1.0

1

As brain is a complex system it is difficult to understand it as a whole. And goal to create humanlike intelligent systems does not require that. More important thing for that is to understand principles of brain functioning. When it is done, there could be different ways to implement those principles using most suitable resources.

One of the ways of understating principles of brain functioning, is to distinguish individual mechanisms of neuron interaction and neuroplasticity, make their most simple realizations and investigate their qualities and capabilities. Using that one could reconstruct intelligent system based on principles that were discovered.

2

Brain learns new information by changing it’s neural structure or characteristics of certain neurons. One of that mechanisms is a "dendritic memory". It is ability to store gained knowledge using branched system of dendritic spines which could be dynamically expanded and aligned. There is also another type of memory, which will be called here as "axonal memory". It is ability to store information using net of connected neurons, which could be changed in certain parts of the brain.

Principles of "dendritic memory" are more of less understandable. Having system of connected neurons that defines basic reflexes and visual elements and other predefined functionaliy, brain can create new dendrites to remember some sequences of spikes of existing neurons. It allows enhance basic reflects and create new behaviors or sequences of actions, that leads to desired states.

There is also second mechanism – creating new neurons. I assume that without creating new neurons it’s not possible to create more advanced behaviors, which contains basic behaviors as their parts.

To make proper investigation of both mentioned kinds of neuroplasticity they should be researched separately. In this work I will show implementation of "axonal memory" or creating new neurons.

2.0

2.1 Environment description

Brain perceives one of two signals – 0 or 1, and tries to suggest what signal will be next. Every time after guess brain gets next input signal and can use it as a feedback to align it’s structure.

So, here is possible samples of right guesses:

111 -> 1

101010 -> 1

110110 -> 1

Brain that will be modelled has that structure:

Two input neurons and two output neurons. Environment could activate one of the input neurons at a time. When signal goes from input neurons to output neurons there could be three situations: first output gets larger signal, second output gets larger signal, both outputs get equal signals. Output that gets maximal output signal is preferred output.

2. Neurons structure samples

As it was mentioned earlier, we will review model where we can create neuron only with axon, and no dendritic tree.

At the start brain has only input and output neurons and no connections between them.

This is neural structure when brain have learned sequence 0..00.

Input 1

Input 2

Output 1

Output 2

When brain have learned sequence 1010 structure would be like

Input 1

Input 2

Output 1

Output 2

When brain have learned sequences 0..00 and 1010… structure would be like

Input 1

Input 2

Output 1

Output 2

This example differs from previous with that here brain uses not only current input but also inputs from previous states.  
Let’s say brain is now on a second position of sequence 101. That means that brain got input 0, and it has two equal possibilities to go to Output 1 through neuron 5 or to Output 2 through neuron 6. Also on a previous step neuron 7 carried signal from 2 to 3. And as that got positive feedback, 7 was hold active for next moment. And at current moment signal from 7 goes to 6 through 8. So, we got neurons 6 and 4 that directs signal to Ouput 2 and one neuron 3 that directs signal to Output 1. Therefore Output 2 get’s larger signal and it becomes preferred output.

3.0

In previous section we saw example of how neurons could store information. Here will be description of application that builds such neuron structure.

3. Structure and definitions

* Every neuron is connected to two other neurons – cause neuron and result neuron.
* If neuron n1 is cause for neuron n, then neuron n is rule neuron for neuron n1.
* Neuron has weight – it is number that characterize it’s influence.
* In a moment of time neuron could be active.
* In a moment of time neuron could be executed.

Essence of neuron – neuron n (from n1 to n2) represents some rule, which defines that if some neuron n1 leads to right output in current moment, then in next moment n2 will also lead to correct output. If rule neuron has been confirmed in current moment, then it could be used as cause neuron in the next moment.

On a picture:

n – rule neuron for n1.

n1 – cause neuron for n.

n2 – result neuron for n.

4. Algorithm

Designations:

– set of input neurons.

– set of output neurons.

– set of active neurons.

Expression means: neuron n connects with dendrite to neuron and connects with axon to neuron .

- weight of neuron n.

1. Perceive input .

2. Let .

3. Compute E – set of executed neurons for A.

4. Compute R – set of result neurons for E.

5. Compute , Ri – connected graph.

6. Compute all sets .

7. Compute preferred output: .

8. Perceive input . Let - corresponding output for input .

9. Make learning using as feedback.

10. Let .

11. Go to step 3.

7. Algorithm execution example.

Given brain structure than already knows 00… and 1010… sequences.

In this example brain perceive input "1" and return output "0". Then brain perceive input "0" and return output "1". Let for all neurons.

First iteration: input "1" -> output "0".

Perceived input .

, ,

,

,

Preferred input .

Input 0

Input 1

Output 0

Output 1

- executed neuron

- active neuron

- result neuron

Second iteration: input "0" -> output "1".

Perceived input .

, ,,

, .

,

Preferred input.

Input 0

Input 1

Output 0

Output 1

- executed neuron

- active neuron

- result neuron

8. Learning

Learning take place at step 9 and it consists of two parts:

* aligning weights,
* creating new neurons.

Aligning weights:

If , then increase weights of neurons from .

If , then decrease weights of neurons from .

Creating new neurons:

If then create new neurons that connect neurons from A to neurons from .

Realization details:

At start there are only neurons with zero weights.

Neuron weight increases and decreases by 0.2. Minimal weight – 0, maximal – 1.

New neuron has weight 0.2.

New neurons connect only neurons that has equal “height”.