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Assessing Body Volume Index Using Neural Networks

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Abstract— **Body fat is an intrinsic edifice that constitutes the body. The main purpose of this study is to evaluate the body fat as a succour for medical examination in order to determine the fitness of a person. There are several number of ways which are available for determining the body fat. This study focuses on one of the anthropometric method called Body Volume Index (BVI). The dataset consist of two hundred and fifty person's data. Hundred and fifty data belong to men and rest are women. The Levenberg – Marquardt algorithm is used as an assessing tool to analyse the dataset. The results are compared with the target data results and the accuracy in determining the body fat using LM network is analysed and found that the results are analogous.**

Keywords—**Levenberg - Marquardt Algorithm, body volume index, body fat.**

I. INTRODUCTION

The abnormal accumulation of excessive fat has vitiated the lives of many people. The number of people suffered with obesity continues to rise across the world. Studies have shown that being overweight can increase health risks, such as high blood pressure, diabetes mellitus, coronary heart disease, and certain forms of cancer such as breast cancer, endometrial cancer, and colon cancer [1]. Obesity mainly happens due to the excess of calorie absorption or lacking of physical exercises or combination of both. Besides, several hereditary, behavioural, and ecological issues plays a vital role in pathogenesis. According to World Health Organisation (WHO), in 2015 over 700 million people were obese worldwide [1].

Body fat is one of the major component that makes the structure of the body. The more anatomical term for body fat is adipose tissue. The distinct cell of adipose tissue is named as adipocytes (adipo = fat; cyte = cell). The amount of body fat percentage is assessed to calculate the fitness level of a person. The technical name of body fat is adipose tissue. The main purpose of adipose tissue is to store lipids from which body gains energy and also conceals some hormones. The excess of body fat will lead to the condition called obesity which has vitiated the lives of many people. A person can be obese due to two reasons. The first way is people are generally predisposed and second way is due to lack of physical exercise and bad food habits. Body fat is also an important factor for producing essential hormones in the human body. The human body functions are controlled by these hormones. The brown fat of human body is used to keep humans warm in the severe cold conditions. So the excess or lack of body fat can lead to the many health problems.

One of the main purpose of body fat is to pump out the chemicals from the immune system called cytokines. The chemicals can surge the risk of cardiovascular disease. These biochemical are supposed to make cells less sensitive to insulin, blood pressure, and blood clotting. The excess of fat in the abdominal area can be very harmful since it is placed close to the portal vein that carries blood from the intestinal area to the liver. The body fat releases certain substances that includes free fatty acids, which arrive at the portal vein and travel to the liver, where they can obstruct its functioning. Abdominal body fat is also called as "bad" cholesterol because it clogs the arteries and can lead to a heart attack. The body's muscle and liver cells don't retort sufficiently to normal levels of insulin which is called as insulin resistance. The body cells take in glucose from Insulin. When there is insulin resistance, there is an escalation of glucose levels in the blood rise, which leads to the risk of diabetes.

Vipin et al [2013] used a questionnaire survey and body composition monitor to analyze the housewives in North India in determining the musculoskeletal pain. Mohammad et al [2011] used a multilayer feed forward network with multiple linear regression (MLR) to access the body fat. Hung et al [2013] used Alyuda NeuroIntelligence for discovering the obesity level. The nutritive intake and living behaviors were taken as parameters to predict the body fat. Barbosa et al [2008] used a neural network model which used skin fold thickness measurement techniques with calipers to determine the body fat.

An Artificial Neural Network [ANN] is a simple electronic prototype which is based on the neural structure of the brain. Neural networks are generally presented as systems of interconnected neurons that exchange messages among each other. The connections have numeric weights which can be altered based on understanding and make them skilled by learning. The structure results into various mathematical models like feed forward structure and feedback structure. The input, hidden and output elements formulate the problem into a mathematical structure.

In Artificial neural network, back propagation algorithm is an extensively used technique. During training process it is one of the best way in finding optimal weight sets. The traditional backpropagation algorithm has some disadvantages such as getting stuck in local minimum and slow speed of convergence. The Levenberg – Marquardt backpropagation method is an iterative algorithm which is mainly used for solving nonlinear least squares problems. The data were collected from various physical fitness centres which is located near Thiruvallur.

II. BODY VOLUME INDEX

Body Volume Index (BVI) is a modern measurement for obesity which is proposed as another way of calculating the body mass index (BMI). BVI uses the extent that has the association between mass and volume distribution. BVI can find about the fat contents present in the different parts of human body whereas BMI only takes height and weight into consideration. BVI is the modern day technique which is used for measuring obesity. This modern day technique can create the differences between the people who wave same BMI score, but have different body shape and weight distribution [2]. Because of this BMI assessment does not precisely reflect the individual's health risk it is frequently used. A recent study has suggested that BVI gives more accurate calculation of chemotherapy for cancer patients [4].

BVI can be calculated from the formula as given below

$$BVI = 3(51.44\frac{W}{H} + 15.3)$$

The formula for surface area can be given as follows

$$S = 0.007184 \, X \, W \, (Kg)^{0.425} \, X \, H \, (cm)^{0.725}$$

where W is the weight in kg

H is the height in cms

S is the body surface area in m^2

III. LEVENBERG – MARQUARDT ALGORITHM

The Levenberg – Marquardt algorithm is a second order learning algorithm which has been fast and efficient in training. The Levenberg Marquardt (LM) algorithm is an imitation of the Newton method. It blends Newton's method and steepest descent method. LM algorithm is graded as one of the most effective training algorithms for small and medium sized patterns. It Inherits speed from Newton method and also has the ability of convergence from steepest descent method. This is one of the complex algorithm because not only the gradient is calculated it also calculates the Jacobian matrix. Templates have the same appearance. The performance index of the Levenberg - Marquardt algorithm is calculated using Mean Square Error (MSE).

The vital part of LM algorithm is the calculation of Jacobian matrix. The approximation of hessian matrix using Jacobian suggestively reduces the computational complication. The forward and backward calculations are the techniques which are typically used by LM algorithm. The feed forward calculations are made in order to determine the error. The error from feed forward calculations are propagated back to the network to obtain the Jacobian values. The approximation of hessian matrix can be given as

$$H = J^T J$$

Finally the gradient value can be computed as follows

$$g = J^T E$$

where J is the Jacobian Matrix that has errors with respect to weights and bias and E vector of network errors.

IV. METHODOLOGY

An artificial neural network is developed to analyze the body fat. It involves three layers: the input layer, hidden layer, output layer. In this paper only one hidden layer with 5 neurons is used and trained. The input and target values is fragmented into training, validation and testing. The training dataset is used to impart the neural network. The validation dataset is improved until the training dataset continues. The networks accuracy is calculated using the testing dataset. In the hidden layer the each neurons learn the pattern of the data and chart the relationship between input and target data. It also uses the transfer function to process the data which is received from input layer and then sends the processed information to the output layer for more processing.

The dataset consist of the weight and height of two hundred and fifty persons input dataset which is given in the table below. The network is given with the all the applications then it is arranged for the training process. The weights are chosen randomly using Nyugen - Widrow initialization algorithm.

In this weights are transported only to the active neurons and then the network uses the activation function tansig for hidden layer and purelin for output layer. The training happens until the approximation of the target is touched. The performance of the network is analyzed using Mean Squared Error (MSE) which gives the exact comparison of values. A sample of five data from two hundred and fifty are given in the Table I. The table comprises of height, weight and surface area. The surface area is calculated using the surface area formula.

TABLE I SAMPLE INPUT DATA

Persons	Height (cms)	Weight (kg)	Surface Area (m^2)
P1	181	69.75	1.9886
P2	198.25	73.5	2.1471
P3	216	76	2.2814
P4	207.5	70	2.1130
P5	134.25	67	1.7011

The target for the sample input dataset is given in the Table II. The training of the algorithm stops until anyone of the following condition is satisfied. Condition one specifies that the value becomes closer to the target values or the maximum of mu is reached or the maximum of the gradient is reached or the maximum number of epochs is reached.

TABLE II SAMPLE TARGET DATA

Persons	Target
P1	77.4579
P2	85.6307
P3	94.0004
P4	89.4140
P5	57.0934

V. RESULT AND DISCUSSION

Neural network toolbox from Matlab R2015a is used to estimate the performance of the proposed network with 250 datasets with two parameters with one hidden layer. The hidden layer comprises of five neurons for this study. It uses a three layer feed forward network. The hidden layer has the tansig function as activation function and from hidden to output layer has purelin function. The study allowed a maximum of 1000 iterations. Fig 1 depicts the architecture of Levenberg – Marquardt neural network. The proposed Levenberg – Marquardt neural network is given below in the figure as follows. The performance is measured using Mean Squared error.

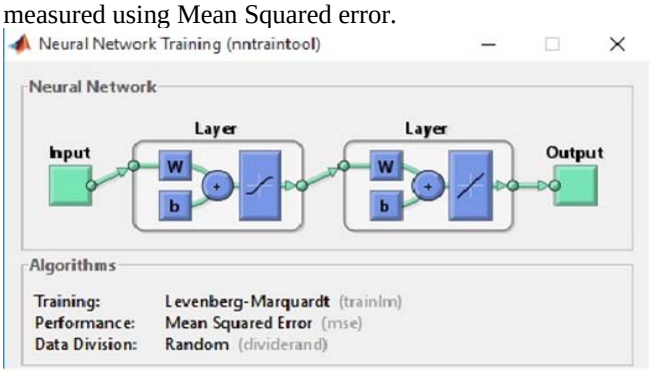

Fig 1 Proposed Neural Network

The training data contains 250x2 where 250 is the number of subjects and 2 represents height and weight of the subject. The two give the value of Body Surface Area (BSA) based upon the calculation of Dubois, Dubois E.F, 1916. The error value is determined using the number of iterations and the threshold value is set as .001. The error value against the epochs were plot to the figure 2. The error value decreases as the number of iterations increases.

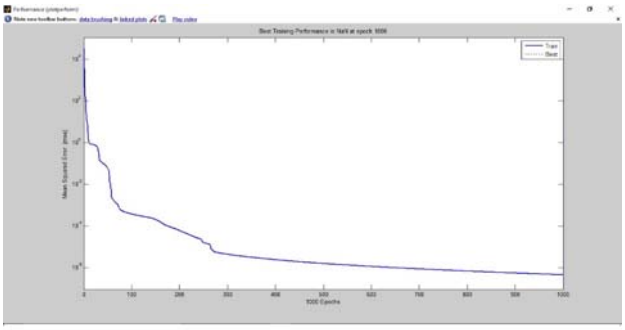

Fig 2 Performance Plot

The performance with respect to number of epochs are shown in the graph which given below in figure 2 respectively. The mu, gradient and validations with respect to epochs is given in the figure 3.

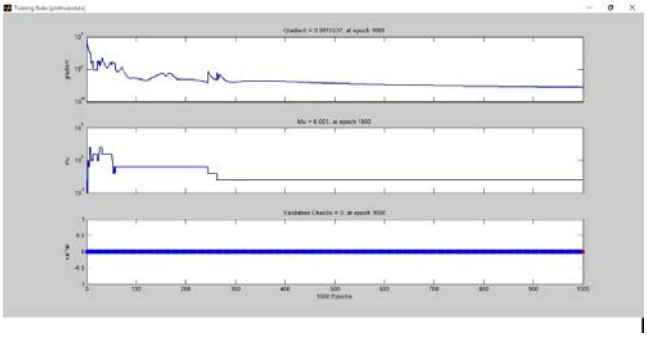

Fig 3 Training Plot

V. CONCLUSION

The BVI method is a contemporary technique which has introduced unambiguous and explicit results. In this paper a neural network based approach for the discovery of body fat is implemented. The detection of body fat is very important, because it leads to many diseases. This paper clearly shows how neural network is used in the clinical analysis in the detection of body fat. This model simply uses the height and weight for the initial execution and calculates the surface area, which gives the body volume index.

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