. 4 Types of memory: a) The long-term memory with recirculation; b) The associative memory; c) The forgetting memory

Now consider another situation in which two facts u_1, u_2 are analyzed we simulate the formation of the memory with a neural network logic base on logic table fig. 5.

	u_2	u_1	AND	OR	NAND	NOR	XOR	INH	IMP	EQI
1	0	0	0	1	1	0	0	0	1	1
2	0	1	0	1	0	1	1	1	1	0
3	1	0	0	1	0	1	1	0	0	0
4	1	1	1	0	0	1	0	0	1	1

Fig. 5 The logic function table

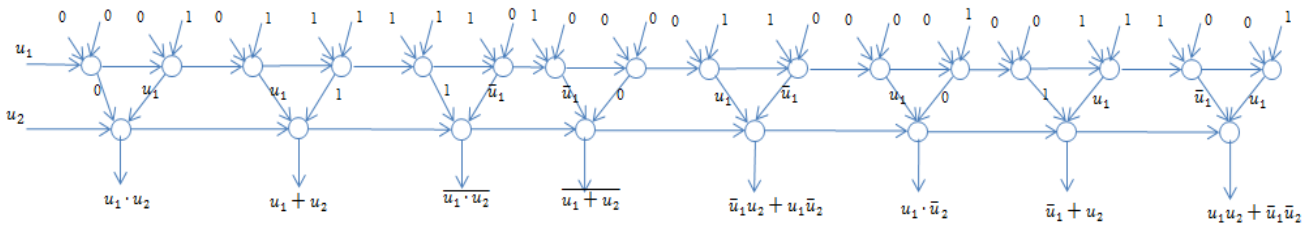


Fig. 6 The 8 logic function of associative memory

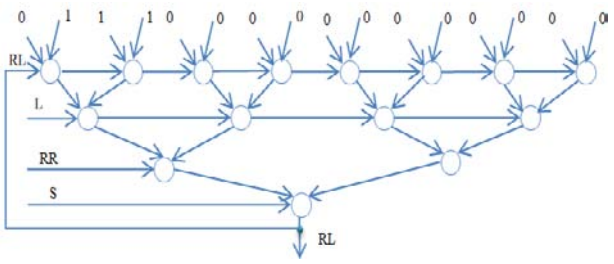
The logical neural network will have 2 inputs and 8 outputs is actually a parallel connection of associative networks. The 8 logic functions are: AND, OR, NAND, NOR, XOR, INHIBITION, IMPPLICATION, EQUVALENCE. For example the paternal impulses"0, 1" are triggered associative memory: OR, NOR, XOR, INH, IMP instead of "1, 0" are only three memories: OR, NOR, XOR.

We consider a technical problem of a reversible control to the motor with commands memorized and simultaneously interlocked commands. Use 3 control buttons: the stop (S), left (L), right (R) and outputs run left (RL), run right (RR).

For each logical outputs are formed the output logic tables and then the 2 neural networks with 4 inputs, two of which is circulating. In the two networks is eliminated the neurons which have the signal inputs equal and that reduce the logical networks.

S	RR	L	RL	RL
0	0	0	0	0
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0

a)



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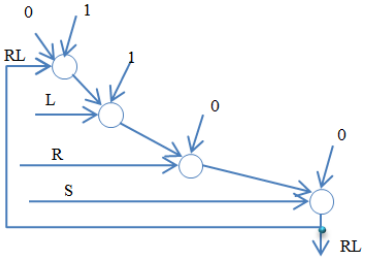

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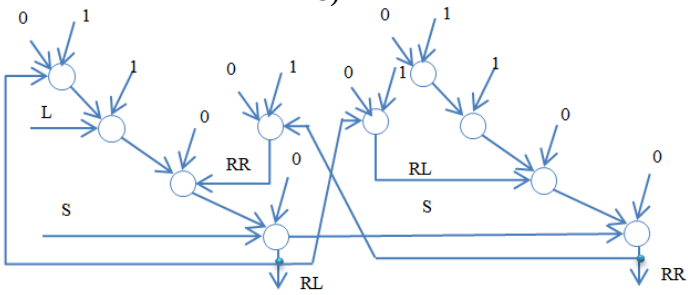
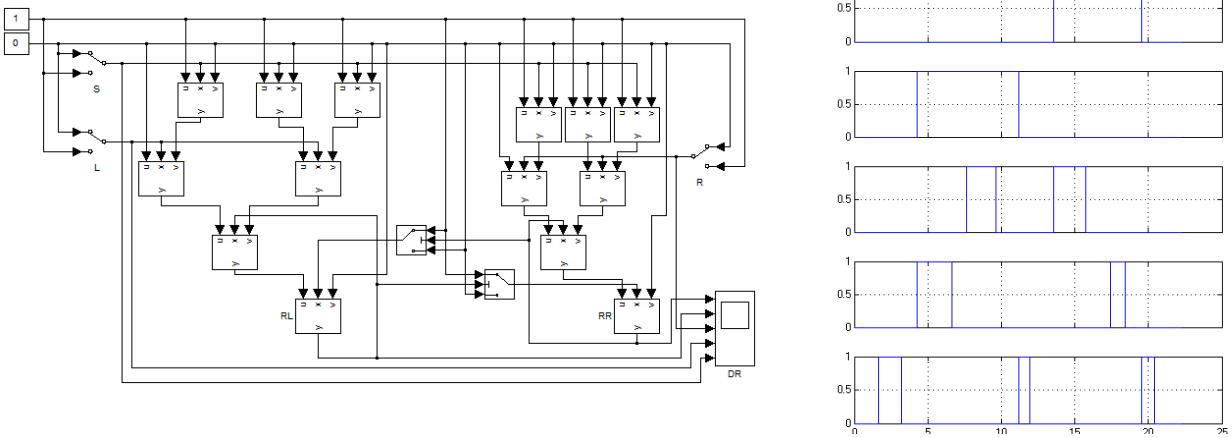


d)



e)

Fig. 7 The neural for motor control logic networks: a) The trues table; b) The neural network for run left; c) The neural network simplification; d) The neural network of control left-right; e) The model results.

ISBN: 978-1-61804-172-2

3 Correlation between memory, Brain-Based-Learning and e-Learning

The education begins with formation of the memories, the knowledge associative memory, the intermediate and the long-term memory following that through superior processing to store values, skills etc.

So that all activities are focused on the use of human hands the education must be also directed to the brain. This is the base of paradigm “Brain-Base-Learning”.

Were drafted a great number principles of this paradigm. Most are addressed to formation of memory and use the information technology, in principle e-Learning. In fig.6 is presented the correlation scheme between Brain-Based-Learning, the memory training and e-Learning.

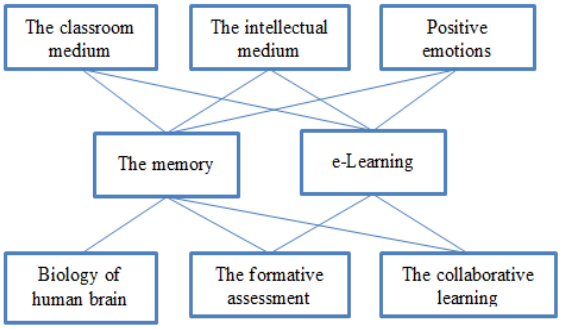


Fig. 6 The correlation between memories Brain-Based-Learning with e-Learning

The ensuring an adequate class for study and an environment for the intellectual activities are very appropriate to the e-Learning education. In this time the positive emotions, formative assessment and collaborative learning are fundamental elements in the e-Learning and memory formation.

4 Conclusion

In the start of this paper has presented the concept and the base events which involved in application of human brain and the mechanism of its formation as a result of strengthening neural networks of the cortex.

In continue was made classification to types of memory after retention time information, by the way training and access its information content. An important part of the work treats method of modeling and simulation of memory both by artificial neural networks as McCulloch-Pitts and logic neural networks.

Is presents some examples of applications that warrant long-term memory formation, memory consolidation by recirculation, the formation of associative memory, recalling and forgetting.

In the applications presented using logic neural networks, can be observed the recirculating signals as inhibition role through using the principle of associative memory. The logical neural networks make the most spectacular solutions in most applications and are very approaching representation of human memory.

Depth knowledge of memory and the formation way, consolidation and release of information of the brain could suggest more ideas to teachers and educators for apply in education, this is shown in the paradigm study "Brain-Based-Learning", using e-Learning technology.

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