An Overview on Computational Techniques in Textile Engineering

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Abstract: This paper discusses a number of computational problems in textile/garment industry. These problems cover quality inspection of textile products, on-line process control and monitoring, process and material modeling and simulation, CAD for clothing and materials, and computerized management of production and supply chain. Recently, more attention has been paid to modeling and analysis of human related complex concepts such as well-being, textile comfort and marketing elements and their integration in the design of new products. The related computational techniques include classical methods such as statistics, physical law based analytical equations, classical signal and image processing and statistical pattern recognition, and intelligent techniques such as soft computing and data mining. The selection of specific computational techniques is strongly related to the nature of the problem of interest. An optimal solution to a complex textile or garment problem can be found by combining several complementary techniques in a suitable way.

Keywords: computational techniques, textile, garment, intelligent techniques, complex concepts, industrial design

1. Introduction

Modern textile/garment industry is faced to a great number of competitive challenges such as:

- Shorter product life cycles: distributors and consumers are looking for more variety and personalization.
- Lack of flexibility in the supply chain.
- Cost reduction: retailers do not want to lose their sales margins which generate a pressure to compete for cheaper prices on products.
- Homogeneity need: the lack of integration, the heterogeneity and the lack of standards is a chronic weakness of the textile and garment industry.
- Consumers demand more comfortable textile and apparel products as casualization becomes a global trend over the decades.
- Biofunctional performance of textile devices and apparel products becomes critical area of concerns as more and more consumers pay attention to making healthy lifestyles.

Under this challenging economic pressure, there is a strong need to develop new methods in order to optimize the quality of textile products, textile design and textile management. Information technology, especially computational techniques can play an important role in this optimization [1].

Since 1950's, computational techniques have been widely applied in textile industry and garment industry for process and materials' structure modeling, simulation and control, optimization of product quality, product design, textile market forecasting. Recently, more attention has been paid to integrating some human related complex concepts into the design of new products. These concepts can be well-being, textile comfort, sustainable development and other market oriented as well as social and economic criteria. The integration of these complex concepts needs powerful computational tools capable of formalizing and analyzing uncertainty and imprecision frequently encountered in human knowledge.

The current computational techniques include classical methods such as statistics, analytical equations, classical signal and image processing (time series analysis and frequency analysis) and statistical pattern recognition, and intelligent techniques such as

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soft computing and data mining. Classical methods are essentially based on formalization of physical laws such as computations of fluid mechanics and finite elements. Basic mechanical laws have been exploited to model and simulate structures of materials and processes. Intelligent techniques are often used to deal with uncertainty and imprecision related to human knowledge on products and processes and linguistic data analysis. In practice, the selection of specific computational techniques is strongly related to the nature of the problem of interest. In general, an optimal solution to a complex textile problem can be found by properly combining several complementary techniques.

In the following sections, we discuss some typical applications of computational techniques in textile and garment sectors. More emphasis is given on the following areas:

- Automatic textile quality inspection,
- Modeling and control of textile process and fabric constitutive relations,
- Modeling and simulation of material's structures,
- Computerized management of enterprises and Supply Chain,
- Computer aided textile and garment design,
- Integration of complex concepts in textile design.

2. Automatic Textile Quality Inspection

Quality control is very important in textile/garment manufacturing industry. The defects in fabrics may reduce the price of a product by 45-65% [2]. Traditionally, textile quality control is performed by human evaluators mainly according to textile appearance and fabric hand. Some key physical and mechanical properties of textile materials (fibers, yarns, fabrics) are usually measured in a specialized laboratory. These normalized physical measures and the subjective human evaluations constitute a vector of features characterizing the quality of textiles. In modern textile industry, in order to increase the accuracy of quality inspection and reduce the corresponding cost, it is necessary to replace human visual and tactile evaluations by a reliable, objective and consistent quality control process for automatically detecting possible defects [3].

2.1 Visual Quality Inspection

A great number of automatic visual quality inspection systems have been developed for detecting defects in woven, knitted and non woven fabrics. These systems are usually composed of three parts: 1) feature extraction from fabric images, 2) relevant feature selection, and 3) textile quality classification.

The features are generally extracted from fabric images using statistical methods, frequency analysis and model based techniques [3]. As most of textile fabrics have high degree of periodicity, frequency analysis, including Fourier Transform, wavelet transform and Gabor analysis, have shown better performance in quality inspection.

Having extracted features from fabric images, we need to select a small number of the most relevant features for improving the accuracy of quality classification [4]. The techniques for relevant feature selection are mostly supervised methods, i.e. the objective of selection is to improve the classification accuracy or class label predictive accuracy of learning data samples [5]. Several well-known methods are the decision-tree method, the nearest-neighbor method, the wrapper model and the information-theoretical connectionist network model.

The last step of visual quality inspection is the classification of vectors of selected features in order to obtain different quality levels [6]. This step can be carried out using supervised methods in which a set of known samples can be used for learning classifiers and the quality of a new fabric sample can be predicted by comparing its features with those of the identified classifiers. Neural networks and fuzzy neural techniques are frequently used in the learning of classifiers [7].

Most of automatic visual quality inspections are performed using static image analysis systems for finished products. However, some of them are done with dynamic image analysis systems each equipped with a high speed camera, an online processing and a controllable transport belt for online inspecting quality of finished products and intermediate products [8].