# A Study of Neural Network for Applying to the Sewing Process : Selection of the Optimal Interlinings

Jung H. Kim, Sung H. Jeong, and Suk K. Song
*Dept. of Textile Engineering, Hanyang University, Seoul, Korea*

## 1. Introduction

Neural Network was defined as a set of very powerful mathematical techniques that learned processes directly from the acquired data for modeling, control, and optimization. Neural Network, a kind of learning algorithm included in the AI (artificial intelligence), has interested researchers in uncertainty reasoning because it could solve the non-linear and complex relationship by parallel computation how the human brain did.

Sewing process combined many stages and each stage needed much labor. For example, in case of manufacturing the men's suits, many stages such as selection of optimal interlinings, layout of pattern pieces, quality assessment, and etc. needed a lot of experts and laborers. For a few decades, the current of sewing process has showed that of automation through the computer and robotics. And this current would be supported and accelerated by Neural Network.

It was very troublesome study to choose proper interlinings because too many considerations were existed for it. For the selection of appropriate interlinings, many factors had an effect on the determination.

To predict the optimal interlinings objectively, Neural Network was used in this study. Two problems were most important in building a fast adaptive Neural Network and selecting optimal interlinings. The first problem was the choice of input and output parameters which characterized the fabrics and interlinings. The second problem was the appropriate normalization of the input and the output data. This paper would be mainly presented about the importance of normalization of the data and the factors accelerating the training speed.

## 2. Experiment

### 2. 1 Sample and Measurement

Thirteen wool fabrics woven for men's suit were used in this study. These fabrics vary in weight, weaving pattern, and structural design. Several interlinings for each fabric were preselected after consultation with a major interlining manufacturer. And then best combination was selected under the consideration of its end use, bond strength, and durability.

The KES-FB System was used to measure the tensile, shear, bending, and compressional properties of the test materials. The measurements were made on the outshell fabrics, interlinings, and fused composites.

## 2. 2 Training with Neural Network

Neural Network was trained with Back-Propagation algorithm and the mechanical properties of fabrics and of interlinings were used as input and output data. The data used for input and output were only warp directional data. The input parameters were chosen by the study of Nagano[2]. He explained the parameters which affected the sophisticated quality of garments. However, the parameters would be changed if Neural Network was not converged through the training because the convergence of network and correct mapping were the most important factors than any others.

After the training, the optimal interlining for a specific fabric was selected by the local approximation[3].

# 3. Results

In order to select proper interlinings, the durability and the stability of interlinings must be considered. The bond strength which was the standard of durability for dry cleaning was evaluated with Tensilometer® when the proper interlinings were preselected by the expert. The environmental deformation caused by the changes of temperature, humidity, and etc was considered in manufacturing stage of interlinings. So the parameters used as input and output were just selected in the range of mechanical properties.

The initialization of weights affected the ultimate solution. Initial weights of the Neural Network to be trained were started at small random values. If all weights started out with equal weight values, and if the solution required that unequal weights be developed, the network might not be trained properly.

Training step started as inputs were presented and the layers' outputs computed with the activation function. In this study, bi-polar sigmoid activation function(①) was used to compute the layers' outputs. The neuron's continuous activation function f(net) was characterized by its steepness factor $\lambda$. Some study led to the conclusion that using activation function with large $\lambda$ might yield bad results for learning. It thus seemed advisable to keep $\lambda$ at a standard value of 1[5].

$$f(net) = \frac{2}{1+\exp(-\lambda\, net)} - 1 \qquad ①$$

Neural Network constructed in this way was trained. But the network didn't get out of low local minimum. So the error value was rippled and it couldn't be converged, which means the training was failed. Therefore another technique, randomizing the computing order of layers, was used to shake the network for getting out of local minimum. But the error value was not decreased under a certain level instead of acquiring desirable value. It was thought that this phenomenon was caused by the fact that the number of data pattern was so small and not effective for learning. The changes of error through the learning were shown in **Fig 1**. So the normalization had to be used for the effective learning of Neural Network.

Neural Network was trained with the conditions that input and output were normalized and other specifications were same with those before normalization. The network was converged through the training as shown in **Fig. 2**. It was inferred that the global minimum was achieved by getting out of local minimum through the adjustment of some factors, insertion of some randomness, and the normalization of input and output.

After the training was finished, the Neural Network was tested to certify the correct learning. To identify the ability of response for the unlearned patterns, Neural Network was tested with three unknown wool fabrics. The averaged values of each unknown fabric were used for input and the results were mapped. In **Fig. 3**, diamond-shaped symbols were the desired output values of 10 kinds of interlinings and the other symbols were the output values acquired by the data of unknown fabric were passed through the learned Neural Network. As the Neural Network was constructed, the optimal output values of the interlinings corresponded to the unknown fabrics could be obtained. The result shown in **Table 1** was that the correct interlinings were selected by using the data of unknown fabrics as those of input. The optimal interlinings were selected in all three unknown fabrics with local approximation technique, too.

## 4. Conclusions

We have reviewed the applicability of Neural Network and local approximation technique for selecting the optimal interlinings. And we have examined the relationship between the learning factors, normalization of data, randomization of Neural Network, and etc, and the convergence properties.

Neural Network and local approximation technique subjoined to select the optimal interlinings in a concrete form were integrated as a tool. The integrated tool used for selecting the optimal interlinings with not only the sampled data but unknown fabric data matched successfully the fabrics to optimal interlinings in all the cases. Consequently, Neural Network and subjoined technique were very effective on the selection of interlinings matched to the wool fabrics for men's suits with only the data of warp direction.

## 5. References


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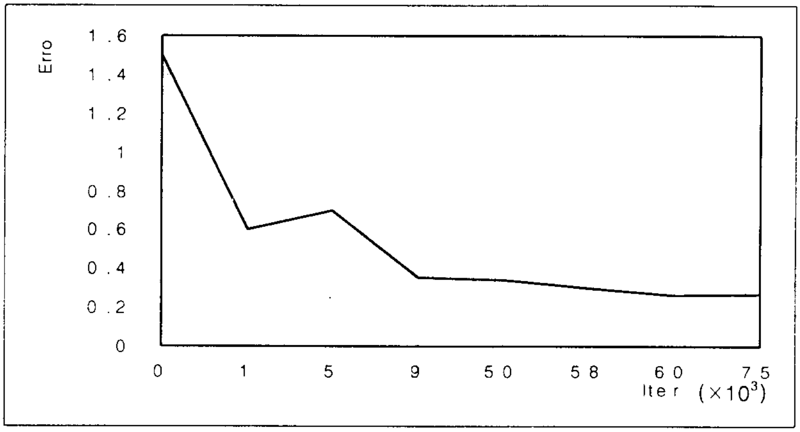


**Fig. 1** Changes of error value before normalization

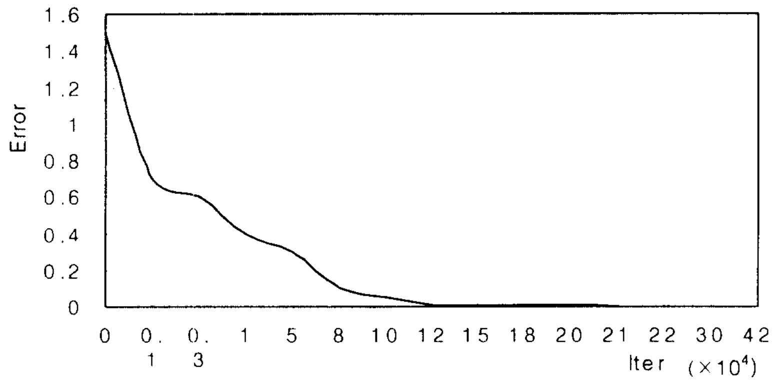


**Fig 2** Changes of error value after normalization

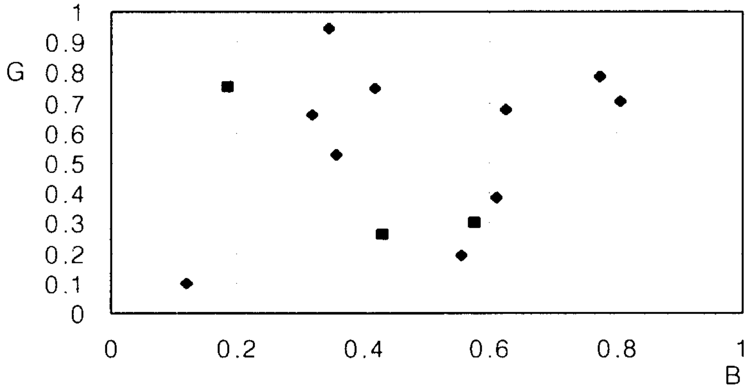


**Fig 3** Mapping for unknown fabrics

**Table 1** The results of local approximation for unknown fabrics

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Min Val. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 0.6895 | 0.0967 | 0.1055 | 0.5293 | 0.4463 | 0.3180 | 0.4763 | 0.3809 | 0.4975 | 0.4681 | 0.0967 |
| 3 | 0.6898 | 0.2210 | 0.1421 | 0.6286 | 0.4147 | 0.2761 | 0.4841 | 0.4566 | 0.3500 | 0.5813 | 0.1421 |
| 5 | 0.2496 | 0.5660 | 0.6744 | 0.5916 | 0.1652 | 0.2870 | 0.2341 | 0.4490 | 0.6578 | 0.6258 | 0.1652 |