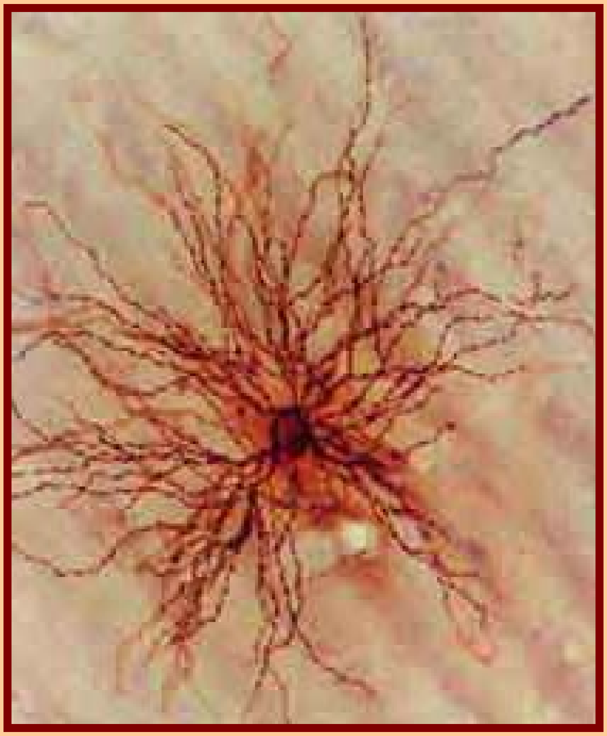
Application of Neural Networks in Fabric Engineering



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Neural Network is an intelligent system that finds widespread applications in many research and engineering fields. Artificial neural network systems is one of the hopes available to textile industry to integrate the elements such as production, quality, cost, information, statistical process control, just-in-time manufacturing computer integrated manufacturing etc,. Artificial Neural Network (ANN) is a field of computer science that seeks to understand and implement computer based technology that can simulate characteristics of human intelligence (that include learning, adapting, reasoning, self-correction and automatic improvement) and human sensory capabilities. Artificial Neural Networks (ANN) are finding applications in textile industry in areas such as fabric engineering, lay planning in garment industry, market prediction, fashion prediction etc

The Basics involved in the understanding of the Neural Networks, their properties, construction, Classification - based on application, advantages of neural computing. Next to the basics, Applications of Neural Networks in the area of fabric engineering is covered extensively. To have a clear-cut idea on exactly how the Neural Network works, a real time expert system (using NN) used in Prediction of Fabric end-uses is presented with the principle involved, Prediction network modeling, Training the network, the logic behind the prediction technique etc. Then, the application list extends and covers the use of NN in detecting the fabric faults, grading the color fastness of the fabric, Measurement / Prediction of comfort properties of the fabric.

1. INTRODUCTION:

Artificial intelligence (AI) is the study of intelligent behaviour and is also concerned with the implementation of a computer program that exhibits intelligent behaviour. AI can be broken into several different disciplines. They are each unique, but often they intermix to accomplish a programming task. The different disciplines are: expert systems, neural networks, fuzzy logic, genetic algorithms and natural language. Among these expert systems and Neural Networks (NN) are finding applications in textile industry

Basically, most applications of NN in textiles fall into five categories: Prediction, classification, data association, data conceptualization and data filtering.

Prediction: refers to predicting some output from inputs using ANN. ex. picking best stocks in the market

Classification: used to identify an unknown pattern that exists in a data

Data association: refers to recognizing data that contains error. It can be used both for identifying the characters that were scanned and also for identifying scanner when it is not working properly. (Feature extraction)

Data conceptualization: it is inferring grouping relationships from the input data. (System modeling, Synthesis etc)

Data filtering: it is concerned with the smoothening of input data. It can also be used for taking noise from the input data.

Since the concept of neural network is very recent in the area of textiles, it is essential to know what neural network is all about and the basic concepts involved in it so that the rest of the information in this paper can be interpreted in the right sense.

2. What neural network is all about...?

A neural network is a computational structure inspired by the study of biological neural processing. Biological neurons transmit electrochemical signals over neural pathways. Each neuron receives signals from other neurons through special junctions called synapses. Some inputs tend to excite the neuron; other tends to inhibit it. When the cumulative effect exceeds a threshold, the neuron fires and sends a signal down to other neurons. An artificial neuron models these simple biological characteristics.

Each artificial neuron receives a set of inputs. Each input is multiplied by a weight analogous to a synaptic strength. The sum of all weighted inputs determines the degree of firing called the activation level. The input signal is further processed by an activation function to produce the output signal which, if not zero, is transmitted along. The activation function can be threshold function or a smooth function like a sigmoid or a hyperbolic tangent function.

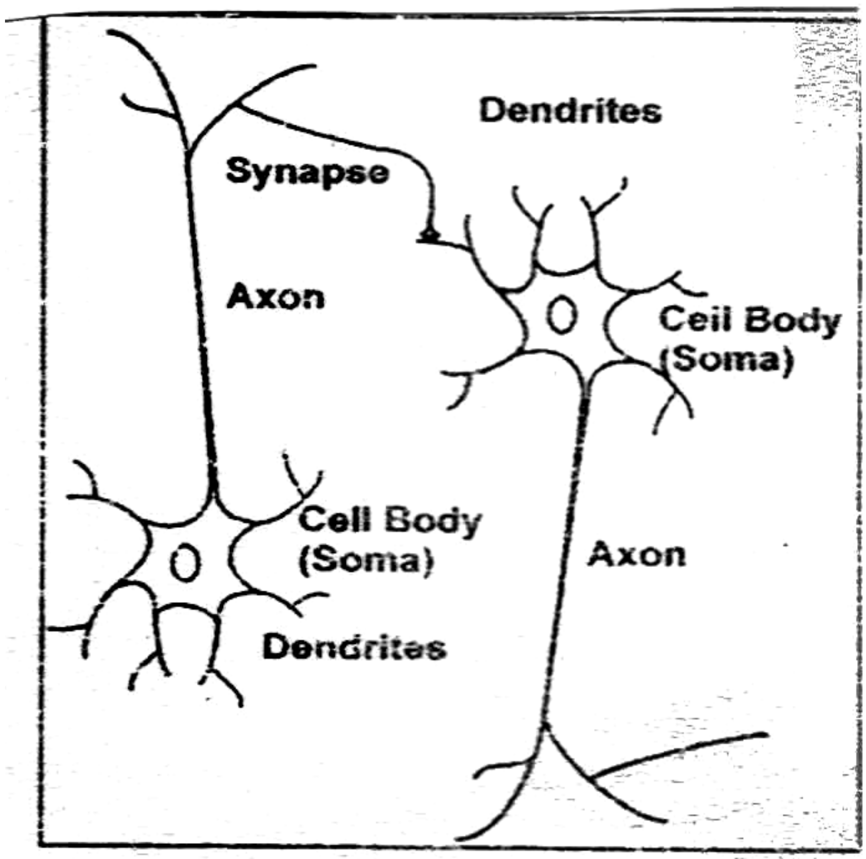
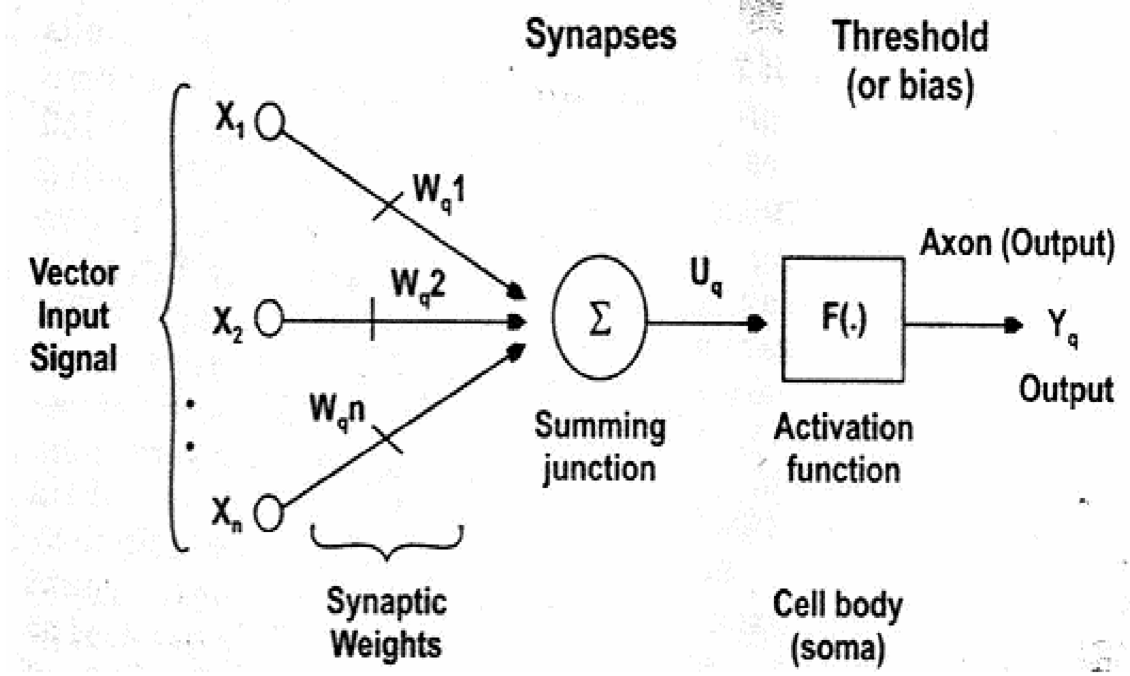


Fig 1 : Schematic drawing of biological neurons

Schematic diagram showing the artificially activated Neuron



Neural networks solve problems by self-learning and self-organisation. They derive their intelligence from the collective behaviour of simple computational mechanisms at individual neurons. Computational advantages offered by neural networks include:

Knowledge acquisition under noise and uncertainty
Flexible knowledge representation
Efficient knowledge processing
Fault tolerance etc…

3. Basic concepts of neural networks

A neural network has a parallel-distributed architecture with a large number of nodes and connections. Each connection points from one node to another and is associated with a weight. Construction of neural network involves the following tasks:

Determine the network properties: the network topology (connectivity), the types of connections, the order of connections, and the weight range.

Determine the node properties: the activation range and the activation (transfer) function

Determine the system dynamics: the weight initialization scheme, the activation-calculating formula and the learning rule.

3.1. Network properties

The topology of a neural network refers to its framework as well as its interconnection scheme. The framework id often specified by the number of layers and the number of nodes per layer. The types of layers include:

The input layer: the nodes in it are called input units, which encode the instance presented to the network for processing

The hidden layer: the nodes in it are called hidden units, which are not directly observable and hence hidden. They provide nonlinearities for the network

The output layer: the nodes in it are called output units, which encode possible concepts to be assigned to the instance under consideration.

According to the interconnections scheme, a network can be both feed forward or recurrent and its connections either symmetrical or asymmetrical. Their definitions are given bellow:

Feed forward networks: all connections point in one direction (from the input toward the output layer)

Recurrent networks: there are feedback connections or loops

Symmetrical connections: if there is connection pointing from node i to node j, then there is also a connection from node j to i

Asymmetrical connections: if connections are not symmetrical as defined above, then they are asymmetrical.

4. Fabric engineering

The very word "fabric engineering" does not restrict itself with fabric alone. It includes back propagation starting from yarn engineering to fiber mixing or sometimes up to the selection of fibers. This paper highlights first the different areas of fabric production where ANN is used and then continues with different areas of application of ANN in yarn manufacturing and ends with the extent of exploitation of ANN in the area of fiber selection and fiber mixing prediction.

4.1. Application of ANN in Fabric engineering

Basically the concept of measurement or inspection using ANN is same for all applications except for the fact that whether the network is going to be a trained one or a back propagating network. Since it will be too lengthy to describe all the measurement principles, here one method of measurement in textile application (prediction of fabric end-uses) is dealt in detail and for the other methods, the basic concept involved for measurement or application is dealt.

4.2. Prediction of Fabric End-use Using a Neural Network Technique

Optimization of fabric end-use in apparel design and garment manufacture mainly relies on human experience in judging fabric hand. With the impact of high technologies on the textile industry, more and more synthetic fibers are now used for developing new fabric search and selection and purchase control in garment making. It is therefore necessary to develop a type of expert system to solve this problem.

4.3. Expert system in the form of Neural Network

The establishment of such an expert system needs a large volume of information input regarding the interpretation of fabric hand, because fabric hand is complicated fabric behaviour. Evaluation of fabric hand is usually divided into subjective and objective assessment. Much of the research was dedicated to the former approach. Recently, neural network model was established for predicting fabric end-use based on the Kawabata instrumental data.

4.3.1. Objective:

To establish a relationship between fabric properties and end-uses that will help apparel designers to integrate fabric properties into garment design so that proper use of fabric materials can be assured. It will also help garment manufacturers in fabric purchase control.

4.3.2. Principle involved:

One hundred samples of apparel fabrics were selected and measured using Kawabata KES-FB instruments. Instrumental data of the fabric properties and information on fabric end-uses, suiting, shirts and blouses, were input into neural network software to train a *multilayer perceptron** MLP model. The prediction error rate from the established neural network model was estimated using a cross-validation method. Then the available fabric samples are predicted for its end-uses in the trained model.

5. Neural network modeling

5.1. Collection of training data:

100 apparel fabric samples from fabric manufacturers and garment manufacturers were tested using the KES-FB instrument, which can provide 15 instrumental parameters. Each fabric sample was tested in both warp and filling direction for some parameters including fabric weight, bending length etc. Then mean values were calculated for each parameter. Thus, the 100 fabrics were divided into three groups as blouses, shirts and suiting that formed the desired output.

5.2. Training and evaluation:

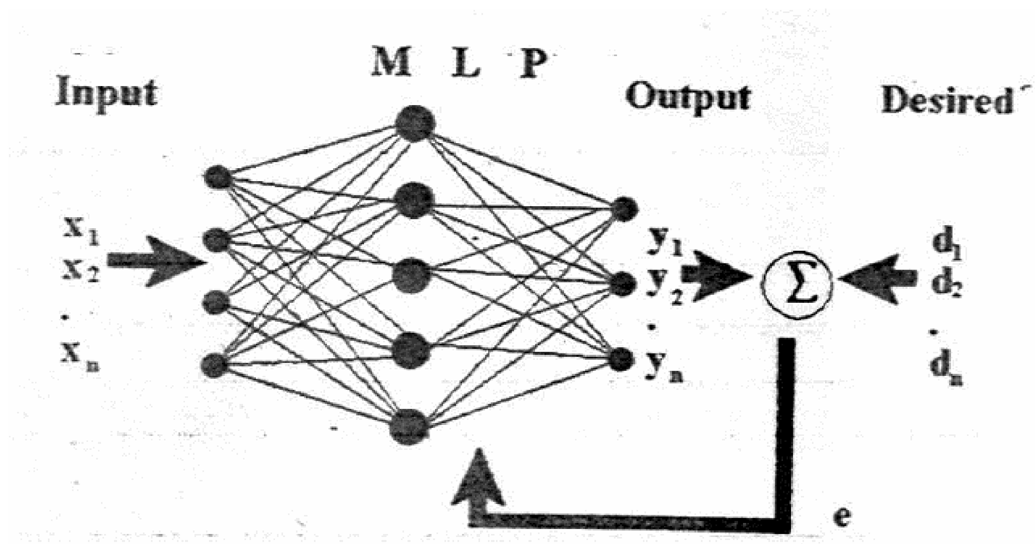
100 samples were split in to two parts: 90 samples for training data set and 10 samples for the testing data set. Before the model was built, the mean square error level was defined as 0.01. The training process would terminate once the mean square error dropped below 0.01. To supervise the training process, the learning curve concept was used. If the training was successful, the learning curve should approach zero as shown in the figure.

To test the effectiveness of the trained model, 10 samples were randomly collected from 90 samples and the computed responses were compared with the desired responses. The computed responses exactly matched the desired responses confirming the effective ness of the system.
The cross validation was done by the left out 10 samples and by batching the 100 samples into groups of 10's.

MLP has two characteristics as, they are non-linear and any element of a given layer is fully interconnected with all the elements of the next layer. They were selected because of its power for solving pattern classification.

Schematic Diagram showing the MLP model

5.3.



Reliability of the system

By cross-validation, the estimated error rate for prediction was 0.07. The established neural network model could be upgraded and the error rate can still be minimized by inputting new fabric samples and be implemented for applications in garment design and manufacture.

5.4. Significance for industrial application

This neural networking technique illustrates its feasibility in textile CAM application. Instrumental characterization for fabric materials will help retain companies' commercial experience and expertise. This is particularly useful as the textile industry is experiencing a scarcity of experienced engineers and material technologists. The results/information can be stored in a computer, analyzed by other computing tools and networks.

6. Fabric color fastness grading

Similar to yarn grading, (which is to be dealt later) the fabric test sample is compared with standards for grading. Even though, computerized color grading is available, they are not successful. ANN can be used here to map the relationship between human grading and the image of the tested sample. Image processing and ANN can b utilized together to achieve better results.

The principle behind this technique is that, by measuring the difference in refractive indices of the parent sample and the washed sample, NN can be used to assign different color fastness grades even with finest deviations.

7. Fabric comfort

Conventionally fabric comfort is measured by subjective measurement. However extensive research has shown that fabric handle can be objectively measured and as a result of that Kawabata system of fabric evaluation has been developed. In Kawabata system, textile fabrics are analyzed in very broad and wide-ranging groups (e.g. men's suiting, women's thin dress) without any real attempt to develop specific or definite fabric categories based on objective measurement taken in conjunction with the organization of the empirical knowledge of human experts.

By using ANN textile materials can be classified into recognizable definite clauses in terms of their measured fabric mechanical and physical properties.

8. Fabric inspection systems

Today much of the fabric inspection is performed manually by human inspectors. Many defects are missed, and the inspection can be inconsistent, depending on the training and skill level of the personnel. Inspection of textile fabrics can be challenging because the industry uses many types of yarns and weave patterns, quality standards can differ by companies and existing system rely on manual process subject to human error.

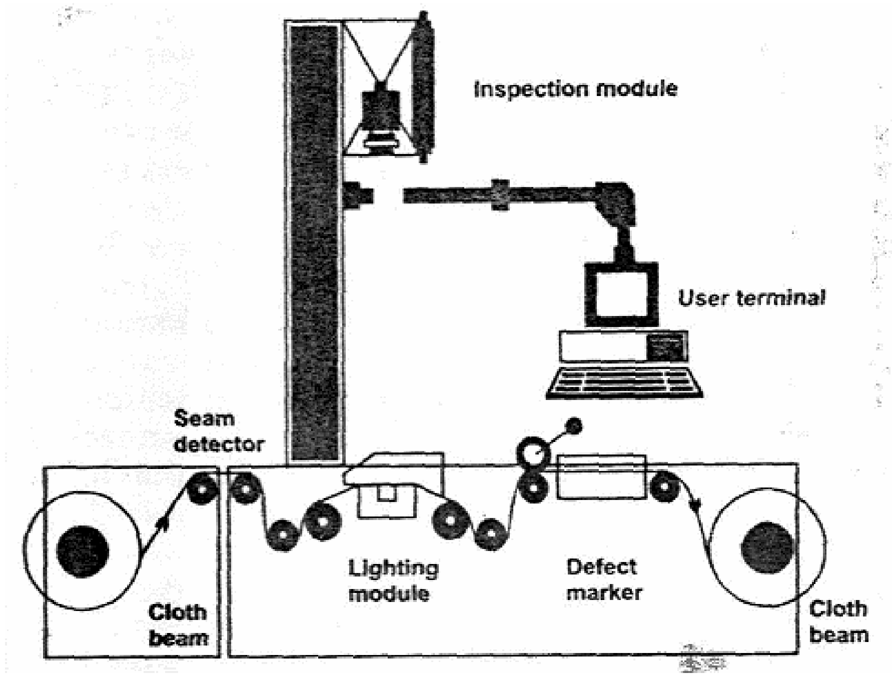
Inspection is expensive for the textile industry. The value of fabric affected can also be significant, since recurring problems in high-speed looms can damage thousands of meters of fabric if not quickly found and corrected. Developing automated on-line fabric inspection systems using Neural Network can solve the above mentioned problem.

9. Classification of textile faults using back-propagation Neural Network Logic involved:

Optoelectronic images of the fabric are Fourier transformed whose peak values corresponding to the zero-th and first order diffraction may be compared with defective piece diffraction spectrums. In this Neutral network are used to identify groups of objects that have minor differences from each other. The present development is taking into consideration the spectrum between zero-th and first order so that more number of fabric defects can be found pout.

Uster has developed a fabric inspection system ANN named as Fabricscan. In this system, CCD cameras are used to scan the fabric and the scanned signals are fed to ANN for analysis. Based on the results of the analysis the system initiates the marking of the fabric using a defect marker wherever, defects are found.

USTER FABRICSCAN SYSTEM



10. Evaluating wrinkled fabrics with Image Analysis and neural networks

Computer image analysis and automatic techniques are very important when judging the aesthetics of apparel and fabric appearance retention in the apparel and textile, industries. At present, fabric inspection still relies on the human eye, and the reliability and accuracy of the results are sometimes questioned because of the mental and physical conditions of the inspector. Wrinkles in cloth usually develop with deformation during storage. It is not easy even for trained observers to judge the wrinkles. Here an objective method is being proposed. People perceive wrinkle size, form, density, contrast, and so on from wrinkle appearance. This visual information stimulates their senses and feelings, making them judge the intensity and grade of the wrinkle. Since visual evaluation is complex and synthetic, we cannot use linear evaluation system fro automatic and inspection of wrinkles in the fabric.

Neural networks are widely used as a useful method for automatic inspection of wrinkles. Since networks are nonlinear, the training rule is generally regularized as a nonlinear optimization problem and optimization algorithm is used.

10.1. Concept of measurement:

Input parameters such as angular second monument, contrast, correlation, and entropy and fractal dimension are obtained using image analysis and are fed to the Neural network algorithm and the mean sensory value presenting the grade of wrinkled fabric as output is obtained along with required or desired output parameters. The parameters to be perceived such as density, size, form, contrast etc can be inspected using the “multi-input and multi-output concept of Neural Network. A specific algorithm namely Kalman’s filter algorithm was used for this purpose and the results are referred to be very much feasible for evaluating wrinkled fabrics.

11. Other applications of Neural Network…

11.1. Cotton grading and fiber mixing prediction

Cotton trades in India assess the commercial value of cotton on the basis of “grade” assigned by hand and eye methods by professional cotton classers. Now, ANN can be used to develop models to predict the cotton grading. By this way cotton grading can be made more reliable. Research should be done in this direction to replace the existing subjective grading with the objective one. To be precise, the properties of the cotton that can be measured are, the color of the cotton, trash present, ginning preparation etc. can be measured using ANN. Also to have blend out of two different kinds of fibers, the exact proportion in which the mixing has to be done, (to obtain the required properties / characteristics of the yarn) can be predicted using the ANN.

11.2. Yarn manufacturing

A summary of the work done using neural network in the area of yarn manufacturing is given as a table below.

Application	Input	Technique	Result
Determining the spinnability of fibers.	Fiber properties of cotton.	Cumulative back propagation network.	95% of reliability.
Prediction of yarn strength	Fiber properties of cotton.	Back propagation network.	A slight non-linear relationship is obtained.
Prediction of cotton yarn irregularity.	Fiber properties measured with AFIS instrument.	Back propagation network.	Predicted yarn irregularities are superior than multiple linear regression measurement technique
Prediction of yarn properties.	Fiber properties and spinning machine setting.	Coupled self-training system.	More than 95% reliability is achieved.
Prediction of yarn characteristics.	M/C settings and fiber characteristics	Back propagation	Better results than manual m/c intervention

12. Conclusion

The application of Neural Network (NN) creates new scopes in the field of fabric engineering. The results obtained by these intelligent devices are much more precise and reliable than the normal method of measurement / inspection. As mentioned earlier, Textile industries in developed counties have started exploiting these techniques to their advantage. Considering the WTO agreement, it is high time for India to adopt these techniques to be globally competitive in manufacturing defect-free fabrics, highly engineered products (Yarns) and effective processing strategies of manufact.

About the author:

Mr. Gopalakrishnan is doing his Diploma in Home Textile Management. He did hisDiploma in Textile Technology & B.Tech in Textile Technology from PSG College of Technology & Polytechnic College. After his diploma he worked as a Production & maintenance Supervisor in Cambodia Mills (NTC) Coimbatore, after three years of experience he came back to his B.Tech.He did 17 paper presentation in various technical symposiums, national & international confrences in all over india and participated in various technical workshops & innovative project works. He published several articles in journals, magazines.

Area of Interest: innovative textiles, Technical textiles

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