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Estimation of Calcium Deficiency by Medical Image Processing with Back Propagation Algorithm

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***Abstract* -Calcium deficiency among children leads to muscle aches, spasms, rickets, memory loss and confusion. Usually blood calcium and blood urine tests are carried out by doctors to check calcium level in the body. But, the accuracy of these test results is affected by increased calcium level in the blood stream by some drugs like antacids, thyroxin, and vitamin D pills. In order to overcome these problems, a novel methodology introduced in this paper, the calcium level is estimated by simply analyzing the X-ray report of the children. An image processing technique with Back propagation algorithm is used to analyze the X-ray report. The experimental result is compared with standard blood calcium test.**

Keywords – Calcium deficiency, Blood Calcium test, Image processing, Back Propagation algorithm.

I. INTRODUCTION:

In Oman, calcium deficiency among children is common and this problem leads to other serious diseases like memory loss, spasms, numbness and tingling in the hands and face, depression, muscle cramps and easy fracturing of bones.

Usually in hospitals, the doctors carried out calcium blood test to analyze calcium level in the body. Sometime comprehensive metabolic panel (CMP) and the basic metabolic panel (BMP) tests are also referred by them to check the calcium level.

A pilot study is conducted on 35 Omani women in Muscat revealed that 11 of them are in moderate to high risk of Osteoporosis.[1] It is a kind of calcium deficiency related disease. For elderly people, calcium deficiency leads to losing bone mass resulting brittle and fragile bones (Osteoporosis). It increases the risk of fractures. For children and adults, it leads to rickets and osteomalacia.[2]-[4]

Usually, in hospitals the calcium deficiency is diagnosed by taking blood or urine samples. It is the paining process and sometimes children face throbbing sensation. Free calcium in the blood stream is normally detected by this test. Sometimes, this test result is not accurate because the patient may use the drugs like antacids, thyroxin and vitamin D pillsfor some other medication.But, the study results showed that 99% of body calcium is in the bones and teeth. Low calcium level in the body usually managed by bones.When the body suffers low calcium. It takes calcium from the bones. In this critical period, the body bones acts like calcium reservoir. Finally, it leads to calcium deficiency in bones. [5]-[7]

So, the accurate level of calcium in the bones is not accessed by blood or urine calcium tests. In this paper, a novel method is used to estimate calcium level in the bones by simply analyzing the patients X-ray report.

This paper is organized as follows. Section two describes the method of converting X-ray images into recognizable format for MATLAB. Section 3 presents step by step procedure of 2-by-2 neighborhood algorithm for image segmentation technique. It also describes the use of Back propagation algorithm to accurately predict the calcium deficiency among children.The experimental results are discussed in section 4. Finally conclusion is presented in section 5.

II. X-RAY IMAGE ACQUIRING

In this paper, An X-ray image of the child's elbow is taken for analysis. Initially the X- ray image is scanned by digital scanners. In digital scanners the X- ray image is stored in the form of DICAM format. Then the DICAM files are converted into JPEG image format. The digital scanners and software used in this paper is given in table 1.

TABLE 1DIGITAL SCANNER AND SOFTWARE DESCRIPTION

Sl.No.	Item	Description
1	Digital Scanner	Epson Perfection V850 Pro
2	Software used in digital scanner	SilverfastXray 8
3	DICAM to JPEG file format converter	Infraviewer

During DICAM to JPEG file format conversion the number of pixels in the width and height of the JPEG image is maintained 400x400 precision for uniformity among JPEG images. [8]-[10]

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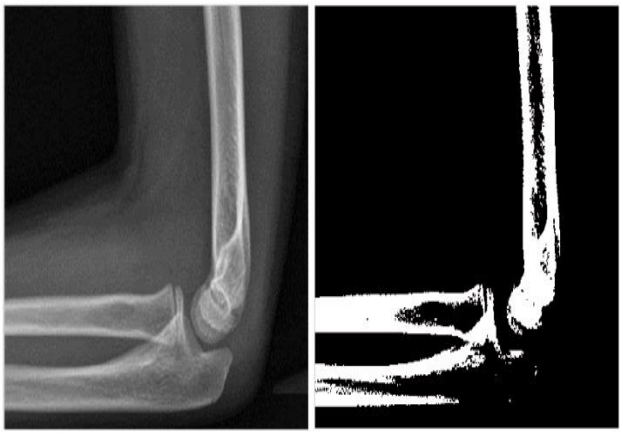
III. IMPLEMENTATION OF IMAGE PROCESSING TECHNIQUE WITH BACK PROPAGATION ALGORITHM

A. Image Segmentation Process

The converted X-ray image in JPEG file format is stored in MATLAB work place to carry out image processing on it. Initially, the JPEG file in the MATLAB workspace is acquired by 'imread' command. Then this gray scale image is converted into binary image by the command 'im2bw'command.In this command all pixels with luminance greater than one are converted as value 1 (white) and replace all other pixels into value 0 (black). The function graythresh is used automatically by the command and the value is set as 0.5.

Other main advantage of using this command is like if the input image is not in the gray color format it automatically converts input image into gray scale image and then convert it into binary image by thresholding. The X-ray gray scale and their corresponding binary images of (a) 5 years old, (b) 10 years old and (c) 15 years old children are shown in figure 1.

A.



(b)

(c)

Figure 1 X-ray gray scale and their corresponding binary images of (a) 5 years old, (b) 10 years old and (c) 15 years old children

B. 12-by-2 Neighborhood Algorithm

Then, the area of white pixels in the binary image is calculated by the command 'bwarea'.By the command 'bwarea'. The area of white pixels is estimated by 2-by-2 neighborhood algorithm. The areas of each individual pixel are estimated by looking 2-by-2 neighborhood. Usually, there are six different types of patterns on pixels are considered to estimate the area of the pixels. They are:

- Patterns with zero (area = 0)
- Patterns with one (area = 1/4)
- Patterns with two adjacent (area = 1/2)
- Patterns with two diagonal (area = 3/4)
- Patterns with three (area = 7/8)
- Patterns with all four (area = 1)

In this algorithm, each pixel is part of four 2-by-2 neighborhoods. Then this calculated area of binary image is given as an input to the Artificial Neural network controller.

C. Artificial Neural Network Controller:

The above said procedure conducted on different aged children and then area of white pixel and the corresponding blood calcium level of healthy children are given in the table 2.

TABLE 2 AREA OF WHITE PIXEL VS BLOOD CALCIUM LEVEL

Age	Blood calcium level	Area of white pixel
5	8.9-10.1	$1.5117*10^4$ to $1.64315*10^4$
8	9-10.3	$1.8989*10^4$ to $2.0143*10^4$
10	9-10.4	$2.0605*10^4$ to $2.1981*10^4$
13	9.2-10.5	$3.5703*10^4$ to $3.7003*10^4$
15	9.4-10.7	$4.5897*10^4$ to $4.6689*10^4$

This information, then, given as an input to the artificial neural network controller.Artificial neural network is a parallel computing system inspired by biological neural network of human brain. It has interconnected processing elements which process information according to the input. Based on topology we can classify the ANN as Feed forward and feedback networks. Normally, feed forward neural network is used because of its simple construction [11]-[13]. In this paper, artificial neural network controller is realized by multilayer feed forward neural network with back propagation algorithm.

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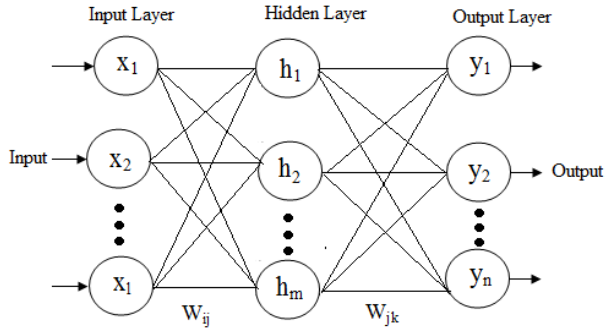

Figure 2Multilayer Feed Forward Neural Networks

The figure 2 shows the structure of Multilayer Feed Forward Neural Network, it has three different layers namely input,hidden and output layers. Here'x' represents the input layer neuron, 'h' represents the hidden layer neuron and 'y' represents the output layer neurons.The input to hidden layer weights are represented by 'W_{ij}'and hidden to output layer weights are represented by 'W_{jk}'

(a) Input Layer: the training data set usually given in this layer, the number of nodes of this layer depends on the data in the training set.In this paper, the area of white pixels in the X-ray image is given as a input training data set.

(b) Hidden layer: the accuracy of the network depends upon the number of nodes in the hidden layer.

(c) Output layer:the number of nodes in this layer depends upon the number of data in the target. In this paper, the patient's age and blood calcium level are set as a target.

Usually, Feed forward neural networks are trained by back propagation algorithm. It is a supervised learning method.The basic concept behind this algorithm is to modify weights between the nodes according to the input signal to get expected output signal. In this algorithm the error between the output and target is used to modify the weightage between the nodes.The network is initialized with randomly chosen weights. The gradient of the error function is computed and used to correct the initial weights. [14]-[17]

The procedure of back propagation algorithm is given as follows.

i) Input training data set is given to the input layer.

$$x_i = (x_1, x_2, \ldots x_i) \quad (1)$$

ii) Net input to hidden layer unit

$$net_{ih} = \sum_{i=1}^{m} w_{ij}\, x_i \quad (2)$$

iii) output of hidden layer unit

$$h_{oh} = \int(net_{ih}) \quad (3)$$

iv) net input to output unit

$$net_{io} = \sum_{j=1}^{L} w_{ij}\, h_{0h} \quad (4)$$

v) output of output unit

$$o_{oo} = \int(net_{io}) \quad (5)$$

vi) delta term for each output unit is calculated by

$$\delta o_n = (d_n - oo_n)\, oo_n (1 - oo_n) \quad (6)$$

vii) The error signals for the hidden layer units

$$\sum_{k=1}^{W} \delta o_n w_{jk} \quad (7)$$

viii) delta term for each hidden unit is calculated by

$$\delta h_j = (h_{oh})(1 - h_{oh}) \sum_{k=1}^{W} \delta o_n w_{jk} \quad (8)$$

ix) The weight error derivatives for each weight between the hidden and output units are calculated by

$$W_{jk} = \delta o_n (h_{oh}) \quad (9)$$

x) The weight error derivatives for each weight between the input unit and hidden unit are calculated by

$$W_{ij} = \delta h_j (x_i) \quad (10)$$

xi) The weight error derivatives between the hidden and output layers are calculated by the equation.

$$W_{jk}(t+1) = w_{jk}(t) + \eta(W_{jk}) \quad (11)$$

Here η represents the learning rate of the network normally I is set at 0.8. [14],[15]

xii) The weights are changed between the input and hidden units

$$w_{ij}(t+1) = w_{ij}(t) + \eta(W_{ij}) \quad (12)$$

The back propagation algorithm is used to find a local minimum of the error function. The network is initialized with randomly chosen weights. The gradient of the error function is computed and used to correct the initial weights.

IV. EXPERIMENTAL RESULTS

Initially the training sets are given to multilayer feed forward neural network. Once the weights of the networks updated. Then the validation sets are given to the network. During this phase the error for each set is monitored.

In the initial state, the error seems to be decreased. If the network is over fit to the data the error starts to rise, at this point the training is stopped. Then the testing sets are given to the network to check the convergence of the network for target.

The validation set given to the network is given in table 3. For this paper, 10 Omani children X-ray report is considered for analysis. The area of white pixels calculated from their X-ray report and their corresponding age and blood calcium level are given in table 3.

From the table 3 it is analyzed that the network gets trained at its 177 epochs with minimum error 1.0e-003 *[-0.3011 0.2212]. at this point the training is stopped. that means the updating of weights are stopped.

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TABLE 3 VALIDATION SET VS ERROR

Validation set	Target	No. of epochs	Error
A1 to A2	Age and Blood calcium level	N	e_p
$1.5117*10^4$	5 8.9	1	[-0.2011-0.0676]
$1.64315*10^4$	5 10.1	2	[-0.1885-0.0521]
$1.8989*10^4$	8 9	3	[-0.1916-0.0678]
$2.0143*10^4$	8 10.3	4	[-0.1858-0.0656]
$2.0605*10^4$	10 9	5	[-0.1801-0.0635]
$2.1981*10^4$	10 10.4	6	[-0.1746-0.0613]
$3.5703*10^4$	13 9.2	7	[-0.1540-0.0546]
$3.7003*10^4$	13 10.5	8	[-0.1041 -0.0233]
$4.5897*10^4$	15 9.4	9	[-0.0792-0.0294]
$4.6689 *10^4$	15 10.7	10	[-0.0567-0.0223]
$1.5117*10^4$	5 8.9	177	1.0e-003 *[-0.3011 0.2212]

Table 4 Testing set Vs output

Testing set	Target	Output from the MFFN in the testing stage
A1 to A2	Age and Blood calcium level	Age and Blood calcium level
$1.5117*10^4$	5 8.9	5.0004 8.89
$1.64315*10^4$	5 10.1	5.0003 10.07
$1.8989*10^4$	8 9	8.0005 8.87
$2.0143*10^4$	8 10.3	8.0002 10..26
$2.0605*10^4$	10 9	10.0006 8.87
$2.1981*10^4$	10 10.4	10.0004 10..38
$3.5703*10^4$	13 9.2	13.0001 9.19
$3.7003*10^4$	13 10.5	13.0003 10.46
$4.5897*10^4$	15 9.4	15.0007 9.35
$4.6689 *10^4$	15 10.7	15.0005 10.66

The table 4 shows the testing set is given to the network after training was over for the network. The test result shows there is no much deviation between the expected output (target) to the output of the multilayer feed forward neural network.

V. CONCLUSION

This paper has shown the step by step procedures to analyze the X-ray report to find the calcium deficiency in child by medical image processing.The calcium deficiency is analyzed by back propagation algorithm. This algorithm is easiest one to implement because of its high convergence speed. He conversion of X-ray images into JPEG images by digital scanners are also seems to be feasible and economical. The experimental results proved that the proposed method is efficient one as compared to the traditional blood calcium test.

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