#### FABRIC HANDLE PREDICTION USING NEURAL NETWORKS

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### ABSTRACT

Handle is an important property of fabrics. In this work we tried to predict the handles of some worsted fabrics by their physical properties using a backpropagation network. Also an unsupervised kohonen network was used for clustering the fabrics. Physical properties of fabrics were measured by universal test equipments and hand values of the fabrics were determined by a panel of judges consisted of some textile experts. The results showed that the backpropagation network could predict the hand values of the untrained fabrics with average one degree of difference. Also the kohonen network could cluster the fabrics well and near to clustering of experts. These results show that these two kinds of neural networks are good tools for predicting hand values and clustering fabrics.

### 1. INTRODUCTION

Handle of worsted fabrics have been in consideration for many years. The first measurement of fabric properties was done by Pierce[6]. He defined the length of a fabric that bends under its weight to a special degree as the bending length of fabric. Using bending length and fabric weight he also defined another parameter named bending rigidity. In 1972 the textile machinery committee of Japan (TMSJ) defined special features for physical and mechanical properties of fabrics like bending rigidity, shearing stiffness,... using comments of worsted mills experts[4]. On the basis of the judgments of experts for different fabrics they defined total hand value (THV) for the fabrics. The value is varying from 1 to 6 and indicates the quality of fabrics. In the Kavabata Evaluating System (KES-F) they designed instruments for measurement of 16 physical properties of fabrics and constructed a model for evaluating fabric hand objectively. Hearle and Amirbayat[3] presented a method for evaluating fabric handle with the use of fewer variables. In another work[1] statistical calculations were done on the physical properties of fabrics to eliminate dependent variables to find a simpler regression model to predict hand value of the fabrics. Their models consist of 3 parameters of physical properties of fabrics. (parameters no 3,6 & 8 in table 1).

## 2. EXPERIMENTS

In the first experiment we used a backpropagation neural net with one hidden layer. Nine important physical parameters of fabrics were used as inputs. The hand value of these fabrics was in the range of 1 for the worst and 5 for the best handle. The network was trained with different hidden layer nodes. The number of training set fabrics was 16 and the output handles were predicted for the other (test) fabrics. This was repeated for all the fabrics and the average of handle prediction was calculated for each network. Learning rates were 0.01-0.05 and the network training was stopped when sum-squared error (SSE) became less than 0.001 or the number of epochs reached 100000. The results of difference between the actual and the predicted hand values are listed in table 2. In the second part we used an unsupervised Kohonen network for clustering the fabrics. Output map was linear and only the winning node was trained. The number of output map nodes was changed from 5 to 10. The learning rate was 0.6 and in each 100 iteration it was divided by two. Training was stopped when the number of iterations reached 100000 or the learning rate became less than 0.0001. Number of input vector parameters was 9 and in another experiment only 3 parameters (parameters no 3,6 & 8 in table 1) were used. The standard deviation of each cluster was calculated and the mean of standard deviation of clusters in each number of output nodes was plotted versus number of output map nodes. The results are shown in figure 1.



**Figure 1.** Average of standard deviation of clusters in the Kohonen network (R: Number of input vector parameters).

### **3. RESULTS AND DISCUSSION**

In the backpropagation network, increasing the number of hidden nodes higher than 6 results the higher difference between the actual and predicted hand value. In other words the generalization ability of the network is decreased. In the case of fewer hidden nodes (5 and 6) some incorrect predictions observed for the training set. It means that with fewer hidden nodes, the memorization of the network is decreased. We see that five hidden nodes construct the best network model for hand value prediction. In this case the average difference between the actual and the network prediction for hand value is about 1.2. This indicates that the selection of number of hidden nodes is very important in neural networks training. Figure 1 shows that the Kohonen network using 3 parameters (parameters no 3,6 and 8) results in lower average standard deviation of hand value in clusters. With 7 output nodes the average of standard deviation of hand values of clusters is minimum and so its correlation with experts clustering is higher. It seems that these networks can successfully apply in textile industry for prediction of hand value objectively and also for quality control and clustering of fabrics to obtain more reliable results.

**Table 1.** List of 9 physical properties of fabrics

Parameter	Parameter	Description	Unit
No			
1	2HB	Hystresis of	gf.cm/cm
		bending moment	-
2	MIU	Coefficient of	None
		friction	
3	SMD	Geometrical	μm
		roughness	
4	LT	Linearity of tensile	None
		curve	
5	WT	Tensile energy	$gf.cm/cm^2$
6	RT	Tensile resilience	%
7	2HG	Hysteresis of shear	gf/cm
		force at 0.5°	
8	RC	Compression	%
		resilience	
9	Т	Fabric thickness	mm

 Table 2. The results of handle prediction by backpropagation network

Number	False	Average	Exact correct
of	handle	difference of	hand value
hidden	prediction	actual and	prediction in
nodes	in training	predicted hand	test fabrics%
	set%	value in test	
		fabrics	
5	17.6%	1.176	23.5%
6	11.7%	1.588	5.9%
7	0	1.588	5.9%
8	0	1.29	23.5%
9	0	1.705	17.5%
10	0	1.705	23.5%
15	0	1.882	5.9%
20	0	1.647	11.7%

learning rate=0.01-0.05

stopping condition: SSE < 0.05 or epoch no=100000

# 4. SUMMARY

Our study has demonstrated that neural networks are good tools for assessing fabric quality. Through the assistance of such intelligent systems, even a person lacking enough experience or skill in evaluation of fabric quality and handle can still easily determine fabric quality in a fraction of a second. To construct a better and more comprehensive model, the number of fabrics that are used for training the network must be increased.

# 5. REFERENCES

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