Predictive Modelling of Musculiskeletal Pain Developed in a Person While Working on VDT Using Artificial Neural Network (ANN)

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ABSTRACT   In this paper predictive model for total pain generated during use of VDT has been developed with the use of Artificial Neural Network. This work consists of two phases, in the first phase persons working on VDTs were asked to fill the questionnaire, with their responses regarding musculoskeletal pain input-output data was framed. Numbers of working hours, sex of persons were considered as input variable however pain is taken as output variable. Using these data Artificial Neural Network has been trained with the help of Feed Forward Back Propagation Technique in second phase. With generating numerous outputs with newer set of inputs, it was predicted through developed model that male person feel less pain with working about 7 hours, however female feels more pain even in 6 hours

INTRODUCTION

Video Display Terminal (VDT) converts many manual tasks into automated tasks in offices, thus making the work place revolutionized. During earlier times Typewriters were used in the offices for hard manuscripts. With advent of VDT the quality associated with the manuscript improved significantly. However stress remained as a factor with the use of VDT. Musculoskeletal Disorders is the state in which musculoskeletal part is damaged with time. Musculoskeletal Disorders (MSD's) MSDs accounted for 29 percent of all workplace injuries requiring time away from work in 2007 (Bureau of Labor Statistics). Studies conducted in Europe and USA shows large number of health complaints, especially visual and musculoskeletal problems, in clerical workers. With the growing use of VDT's musculoskeletal problems among workers is a common problem now days. Due to the introduction of automatic data processing applications there is increase in the musculoskeletal load involved in VDU work (Cooper & Straker, 1998). The musculoskeletal problems mostly associated with VDT workers is pain in shoulders, pain in neck, pain in elbow and pain in hands. Further problem seems to be unseen in Indian industrial culture. In India computers and laptops are used both in government and private offices. Computers and Laptops are more frequently used in service and manufacturing industries. However Indian industries are unaware of MSD's associated with working on computers and Laptops.

Static muscular tension, combined with prolonged shoulder elevation, has been demonstrated to produce significant pain in VDT operators. Static and repetitive postures are repeatedly cited as the major causes of cumulative trauma disorders. Generally VDT standards do not typically follow neutral body posture or encourage appropriate biomechanical movement patterns. (E. Dowler, B. Kappes, A. Fenaughty, AND G. Pemborton)

Computer use is associated with occurrence of musculoskeletal problems. Females had a higher prevalence of musculoskeletal symptoms while males had a higher prevalence of visual symptoms. (D R De A Seneviratne, G K K Sewwandi, S Sharmilee)

Prolonged static loading and the lack of task diversity may contribute to physiological and mechanical stresses on tissues. Although ergonomically correct workstations and unconstrained postures are important in minimizing biomechanical stress on the VDT operator, exercises and increased task diversity may be just as important in preventing cumulative stress and overuse syndromes. (David M kietrys, Philip W McClure, G Kelley Fitzgerald)

VDT workers experience greater subjective response to stress than "office workers" and confirm the gender differences in stress experiencing. VDT workers of both sexes showed higher total stress score vs. office workers. Gender differences were present. Female VDT workers showed higher scores of clusters anxiety and aggressiveness. Male VDT workers' score were significantly higher in somatization and aggressiveness cluster. (Gianfranco TOMEI, Maria Valeria ROSATI, Agnese MARTINI, Lorenzo TARSITANI)

Although many authors reported about MSD developed during use of VDT, despite lack of predictive model has been observed for prediction of MSD. This predictive model is useful for prediction of MSD for both foreign and Indian working condition.

The neural networks are used as a tool for optimizing the placement of icons in an interface. Such networks will be used to determine the exact placement of icons on the screen. This method will be applied in the final phase of system interface evaluation, to give a group of users the opportunity to move icons on the screen as they see fit. Each new position is recorded by a neural network. Afterwards, the networks can be interrogated to deduce the optimal placement of each icon, thus avoiding the necessity of re-programming the interface several times (Arcand, J F)

Artificial neural networks are used in industrial design cases; there is a need to take into consideration various postures of the human body when the product is designed. The research carried will speed the posture transformation of the digital human modeling computationally for design purpose.(B. Zhang, I Horvath, J.F.M Molenbroek, C Snijders).

Keeping these above views artificial neural network is opted in this study for prediction of MSD.

DEFINITION OF THE PROBLEM

As mentioned in previous section MSD was found to be inevitable in both service and manufacturing industries. However complains have been reported mainly from services especially software industries. A problem has been taken from a software industry. Twenty five numbers of employees have been selected randomly based on systematic sampling. It is to be noted that sampling procedure reduces the biased error. Afterwards various questions had been framed regarding related to the pains in hands, neck, shoulder and elbow. Further through questionnaire technique employees have been asked to rate the pain on 5 point scales. In this problem number of working hours and sex of an employee were considers as input variable and sum of all above mentioned pain were taken as output variable.

SOLUTION METHODOLOGY
1. Artificial Neural Network

Artificial Neural Network is an imitating tool which predicts results like human brains (Sangeeta yadav et al. 2010) However unlike of human brains it is programmed tool. Human brain consists of number of neurons which synthesizes into a particu-

lar output. Similar to that Artificial Neural Network also works, in which first weight is assigned on each and every neuron. Further weight is adjusted through iterative procedure in order to minimize the mean square error (MSE). It is to be mentioned that these iterative procedure is followed through a set of programs based on Feed forward Back Propagation Technique. Artificial neural network is a cynosure of researchers in many fields. ANN imitates the activities of the human brain based on the operations of biological Network. (Sangeeta yadav et al. 2010).

2. Neural Network Structure

Processing neurons is the fundamental element of Artificial Neural Network. Input signals are received by natural neurons through synapses located on the membrane of the neuron. Activation function is produced when input data is received by neuron. (Neural Network for beginners, Gershenson, C., 2011). Furthur information is processed through each neuron of hidden layer from the neurons of input layer. This communication continues till information is obtained at outer layer.

3. Artificial Neural Network based Predictive Model

The input-output data obtained through questionnaire as mentioned in previous section are given in table 1.Using these data neural network has been trained with Feed Forward Back Propagation Method. FFBP method is based on iterative procedure. Initially random weight has been assigned on each neuron, and then network develops their own input-output relation on the basis of their weight functions. Further difference in observed value and predictive value from model results into errors. The MSE is given by following equation

$$\text{MSE}(t) = \frac{1}{n}\sum_{i=1}^{k} f_i \left(x_i - t\right)^2 = \sum_{i=1}^{k} p_i \left(x_i - t\right)^2 \quad *$$

* http://www.fmi.uni-sofia.bg/vesta/Virtual_Labs/freq/freq5.html

The back propagation method iteratively tries to minimize the MSE to be 0.00001. The various parameters of neural network model such as momentum, learning rate, number of epochs, number of hidden layers and number of neurons on hidden layer are adjusted through trial and error procedure. The value momentum was tried from 0.6 to 0.8 but found more suitable at 0.75. Similarly learning rate was considered to be 0.35.The number of hidden layers were tried between 2 to 5 but 2 no. of hidden layers are chosen because it gave better result through trial and error method. Similarly number of neurons was tried between 3 to15, but while 10 neurons on each hidden layer were assigned, solution was converging very well i.e. convenience in achievement of goal of Minimum MSE. Number of epochs where solution converged has been taken as 42000. Tan sigmoid transfer function is used in hidden layer and linear transfer function (purelin) is assigned at output layer. The mean squared error is set in the order of. The architecture of developed ANN model is shown in Figure 1.
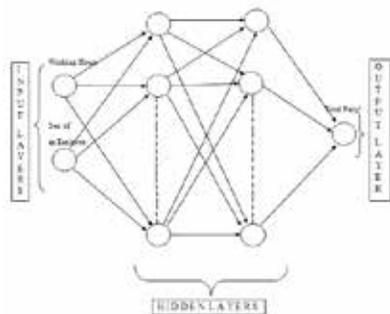
An ANN Architecture for VDT Ergonomic Problem
*Total Pain= Pain in hand + Pain in Neck + Pain in Shoulder + Pain in Elbow

Table 1. Input-Output data obtained through questionnaire

Sex	Hours Spent On VDT per day	Total amount of Pain
Female	6	8
Male	8	9
Male	4	5
Male	9	11
Male	5	6
Female	8	10
Male	7	7
Female	8	10
Male	7	9
Female	8	11
Female	8	8
Male	4	5
Male	7	7
Male	8	9
Male	4	5
Male	6	9
Female	5	6
Male	8	9
Male	8	11
Female	4	7
Male	4	5
Male	9	12
Male	8	8
Male	8	7
Female	8	9

After training of data through Feed Forward Back Propagation method the model was developed through above mentioned procedure. Some of new input values are given in this newly developed model to get new output values. This is summarized in table 2.

Table 2 ANN Model Predicted Values

Sex	Hours Spent On VDT per day	Total amount of Pain
Male	6	8.98
Male	7	7.67
Female	9.4	10.61
Female	4	6.95
Male	6.4	8.75
Female	5.6	5.9
Male	7.4	8.2
Female	8.3	12.94
Female	7.1	7.45
Male	9.2	11.43
Female	9.4	12.656
Female	8.6	10.08
Female	7.7	9.26
Male	6.6	9.15
Female	5.9	7.25
Female	7.8	9.3
Male	6.3	7.64
Female	7.6	10.82
Male	8.8	9.05
Female	7.3	11.69
Female	6.4	11.50
Male	8.3	9.74
Male	4.7	5.41
Female	7.4	8.05
Male	5.2	6.89
Male	7.1	7.48

CONCLUSION

A predictive model for pain generated while working on VDT was developed with ANN. Matlab version 7.10.0.499(R2010a) was used. All input-output data was normalized between 0 and 1. This developed model would help persons who used to regularly working on VDT. It was observed through questionnaire and predictive model that female person fells more pain as com-

pared to male person when they work near about 6 hours. In addition to that predictive model also gives a conjecture about pain for both male and female for a particular span of working time.

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