ARTIFICIAL NEURAL NETWORKS APPLICATIONS IN COTTON SPINNING PROCESSING

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Abstract

Nowadays, spinning requires a much larger knowledge of the raw materials and process, in a sufficient detail to develop mechanisms that will manipulate the "input" without human intervention.

With the spread use of HVI/HVT Systems (in the fibers and yarns quality field) and the arrival of artificial intelligence, patterns of binary data may be analyzed to detect deviations from patterns produced under "statistical control" and making recommendations concerning the root cause of the problem and the appropriate "corrective" action.

Expert systems are suitable for understanding agregate data, comparing what is seen today with patterns from historical databases, can select from several procedures the one or ones that are appropriate with today's data and determines when the parameters of the model describing the data or model being used for predictive purposes should be changed.

In this paper we shall present some work developed in the application of Artifical Neural Networks for the blending of cotton fibers and in the view of real-time quality decision and assurance.

Introduction

The representation and use of engineering knowledge by computers are for long thought as a touchstone of artificial applications: on the one hand, engineering is an intricate domain with a mix of such dissimilar kinds of knowledge as procedures based in first principles and patterns of personal experience. On the other hand, the quality of the results can usually be verified by straightforward methods, so solving engineering problems can be used as a standard of various AI methods.

Nowadays, automated spinning requires a much larger knowledge of the raw materials and processes, in a sufficient detail to develop mechanisms that will manipulate the 'input' without human intervention.

With the spread use of HVI/HVT Systems and the advent of artificial intelligence, patterns of binary data may be analysed to detect deviations from patterns produced under 'statistical control' and making recomendations concerning the root case of the problem and the appropriate 'corrective action.

The expert system, comparing what is seen today with patterns from historical databases, can select from several procedures the one or ones that is appropriate with today's data and determines when the parameters of the model describing the data or model being used for predictive purposes should be changed.
Expert systems are suitable for understanding aggregate data from multiple sensors and making a qualitative evaluation of these data for control process.

This project aimed at the application of AI methods for analyzing the domain and the perspectives of solution procedures in selected spinning problems.

Based on the results of our previous research efforts aimed at the modeling and representation of design processes and at the development of design strategies, the focus of our activities was shifted toward manufacturing.

The Portuguese Situation in the Cotton Spinning Industry

With the IS0 9000 rules, the internal audit function is considered the most important function for management's own verification of its quality policies and procedures. An integral part of the management review process, internal audits provide the foundation for management decisions regarding the future of the organization's quality system.
The Portuguese Cotton Spinning Industry is very interested in ISO certification. Nevertheless, with the certification, the problems grow.

We have some difficulties concerning the 'quality levels'. The degree to which the relative specifications are defined and, above all, used, is varied and is also in continuous evolution, partly due to the development of new laboratories methodologies. Clearly, there is still many room for improvement in the use of raw materials and the manufacturing processes and this can be done by approaching the problem from a more scientific viewpoint that is done now (and above all more quantitative).

Even after the main principles of the processes have been defined, its efficiency depends on the determination of its optimum conditions, some of which are controllable (machine settings and some characteristics of fibers) while others present problems that are difficult to keep under control (e.g., the physical conditions of the working environment.

The role of Statistical Methods

Statistical methodology plays a fundamental supporting role in the management of the quality of textiles, intervening in all of the essential phases:

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- the definition of the quantitative parameters, in all questions connected with yarn quality (involving recourse to particularly advanced techniques, like multivariate analysis);

- the measurement of qualitative and quantitative characteristics;

- the quality control, in the narrowest sense, checking that certain given specifications have been met;

- the improvement of quality, based in a scientific basis for the study of processes by designing and analyzing the industrial experiments, with the aid of advanced techniques such as analysis of variance and regression.

Nevertheless, the conventional statistical processes like regression method allows mathematical solutions with limited predictive capacity or unrepresentative of the real systems.

Nonparametrics methods are interesting to textile research because simple relationships between dependent and independent variables are not assumed.

Artificial neural networks comprise many nonlinear computational elements that operate in parallel and are highly connected. Artificial neural networks are very useful to analyze nonlinear data with many interactions and require no assumptions of underlying distributions and relationships.

Neural Networks

Definition

ANN is a network of many very simple processors ("units"), each possibly having a (small amount of) local memory. The units are connected by unidirectional communication channels ("connections"), which carry numeric (as opposed to symbolic) data. The units operate only on their local data and on the inputs they receive via the connections. A neural network is a processing device, either an algorithm, or actual hardware, whose design was motivated by the design and functioning of human brain.

The design motivation is what distinguishes neural networks from other mathematical techniques. Neural networks normally have great potential for parallelism, since the computations of the components are independent of each other.

In principle, ANN's can compute any computable function, i.e., they can do everything a normal digital computer can do. Especially anything that can be represented as a mapping between vector spaces can be approximated to arbitrary precision by feedforward ANN's.

There is considerable overlap between the fields of neural networks and statistics. Statistics are concerned with data analysis. In neural network terminology, statistical inference means learning to generalize from noisy data. Some neural networks are not concerned with data analysis and therefore have little to do with statistics. Nevertheless, most neural networks that can learn to generalize effectively from noisy data are similar or identical to statistical methods.

While neural nets are often defined in terms of their algorithms or implementations, statistical methods are usually defined in terms of their results.

It is sometimes claimed that neural networks, unlike statistical models, require no distributional assumptions. In fact, neural networks involve exactly the same sort of distributional assumptions as statistical models, but statisticians study the consequences and importance of these assumptions while most neural networkers ignore them. If we study the distributional assumptions, then we can recognize and deal with violations of the assumptions.

Using Neural Networks

Neural Networks are models for computational systems, either in hardware or in software, which imitate the behaviour of the humain brain by using a large number of structured interconnected artificial neurons.

Neural Networks (NN) consist of an agglomerate of neurons interconnected in some specific architectural way. Neural Networks are learning systems: i.e. they are trained by real-life examples, whereby the weighting factors are adapted following a certain strategy until they converge to a more or less stable steady state. After learning, the system may enter the recall stage, whereby unknown exemplars are presented at the input, leading by a simple computation to an output value.

Although the training phase may be very high demanding in computing power and execution time (because it is simulating in fact a highly parallel system on a sequential computer), the recall phase itself is very straightforward and fast. This characteristic makes N.N.'s very powerful and interactive.

Implementation of Neural Networks for Quality Assessment and Decision Making for Spinning Processes

We developed a Windows based Neural Network simulator with back-propagation learning. **nnTeXpert** have a user friendly interface written in Visual Basic and uses a Fortran bacground for fast networks calculations.

The **nnTeXpert** application is a very powerful and a very simple tool for solving the problems that are usually solved with artificial neural networks (ANN).

One important feature is the ability to dynamically change the "knowledgement base". This means that we can add some new data to neural network, add some additional parameters.

In real life problems it is usually very difficult to find a perfectely assembled knowledge base (there is always some data missing). It is very suitable to work with missing data values in data. and can handles missing data automatically.

We use this application like a "Decision Support Systems" in Quality Engineering Spinning , to facilitate the use of data, models, and structured decison processes in decision making.

Results and Discussion

We decided to 'model' one production line of carded cotton yarns. The data consider yarns from Ne 6/1 to Ne 40/1, with twist multiplier ranging from 3.1 to 4.5.
We consider 130 different blends. This is our historical database.
The fibre characteristics are evaluated with the HVI/HVT systems (Motion Control) and their database concerning the following properties: upper half mean lenght (UHM), micronaire, SL 50%, SL 2.5%, uniformity index (UI) and uniformity ratio (UR), elongation and the strength (cN/tex), reflectance degree (RD), yellow content (+B), area, count, trash weight,color grade (CGRD) and final garde, for the fibres. The yarn's properties have been evaluated by the USTER's systems and the database content the following characteristics: twist multiplier, evenness (U %), hairiness,thick and thin points tenacity (RKM - cN/tex) and the count (Ne).

Case 1:

One of the most important problems concerns the 'definition' of the cotton mix, for quality assurance reasons. For a first approach we applied linear regression to 'see' the most important parameters that influence the tenacity of the yarns, in our historical database. The results are shown in the TABLE I.

TABLE I . Regression analysis of spinning data

Variable	Coefficient
twist	**1.863**
CGRD	**- 0.075**
+B	**0.146**
Ne	**-0.153**
STR	**-0.106**
UI	**-0.155**
Multiple R	**Square Multiple R**
0.863	**0.744**

TABLE II represents de analysis of variance of our spinning database.

TABLE II .Analysis of variance of spinning data

Source	SUM-of Squares	DF	MEAN-of Squares	F-	P
Regression	338.487	6	56.415	59.643	0.000
Residual	116.342	123	0.946		

Using the **nnteXpert**, we predict the parameters of the different mix for 4 different yarn counts. We used the 'twist' and the count to 'define' the characteristics of the yarns. These properties are the **'inputs'** (I).of the neural network.

In TABLE III we represent the prediction of same of the 'optimum' characteristics of the cotton blends. They are the **'outputs'** (O) of the neural network.

Table III . Prediction of Mix Properties. (Fixed yarn)

O	O	O	O	O	O	O	O	I	I
Mike	UHM	UR	STR	RD	+B	Neps	cN/te	twist	Ne
4.3	29.20	50.9	37.5	79.3	10.1	57.7	14.9	3.5	12.0
4.4	28.70	50.1	37.1	77.5	10.6	224.	13.9	3.6	16.0
4.3	29.15	50.6	37.3	78.5	10.1	263.	13.6	3.7	24.0
4.2	30.70	57.6	38.8	84.0	9.7	367.	14.0	3.8	26.0

Case 2:

Another question to solve, it was the 'hariness'. It was more and more evident that with the new specifications, the degree of 'hariness' of the yarns was not aceptable for specific end-users.

We decide to define one 'new' specification of quality for these cases, considering 'tenacity' specifications and a broad range of counts. The results are shown in TABLE IV.

Table IV . Prediction of Mix Properties with Hairiness and Tenacity specified

O	O	O	O	O	O	I	I	I	I
Mike	UHM	UR	STR	RD	+B	Hair.	cN/tex	Twist	Ne
4.4	29.30	52.3	36.7	79.9	10.1	10.1	13.5	3.3	6.0
4.4	29.00	51.7	33.8	77.2	11.0	10.5	13.7	3.3	8.0
4.7	29.00	50.5	37.8	81.0	9.3	9.0	13.8	3.3	10.0
4.4	29.50	53.0	36.3	80.4	10.1	8.5	14.8	3.4	12.0
4.3	29.20	51.4	37.4	78.3	10.5	7.0	14.8	3.5	16.0
4.4	29.20	51.5	37.0	79.1	10.5	6.5	14.9	3.6	24.0
4.4	30.70	51.7	36.8	79.0	10.1	5.6	15.0	3.7	30.0

Conclusions

Neural network applications, like nnTeXpert permits obtain good predictions for quality assurance purposes in cotton spinning processing. If the data are just noisy, the nnTeXpert gives excellent results, much better than conventional multivariate statistical procedures. Artificial neural networks are a very good tool for spinning engineering design, and quality assurance purposes in cotton spinning. We intend to use this prediction technique, in others fields of spinning engineering.

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