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An approach of curing Depression by Artificial Neural Networks (ANN)

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Abstract: **Psychologists have various medical ways to treat depression using counselling, medicines and much more. These ways do not guarantee that depression is totally cured. Depression affects the neurons in brain, decreasing the amount of Neurotransmitter. As neuron suspends reproduction shortly after birth thus the damaged neuron can't be replaced, it can only be treated. Thus if the biological neurons are replaced by artificial neurons then the cure of depression would be permanent. The mathematical equations in the paper also show that the artificial neurone replacement would give a permanent cure to depression.**

***Keywords*: Depression, Artificial Neural Network (ANN), Neurons, Nervous System, Neurotransmitters.**

I. INTRODUCTION

Depression – a word synonymous to today's world. Every instance we come across various people who have suffered depression at some point of time in their life or suffering from it at this very moment. Is depression fully curable? Can medication fully recover a person of depression or the patient has still traces left in him/her? A big question which still stands not fully answered. Let's try and find it. Neural Network one of the pillars of Artificial Intelligence is very similar to our central Nervous System (CNS) and depression affects our CNS very badly. Using these powerful tools of Artificial Neural Network we can try to give a permanent cure to depression.

II. DEPRESSION

Depression is responsible for loss of many budding talents and as well as loss of lives unanswered. Depression as defined in dictionary is:-

- Feeling of sense despondency and dejection
- A long severe recession in an economy and market.

Here in we would be talking about despondency and dejection. Depression may be a part of life as a normal reaction to life struggles and problems. But persisting sadness along with a feel of helplessness and hopelessness may be a condition of medical depression – a medical condition which is treatable but not fully curable.

III. NERVOUS SYSTEM

The nervous system controls the functioning of passing of message throughout the body. Nervous system controls total body functioning – from breathing to sleeping. The nervous system can be segregated into two major parts – CNS (Central Nervous System) and PNS (Peripheral Nervous System). The CNS consists of the brain and the spinal cord. PNS consists of the remaining part of the nervous system other than the brain and spinal cord. The main consistent of the nervous system are the nervous tissue. These nervous tissues are made of two classes of cells, neurons and neuralgia. Neurons are the basic cells of the nervous system which help in transmitting message. The neuron body is divided into dendrites and axon. The neuroglia is present to help the cells to feed, protect and

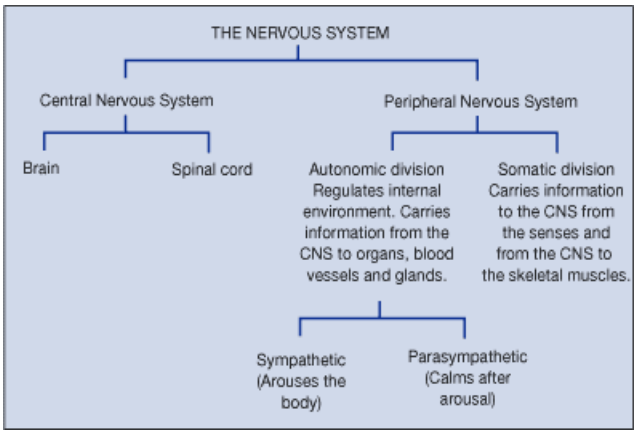

Figure1: Nervous System bifurcation insulate neuron. Neurons almost never reproduce and are vital to the functioning of the nervous system.

IV. NEURON

Neurons are the building blocks of the nervous system. Neurons are nerve cells, similar to other cells in the human body, but they differ in two key ways. One that the neurons are enabled to transmit information inform of electronic impulses form one nerve cell to another. Secondly neurons stop reproducing shortly after birth. Neurons being the basic information processing structure of nervous system, it accepts information as input from other neurons, process information at synapse and then sends it to the next neurons as output. The body structure of neurons includes a cell body with the nucleus, axon, axon, terminal and dendrites.

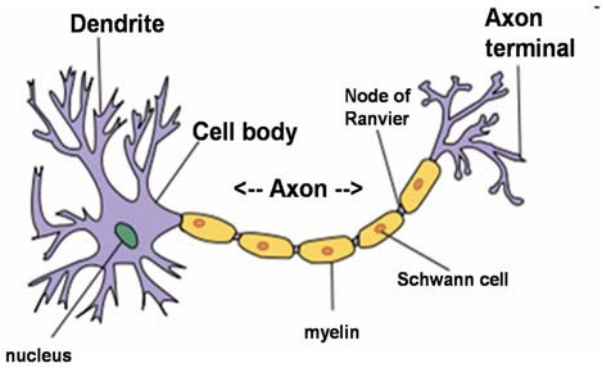

Figure 2: Neuron Structure

V. NEUROTRANSMITTERS

Neurotransmitters are those chemicals which help in transmission of message impulse from one neuron to the next neuron, through synapse. Generally neurotransmitters are released from axon terminals of neurons. The exact number of types of neurotransmitters is yet not known, but it is assumed that there are more than 100 of such kinds available. There are two kinds of neurotransmitters – Inhibitory and Excitatory.

Inhibitory transmitters are those which do not stimulation the brain and helps in creating balance. On the other hand excitatory transmitters are those which stimulate the brain. Thus as these neurotransmitters directly affect the stimulation of brains i.e., mood and reactions of humans, the over active or less active presence may be a reason behind depression. Some familiar names in the types of neurotransmitters are dopamine, nor epinephrine, serotonin, adenosine, epinephrine, GABA and so on.

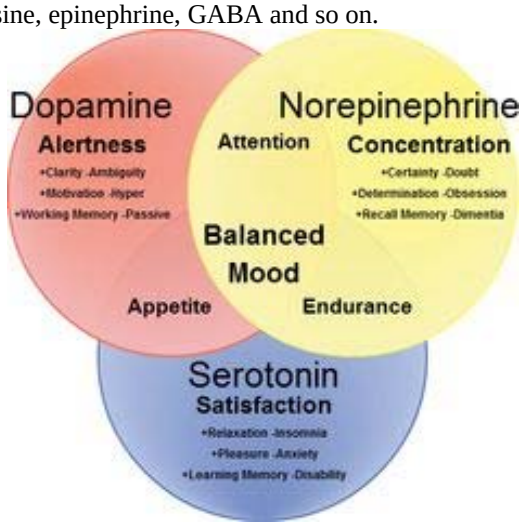

Figure 3: Perfect balance of neurotransmitters

VI. ARTIFICIAL NEURAL NETWORK (ANN)

Artificial Neural Network; This network is quite similar to our nervous system, the functioning of Neurons and their linkages In ANN the biological neurons are replaced by artificial neurons and computational techniques are used for message passing. The human neural network shows the travel of information form dendrites to the target neurons in form of electronic impulses. Similarly the ANN shows the follow of information from inputs to output. Structure of ANN consists of three layers:

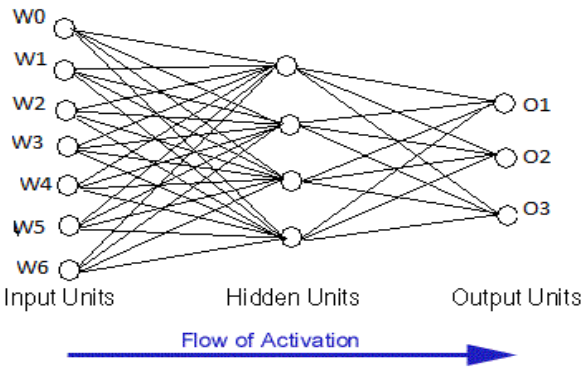

Figure 5: Artificial Neural Network

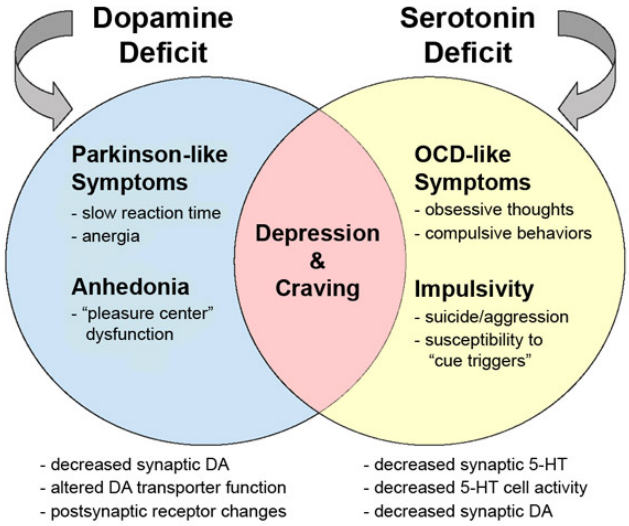

Figure 4: Deficiency in neurotransmitters

A. *Input Layers*

There is only one neuron in the input layer for each predictor variable. If n number of Categories (n-1) neurons are use for categorical variables. It can be standardized by range of values by subtracting the median and dividing by the interquartile range. The input neurons then feed the values to each of the neurons in the hidden layer.

B. *Hidden Layers*

The centres and spreads are determined by the training process. When presented with the x vector of input values from the input layer, a hidden neuron computes the Euclidean distance of the test case from the neuron's center point and then applies the RBF kernel function to this distance using the spread values. The resulting value is passed to the summation layer.

C. *Output Layers*

The value coming out of a neuron in the hidden layer is multiplied by a weight associated with the neuron (W1, W2, ...,Wn in figure) and passed to the summation which adds up the weighted values and presents this sum as the output of the network. Not shown in this figure is a bias value of 1.0 that is multiplied by a weight W0 and fed into the summation layer. For classification problems, there is one output (and a separate set of weights and summation unit) for each target category. The value output for a category is the probability that the case being evaluated has that category.

VII. IMPLEMENTING ARTIFICIAL NEURAL NETWORKS (ANN) TO CURE EFFECTS OF DEPRESSION ON NERVOUS SYSTEM

Referencing to figure, the message transmission takes place between two neurons with help of synapse, adding the nerve cells to pass on the electronic impulses. Similarly, if we consider the artificial neurons the input acts as the message from the pre synaptic neuron, the process acts as the synaptic space for impulse exchange and the output is the message to another artificial neuron acting as the post synaptic neuron.

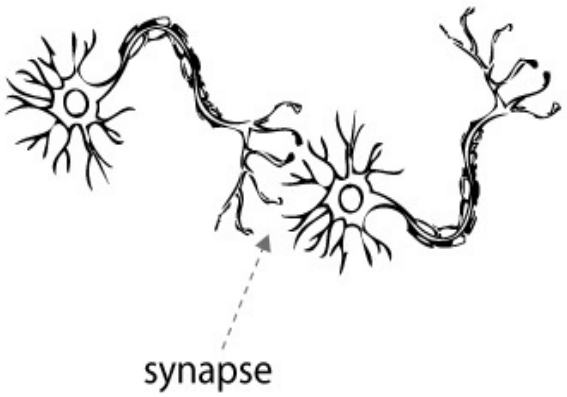

Figure 6: Biological synapse

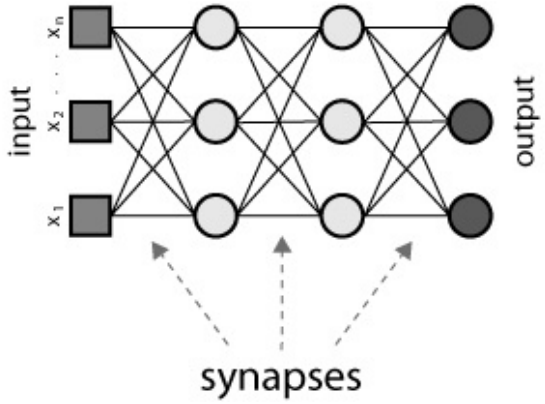

Figure 7: ANN Synapse

Considering the transmission of message for a person in depression, Figure describes the number of neurotransmitters are remarkable less in count. These less numbers neurotransmitters can lead to disrupted message transmission, leading to aggravation of depression conditions. Similarly in the neural network if the links between any of the nodes get disrupted then there can also be a faulty message transmission; leading to erroneous results but damaged artificial neurons can be readily replaced and this problem can be treated effectively.

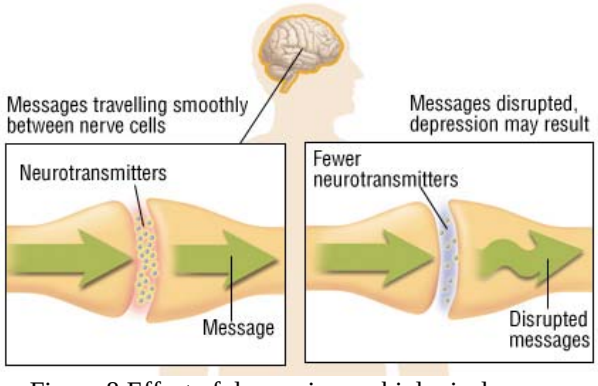

Figure 8:Effect of depression on biological synapse

Neurotransmitters are produced by neurons and if neurons get damaged they are not recoverable naturally. Thus neurotransmitter level cannot be increased without any medical treatment. Medical science till date can't substantially establish that depression is fully curable or recoverable. It has also been observed that neurological effects caused due to depression persist throughout the life.

In this age of advent of computational techniques, cure for depression can be done utilizing the concept of Artificial Neural Networks. As biological neurons do not replace themselves naturally we can replace them with the help of Artificial Neurons. Replacing the damaged neuron by an artificial neuron can give a permanent treatment for depression patients.

VIII. MATHEMATICAL IMPLEMENTATION OF NEURON REPLACEMENT

The body of artificial neuron is a summation of weighted input, bias (due to depression) and it is processed to a transfer function. The output expressions are described below:

$$Y(j) = f\left(\sum_{i=0}^{m} w_i(j) \cdot x_i(j) + b\right)$$

Where:

- $W_i(j)$ is weight value in the discrete time j where i ranges from 0 to m
- X_i (j) the input value in discrete time j where i ranges from 0 to m
- b is bias
- f is the transfer function
- Y(j) is the output value in discrete time j

Transfer function defines the properties of the artificial neuron. The transfer function depends on the problem to be solved using artificial neuron. Generally it is chosen from the following set of functions: Step function, Linear function and Non linear (sigmoid) function.

Step function is a binary function having only two possible outputs zero and one. Thus it can be concluded that if the input value reaches the specific threshold value the output is one otherwise it is different. The following equations describe the function:

$$Y = \begin{cases} 1 \text{ if } w_i x_i \geq \text{Threshold} \\ 0 \text{ if } w_i x_i < \text{Threshold} \end{cases}$$

Here in feed forward approach is used for biological neuron replacement by artificial neurons for depression patients.

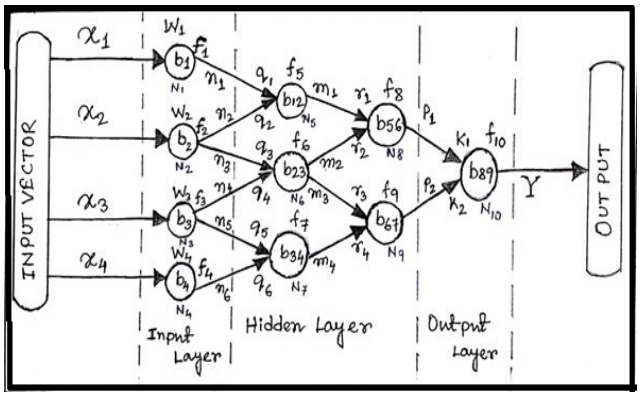

Figure 9: Feed-Forward Artificial Network for 4 input

Considering x, n, m, p, Y as signals and w,q,r,k as weights and f is the Transfer function .

○ Represents Single Neurons. n with suffix number starting from 1 to 10.

The following analytical expressions define the approach:

$$n_1 = f_1(w_1 x_1 + b_1) \quad \text{.....(1)}$$
$$n_2 = f_2(w_2 x_2 + b_2) \quad \text{.....(2)}$$
$$n_3 = f_2(w_2 x_2 + b_2) \quad \text{.....(3)}$$
$$n_4 = f_3(w_3 x_3 + b_3) \quad \text{.....(4)}$$
$$n_5 = f_3(w_3 x_3 + b_3) \quad \text{.....(5)}$$
$$n_6 = f_4(w_4 x_4 + b_4) \quad \text{.....(6)}$$

For next level Hidden layers function as

$$m_1 = f_5(q_1 n_1 + q_2 n_2 + b_{12}) \quad \text{.....(7)}$$
$$m_2 = f_6(q_3 n_3 + q_4 n_4 + b_{23}) \quad \text{.....(8)}$$
$$m_3 = f_6(q_3 n_3 + q_4 n_4 + b_{23}) \quad \text{.....(9)}$$
$$m_4 = f_7(q_5 n_5 + q_6 n_6 + b_{34}) \quad \text{.....(10)}$$
$$P_1 = f_8(r_1 m_1 + r_2 m_2 + b_{56}) \quad \text{.....(11)}$$
$$P_2 = f_9(r_3 m_3 + r_4 m_4 + b_{67}) \quad \text{.....(12)}$$

Output layers function can be written as

$$Y = f_{10}(k_1 P_1 + k_2 P_2 + b_{89}) \quad \text{.....(13)}$$

after replacing value from equation 7, 8, 9, 10

$$Y = f_{10}\left[\begin{matrix} K_1(f_8(r_1 m_1 + r_2 m_2 + b_{56})) + \\ K_2(f_9(r_3 m_3 + r_4 m_4 + b_{67})) + b_{89} \end{matrix}\right] \quad \text{.....(14)}$$

Then again replacing value from equation

$$Y = f_{10}\left[\begin{matrix} K_1(f_8(r_1(f_5(q_1 n_1 + q_2 n_2 + b_{12})) + \\ (r_2(f_6(q_3 n_3 + q_4 n_4 + b_{23})))) + \\ K_2(f_9(r_3(f_6(q_3 n_3 + q_4 n_4 + b_{23})) + \\ (r_4(f_7(q_5 n_5 + q_6 n_6 + b_{34})))) + b_{89} \end{matrix}\right] \quad \text{.....(16)}$$

Finally the output layer equation will be

$$Y = f_{10}\left[\begin{matrix} K_1\left(f_8\left(r_1\left(f_5\left(q_1(f_1(w_1 x_1 + b_1)) + q_2(f_2(w_2 x_2 + b_2))\right) + b_{12}\right)\right.\right. \\ \left.\left. + r_2\left(f_6\left(q_3(f_2(w_2 x_2 + b_2)) + q_4\left(f_3(w_3 x_3 + b_3)\right) + b_{23}\right)\right)\right) \\ + \\ K_2\left(f_9\left(r_3\left(f_6\left(q_3\left(f_2(w_2 x_2 + b_2)\right) + q_4\left(f_3(w_3 x_3 + b_3)\right) + b_{23}\right)\right)\right.\right. \\ \left.\left. + r_4\left(f_7\left(q_5(f_3(w_3 x_3 + b_3)) + q_6\left(f_4(w_4 x_4 + b_4)\right) + b_{34}\right)\right)\right)\right] \end{matrix}$$

.....(17)

In equation no 17 represents all combination of weighted value and biasness. A Hoped Artificial Network used to store more stable target vector. So, those stable vectors recalls when provided similar vectors that act as a cute to the network memory. Those binary units can takes two different values for their states like values of 1 or -1, or values of 1 to 0. There are two possible values for binary unit activations a_i

$$a_i = \begin{cases} -1 & if \sum_j w_{ij} s_j > \theta_i, \\ 1 & otherwise. \end{cases} \quad \text{.....(18)}$$

$$a_i = \begin{cases} 0 & if \sum_j w_{ij} s_j > \theta_i, \\ 1 & otherwise. \end{cases} \quad \text{.....(19)}$$

Where

- Wij is the connected Wright from unit j to unit i.
- Sj state of unit j.
- θ_i Threshold of unit i.

Now from that replacement of damaged neurons by the ANN neurons possible as shown in figure.10

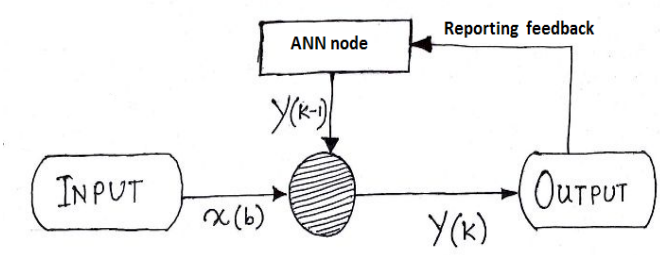

Figure 10: Hopped Network for ANN

After finding the binary equivalent value of Hoped network, a comparison is made with normal network. The damaged neurons are detected and denoted by different color for identification referring to Figure 11.

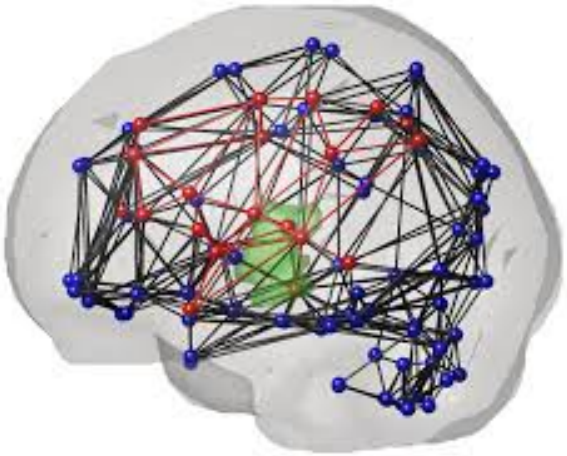

Figure 11: Denoting the damaged and the active neurons in brain by red and blue respectively.

Black dots point the neurons which are damaged and are non active. The blue dots represent the positive thinking, which acts for the betterment of the depressed patients.

CONCLUSION

Replacement of biological neurons by ANN would be an evolutionary step in curing depression fully. Moreover if diagnostics studies are done on a human body using these ANN techniques many more neurological conditions can be fully cured. The computational techniques are being upgraded on every instance thus leading to more advancement and these advancements can be used in betterment of the human race. The race one of the most extraordinary in its form is falling prey to various disorders in course of time. Thus to keep the finest race of earth medically fit, these advanced techniques can be highly utilized.

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