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NEURAL NETWORK FOR RECOGNIZING SIGNAL-SHAPE OF NUCLEAR DETECTOR OUTPUT

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ABSTRACT

NEURAL NETWORK FOR RECOGNIZING SIGNAL- SHAPE OF NUCLEAR DETECTOR OUTPUT. *The use of artificial intelligent technique in the engineering field has been familiar especially in the field of pattern recognition. By using this technique either simple routine works or complicated routine works can be done by the help of a d1g1tal camera and a personal computer. One of the complicated works that can not be solved easily is how to separate two kinds of nuclear radiation types wnich are mixed in the same field. The separation of the two kinds of radiation become is very important for the radiation dosimetry purposes. For doing this we have carried out a preliminary research in applying a neural network technique for recognizing C and T letters with right, left, up, and down positions. We arranged a three-layer neural network i.e. input layer (9 neurons with/without 1 bias neuron), hidden layer (11 neurons), and output layer (1 neuron). From this preliminary study the use of a bias neuron gave faster learning process compared with the one without the bias neuron. The neural network could work successfully in determining the letter S and T without any mistake.*

ABSTRAK

PENGGUNAAN NEURAL NETWORK UNTUK MEMBEDAKAN BENTUK SINYAL KELUARAN DARI SEBUAH DETEKTOR NUKLIR. *Pemakaian teknik jaringan di dalam bidang keteknikan sudah sangat dikenal terutama untuk membedakan bentuk suatu sinyal. Dengan menggunakan teknik ini baik pekerjaan rutin yang sederhana maupun pekerjaan rutin yang sulit dapat dilakukan secara otomatis dengan bantuan sebuah komputer pribadi dan sebuah kamera digital. Dalam bidang dosimetri nuklir, pemisahan antara dua jenis radiasi merupakan hal yang sangat penting. Untuk tujuan itu kami melakukan penelitian untuk menggunakan system jaringan tiruan neural network untuk membedakan dua buah huruf yakni huruf C dan T dengan 4 posisi yang berbeda. Untuk tujuan itu digunakan jaringan tiruan dengan 9 input neuron, 11 neuron pada lapisan tengah dan 1 neuron pada keluarannya. Dari penelitian ini diperoleh hasil bahwa dengan menggunakan 1 bias neuron pada lapisan input dapat mempercepat proses pembelajaran yakni dari 10 iterasi menjadi 5 iterasi. Setelah dilakukan pembelajaran maka jaringan mempu membedakan kedua huruf dalam 8 posisi tanpa adanya kesalahan.*

1. INTRODUCTION

Semiconductor detector becomes more and more popular in nuclear spectrometry caused by its excellent capability in presenting high resolution energy spectrum compared with gas chamber type and scintillator detector . There are many types of semiconductor detectors which have been produced and some of them are still under researched. The utilization of semiconductor detector such as CdTe, CdZnTe or HPGe detectors for gamma and X-rays is more familiar compared with the others due to their suitability in their production and usage.

For high resolution spectrometry purposes some efforts for improving their resolution is still necessary due to their natural fact that their signal shape is strongly affected by the position of interaction between the radiation with the detector. H. Takahashi et al [1,2] reported their woks to improve the spectrum energy resolution and peak-to-Compton ratio of coaxial HPGe detector by using averaging method and leading edge analysis. The improvement of CdZnTe detector performance was also done by A. Niemela et al [3] by cooling the detector to about –30 C and rise time discrimination circuitry to reduce the tailing effect. Similar work has also been done by R.Hess, P.DeAntonis, E.J.Morton and W.B. Gilboy [4] by rejecting pulses which would lead to degradation of the photopeak resolution using the information from the digitized data. H.Sakai et al [4] used neural network to recognize the output signal of CdZnTe and then made a correction of the signal amplitude in order to improve the energy spectrum resolution.

In this meeting I will present my preliminary study to use Neural Network for recognizing two letters T and C with four different positions as the first step to reach the goal namely using Neural Network in recognizing pulse shape from semiconductor detector. The information will be used to determine beta particles and gamma rays pulse shapes.

2. NEURAL NETWORK

It is well known that neural network can be used for pattern recognition. For the preliminary study a simple back propagation neural network is adopted. The way how neural network identify an object is by simulating the human being way of thinking instead of comparing a referent object pixel by pixel with the object being recognized. Neural network consists of neurons and synapses to transfer signal from input to the neuron in the output. Some neurons are arranged as its input layer, hidden layer or layers

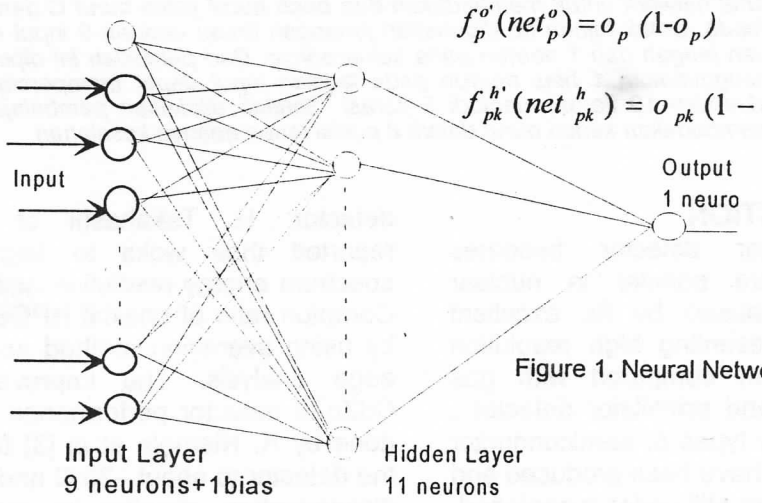

Figure 1. Neural Network system

and output layer and the synapses connect the neurons from one layer to the next one (Figure 1).

During the process of transmitting information there is a difference in efficiency from one synapse to the others. The difference manifests as a multiplication factor that modified the incoming signal. This factor is usually called as connection strength or weight. The value of the weights will be updated during the learning process based on an error value. The error value was obtained from the difference between a teacher with the output of the network. In this study the momentum updating method was used for updating the weights[6].

In the updating process two steps were done namely the procedure of calculating the output and hidden delta values and updating the weights of the output and hidden layer. For calculating the output delta the relation

$$\delta_p^o = (y_p - o_p) f_p^{o'}(net_p^o) \ldots\ldots (1)$$

bellow was used.

And for the hidden :

Where : $(y_p - o_p)$ = the difference

$$\delta_{pk}^h = f_{pk}^{h'}(net_{pk}^h) \sum_{k=1}^{M} \delta_p^o w_{pk}^o \quad \ldots.(2)$$

between

the teacher and the output.

$$f_p^{o'}(net_p^o) = o_p\,(1\text{-}o_p)$$

$$f_{pk}^{h'}(net_{pk}^h) = o_{pk}(1 - o_{pk})$$

O = output function

W_{pk} = weight function of ouput neuron

p= number of letter positions

k=number of hidden neurons

Using these definitions the weight-update equations on both output layer is :

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$$w^{o}_{pk}(t+1) = w^{o}_{pk}(t) + \eta\delta^{o}_{p}o_{pk} + \alpha\Delta w_{pk}(t) \ldots (3)$$

And in the hidden layer is :

$$w^{h}_{ki}(t+1) = w^{h}_{ki}(t) + \eta\delta^{h}_{pk}x_{pi} + \alpha\Delta w_{ki}(t) \ldots (4)$$

Where : i= number of input neurons
η and α = constants which are determined during the learning process.
x_{pi} = inputs

The learning iteration was terminated after obtaining an acceptable error value. After finishing the learning process the weight values were used for recognizing the true input from the measurement.

3. EXPERIMENTAL SETUP

Neural Network which was used is shown in Figure 1. It consists of three layers namely input, hidden and output layers. In this study the network was trained to determining a letter C and T with 4 different positions i.e. right, down, left, up positions for the letter C and down, left, up and right for the letter T, so there are 8 positions. To identify each letter they were divided into 9 parts using Hinton diagram (Figure 2). Based on the division the input layer is composed with 9 neurons if there is no bias.

The number of neurons in the hidden layer was determined by optimizing the iteration number for a certain acceptable error value. The output layer consisted of one neuron. The utilization of a bias neuron in the input layer was tried to speed up the decrease of the error.

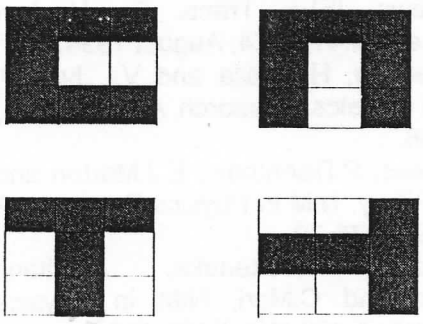
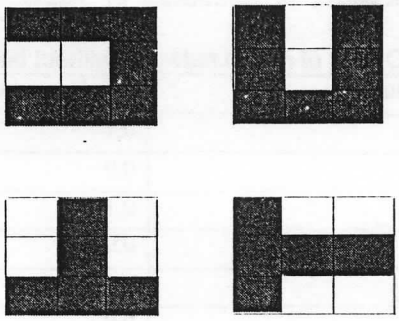


Figure 2. Hinton Diagram of letter T and C in one position



3. RESULT AND DISCUSSION

Neural Networks were made with and without bias neuron. The purpose of using bias neuron is to speed up the learning process. The bias neuron can be put either in the input layer, hidden layer or both layers. For the present study I just added one bias neuron in the input layer to see its influence in improving the speed of learning process. The results of the learning process can be seen in Figure 3 and 4.

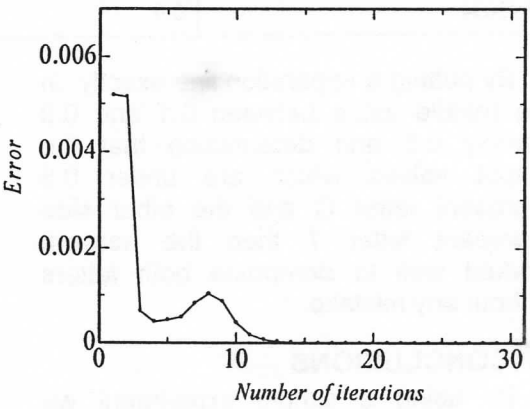


Figure 4. Error during learning process (with bias neuron)

From Figure 3 and 4 we can see that the use of bias neuron in the input layer improved the speed of learning process. The learning process was ended when a certain value of an acceptable error was reached and the acceptable error of 0.000001 was used. After finishing the learning process the last iteration output and hidden weight values were used in the real network. Finally the network was used to determine the letters which were used in the learning process. The outputs

of the network is illustrated in Table 1 and 2

Table 1. Output of neural network (without bias)

Output values	Teacher values	Name of the letter
0.367556	0.1	C (right)
0,982810	0.9	T (down)
0.260192	0.1	C (down)
0.970718	0.9	T (left)
0.404991	0.1	C (left)
0.922477	0.9	T (up)
0.360026	0.1	C (up)
0.898549	0.9	T (right)

Table 2. Output of neural network (with one bias)

Output values	Teacher values	Name of the letter
0.213826	0.1	C (right)
0.733892	0.9	T (down)
0.346487	0.1	C (down)
0.863356	0.9	T (left)
0.285809	0.1	C (left)
0.670622	0.9	T (up)
0.353797	0.1	C (up)
0.892034	0.9	T (right)

By putting a separation line exactly in the middle value between 0.1 and 0.9 namely 0.5 and determining that the output values which are under 0.5 represent letter C and the other side represent letter T then the network worked well to determine both letters without any mistake.

4. CONCLUSIONS

By using a simple experiment we could make a study of the possibility of using a neural network algorithm to determine two different letters namely S and T in four different positions. The neural network will be applied for pattern recognition of the pulse shape of the output of a CdZnTe semiconductor detector in gamma-ray spectrometry. We arranged a three-layer neural network i.e. input layer (9 neurons with/without 1 bias neuron), hidden layer (11 neurons), and output layer (1 neuron). From this preliminary study the use of a bias neuron gave faster learning process compared with the one without the bias neuron. The neural network could work successfully in determining the letter S and T without any mistake.

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