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Role of Balanced Excitation and Inhibition in Modulating the Response Properties of Neural Circuit (Neocognitron)

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***Abstract*—** The visual Pathway system of our brain is very complicated to understand. The Primary visual cortex is used for the vision in our brain. These processes of vision starting from the retina to visual cortex create a long visual pathway a layer by layer approach and hierarchical connection between them. The brain consists of billions of cells for information processing known as neurons. There are two types of Neuron first is excitatory and second inhibitory .So when the information processing is is required the balance between excitation and inhibition. In this research paper we used the Neocognitron an artificial neural network for visual pathway and demonstrate using this that how role is play using the balancing of excitation and inhibition used for pattern recognition task in the various parameters. In this research paper we demonstrated that how excitation and inhibition ratio can be balanced and what happened when it become imbalanced and impact of pattern recognition and using the Neocognitron Simulator tool developed in .NET platform.

***Keywords*—**Visual Pathway,Neocognitron, Exitation and Inhibition, Artficial Neural Network

I. INTRODUCTION

The visual Pathway system of our brain is very complicated to understand. The Primary visual cortex is used for the vision in our brain. These processes of vision starting from the retina to visual cortex create a long visual pathway a layer by layer approach and hierarchical connection between them. The brain consists of billions of cells for information processing known as neurons. There are two types of Neuron first is excitatory and second inhibitory .So when the information processing is required the balance between excitation and inhibition.

Artificial Neural network have confirmed that it is very useful tool for recognition of patterns and image analysis in incredibly efficient manner. So far we say that ANNs are tolerates inexactness, learn from the experienced examples and facilitated high degree of parallelism with massively distributed network. Although, the flare-up of pattern recognition applications in recent years, artificial neural systems have been able to match the capabilities of biological visual systems under very specific and potential conditions. Visual pattern recognition deals with the identification of objects in a image. Optical character recognition, face recognition and automatic target recognition are typical application areas. Conventionally, the recognition problem is broken down into two stages: Feature extraction and classification.[1]

II. RELATED WORK

Neurons are biological cells which are electrically triggered with abilities to process and transmit information through electrical and chemical signals. Neurons are linked to each other via connections known as synapses that enable this signaling.

Neurons are the basic units of neural networks and they transmit signals to each other via using neurotransmitters, which are chemical messengers. The basic structure of neuron is composed of a cell body, dendrites, and an axon. The cell body contains the nucleus and receives the chemical message via input to the dendrites. Then the cell body converts the chemical message into and electrical signal. As a result, potential change in the cells membrane potential will be generated. If the membrane potential goes above the threshold, then the neuron generates an action potential, which is an electrical signal that propagates down the axon and reaches the axon terminal. [2]

Hubel and Wiesel used an amazing technique to discern the function of the various nerve cells in the visual system. They used microelectrodes to record the response of individual neurons in the cortex while stimulating the retina with light. By applying a variety of patterns and shapes, they were able to determine the particular stimulus to which a neuron was most sensitive. The retinal ganglia and the cells of the Lateral

Geniculate Nucleus (LGN) appear to have circular receptive fields.

III. METHODOLOGY AND NEOCOGNITRON

The neocognitron is a multi-layered network, which consists of layers of S-cells and C-cells. These layers of S-cells and C-cells are arranged alternately in a hierarchical manner. S-cells work as feature-extracting cells. Their input connections are variable and are modified through learning. After learning, each S-cell comes to respond selectively to a particular visual feature presented in its receptive field.

The features extracted by S-cells are determined during learning. Generally speaking, local features, such as edges or lines in particular orientations, are extracted in lower stages. More global features, such as parts of learned patterns, are extracted in higher stages.

C-cells are inserted in the network to allow for positional errors in the features of the stimulus. The input connections of C-cells, which come from S-cells of the preceding layer, are fixed and invariable.

Each C-cell receives excitatory input connections from a group of S-cells that extract the same feature, but from slightly different locations. The C-cell responds if at least one of these S-cells yields an output. Even if the stimulus feature shifts and another S-cell comes to respond instead of the first one, the same C-cell keeps responding. Thus, the C-cell's response is less sensitive to a shift in location of the input pattern. We can also express that

C-cells make a blurring operation, because the response of a layer of S-cells is spatially blurred in the response of the succeeding layer of C-cells.

There are several versions of the neocognitron, which have slightly different architectures.[3]

IV. RESULTS AND DISCUSSION

Finally, we discuss the outcome of our research in this section. In this research we take various results that show the role of balanced excitation and inhibition is most important part of neural circuit. In our case we discussed about an artificial neural network (Neocognitron) for pattern recognition and identification task.[4]

First we discuss here the task that deal with the structure of the Neocognitron that we used in the simulator. We divided the task into the main category of learning that is supervised learning and unsupervised learning. Self organizes map and winner-takes-all methods. Figure 1 shows the

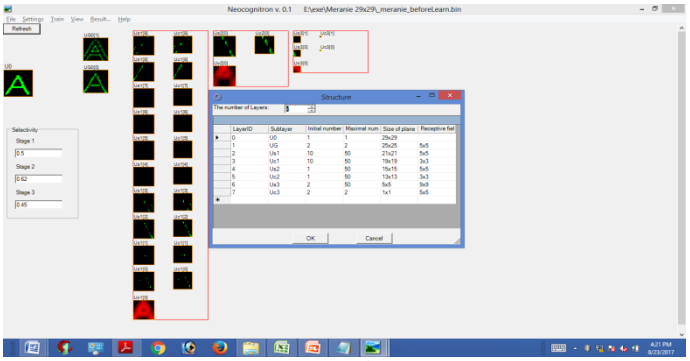


Figure 1 : Structure used for Neocognitron

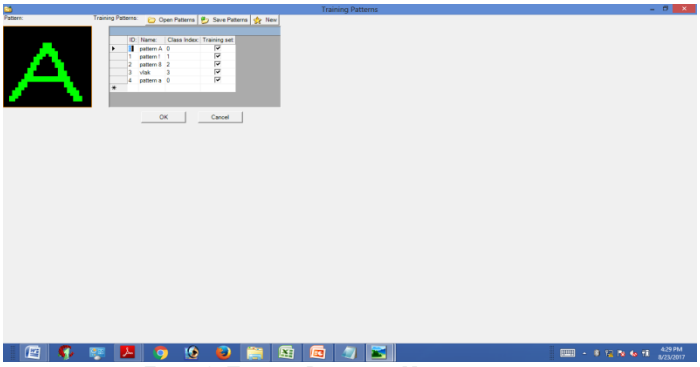


Figure 2: Training Patterns in Neocognitron

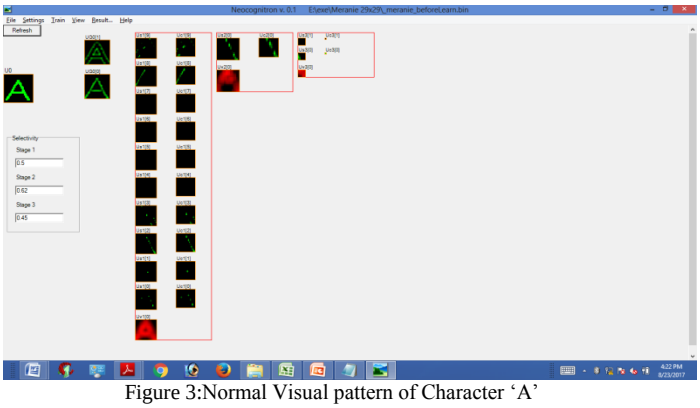
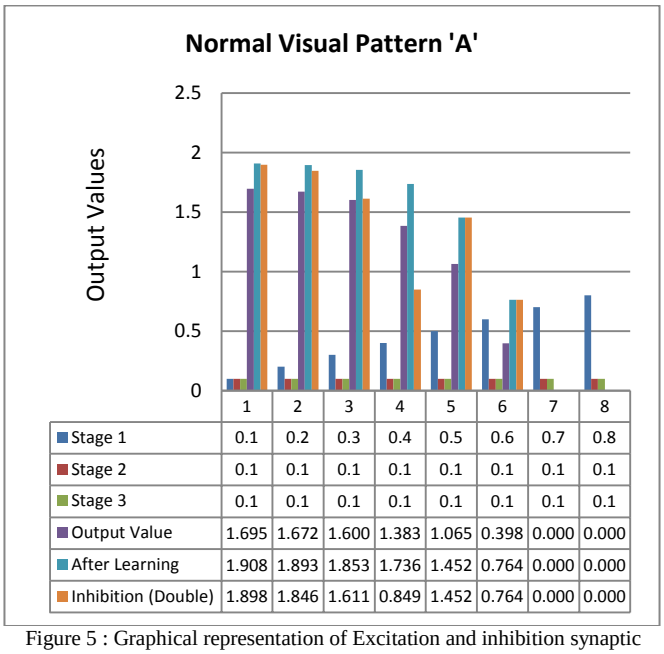


Figure 3:Normal Visual pattern of Character 'A'

Normal A Pattern

Stage 1	Stage 2	Stage 3	Output Value	Winning Output Class	After Learning	Inhibition (Double)
0.1	0.1	0.1	1.695	0	1.908	1.898
0.2	0.1	0.1	1.672	0	1.893	1.846
0.3	0.1	0.1	1.600	0	1.853	1.611
0.4	0.1	0.1	1.383	0	1.736	0.849
0.5	0.1	0.1	1.065	0	1.452	1.452
0.6	0.1	0.1	0.398	0	0.764	0.764
0.7	0.1	0.1	0.000	Not Identified	0.000	0.000
0.8	0.1	0.1	0.000	Not Identified	0.000	0.000

Figure 4 : Excitation and inhibition synaptic weights for Normal Visual Pattern 'A'



	1	2	3	4	5	6	7	8
Stage 1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Stage 2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Stage 3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Output Value	1.695	1.672	1.600	1.383	1.065	0.398	0.000	0.000
After Learning	1.908	1.893	1.853	1.736	1.452	0.764	0.000	0.000
Inhibition (Double)	1.898	1.846	1.611	0.849	1.452	0.764	0.000	0.000

Figure 5 : Graphical representation of Excitation and inhibition synaptic weights of Normal Visual Pattern character 'A'.

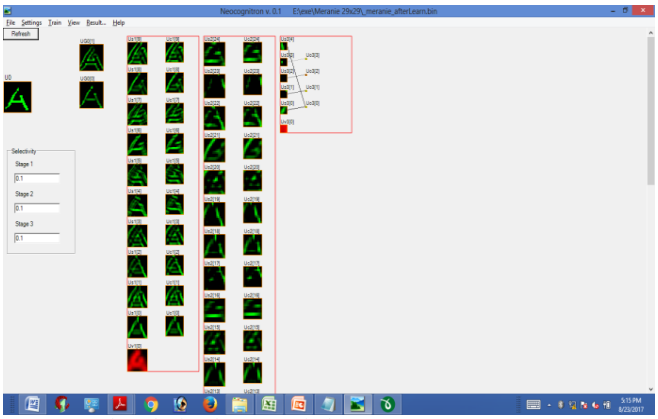
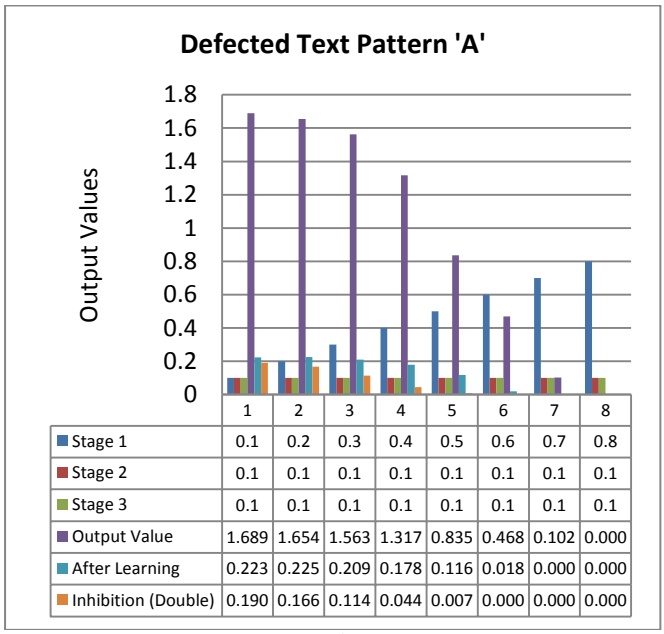


Figure 6:Defected Visual pattern of Character 'A'

Defected Pattern A						
Stage 1	Stage 2	Stage 3	Output Value	Winning Output Class	After Learning	Inhibition (Double)
0.1	0.1	0.1	1.689	0	0.223	0.190
0.2	0.1	0.1	1.654	0	0.225	0.166
0.3	0.1	0.1	1.563	0	0.209	0.114
0.4	0.1	0.1	1.317	0	0.178	0.044
0.5	0.1	0.1	0.835	0	0.116	0.007
0.6	0.1	0.1	0.468	0	0.018	0.000
0.7	0.1	0.1	0.102	0	0.000	0.000
0.8	0.1	0.1	0.000	Not Identified	0.000	0.000

Figure 7: Excitation and inhibition synaptic weights for Defected Visual Pattern 'A'



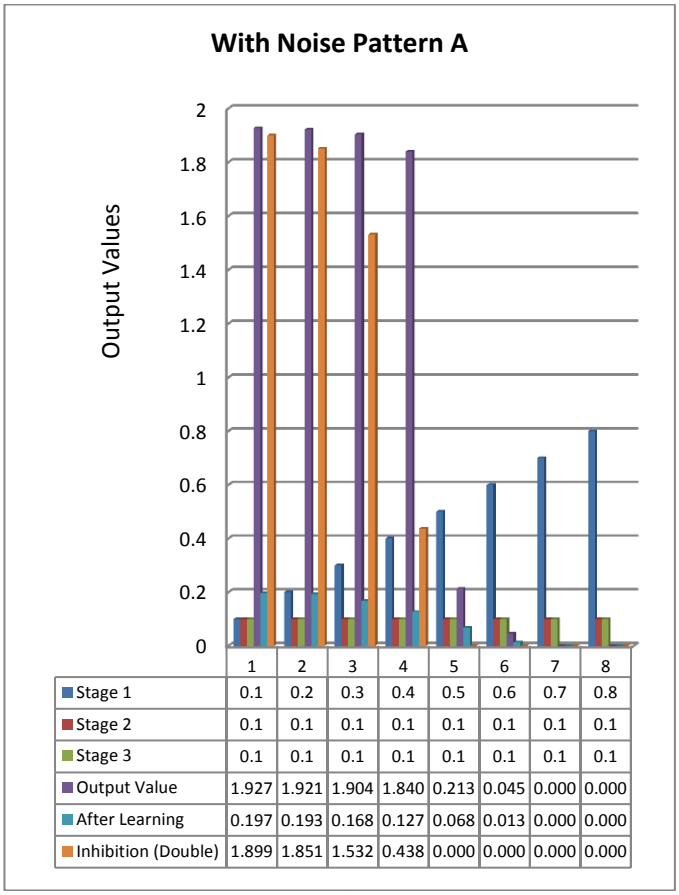
	1	2	3	4	5	6	7	8
Stage 1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Stage 2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Stage 3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Output Value	1.689	1.654	1.563	1.317	0.835	0.468	0.102	0.000
After Learning	0.223	0.225	0.209	0.178	0.116	0.018	0.000	0.000
Inhibition (Double)	0.190	0.166	0.114	0.044	0.007	0.000	0.000	0.000

Figure 8: Graphical representation of Excitation and inhibition synaptic weights of Defected Visual Pattern character 'A'.

Figure 9 :Defected Visual pattern of Character 'A'

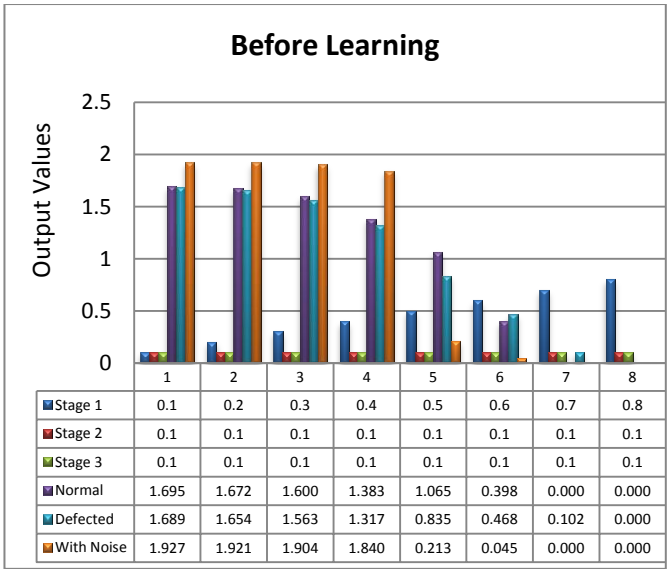
Experiment No.	Stage 1	Stage 2	Stage 3	Output Value	Winning Output Class	After Learning	Inhibition (Double)
1	0.1	0.1	0.1	1.927	0	0.197	1.899
2	0.2	0.1	0.1	1.921	0	0.193	1.851
3	0.3	0.1	0.1	1.904	0	0.168	1.532
4	0.4	0.1	0.1	1.840	0	0.127	0.438
5	0.5	0.1	0.1	0.213	0	0.068	0.000
6	0.6	0.1	0.1	0.045	0	0.013	0.000
7	0.7	0.1	0.1	0.000	Not Identified	Not Identified	Not Identified
8	0.8	0.1	0.1	0.000	Not Identified	Not Identified	Not Identified

Figure 10 : Excitation and inhibition synaptic weights for Noisy Visual Pattern 'A'



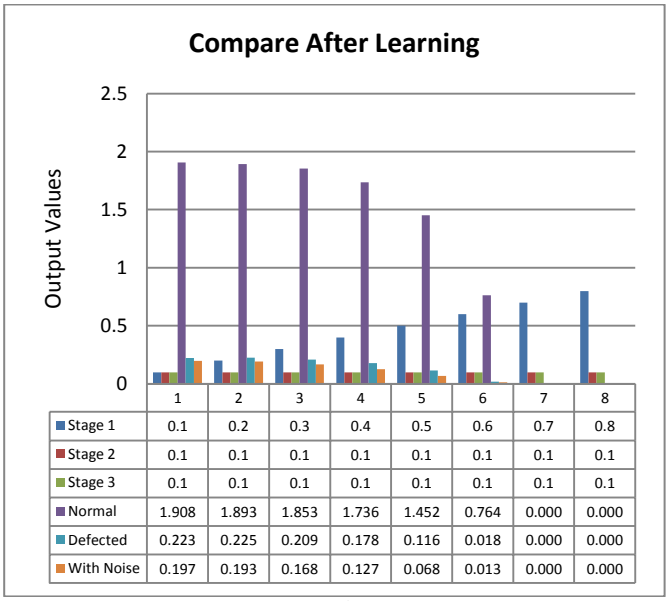
	1	2	3	4	5	6	7	8
Stage 1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Stage 2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Stage 3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Output Value	1.927	1.921	1.904	1.840	0.213	0.045	0.000	0.000
After Learning	0.197	0.193	0.168	0.127	0.068	0.013	0.000	0.000
Inhibition (Double)	1.899	1.851	1.532	0.438	0.000	0.000	0.000	0.000

Figure 11: Graphical representation of Excitation and inhibition synaptic weights of Noisy Visual Pattern character 'A'.



	1	2	3	4	5	6	7	8
Stage 1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Stage 2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Stage 3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Normal	1.695	1.672	1.600	1.383	1.065	0.398	0.000	0.000
Defected	1.689	1.654	1.563	1.317	0.835	0.468	0.102	0.000
With Noise	1.927	1.921	1.904	1.840	0.213	0.045	0.000	0.000

Figure 12: Graphical representation of Excitation and inhibition synaptic weights of Normal ,Defected and Noisy Visual Pattern character 'A' Before Learning phase(Feature Extraction Stage).



	1	2	3	4	5	6	7	8
Stage 1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Stage 2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Stage 3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Normal	1.908	1.893	1.853	1.736	1.452	0.764	0.000	0.000
Defected	0.223	0.225	0.209	0.178	0.116	0.018	0.000	0.000
With Noise	0.197	0.193	0.168	0.127	0.068	0.013	0.000	0.000

Figure 13: Graphical representation of Excitation and inhibition synaptic weights of Normal ,Defected and Noisy Visual Pattern character 'A' After Learning phase(Recognition Stage).

V. CONCLUSION AND FUTURE SCOPE

Now, we conclude our research work on basically done on an Artificial Neural Network (ANN) Neocognitron and role of balanced excitation and inhibition that showed its response properties. We seen that the excitatory and inhibitory neurons in this network plays a very important role to justify in pattern or object recognition activity. If the unbalancing of excitation and inhibition caused the detects only the global feature not local feature of the patterns. We also checked here each and every stage selectivity(Orientation selectivity) value to match the current and previous values that showed the dramatically changes in the behaviour of the Neocognitron's output. The output of the data from the Neocognitron Simulator is used before learning phase and after learning phase. We also compare the data in each stages .The value of Stage1 is clearly mentioned that it will be the feature extraction and Stage 2 and Stage 3 are totally depends upon the Stage1.

In the before learning phase Value 1.69,1.68 and 1.92 is the synaptic weights of Normal, Defected and Noisy Pattern respectively in the stage 1 value of weights are 0.1. It will be depends upon the parameters and orientation selectivity. After Learning we also compared the values of stage selectivity 1.9, 0.2, and 0.1 synaptic weight of Normal ,Defected and Noisy Pattern respectively in Stage 1,2 and 3 value is 0.1.

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