A Review of Detection of Structural Variability in Textiles using Image Processing and Computer Vision

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Abstract

As a result of globalization & also increasing competition, it has become very important for any industry to develop solutions regarding the quality of products. Effective monitoring and control, better data predictions, quick response to query is necessary for effective Quality Control. For a long time the fabric defects inspection process is still carried out with human visual inspection. However, they cannot detect more than 60% of the overall defects for the fabric if it is moving at a faster rate and thus the process becomes insufficient and costly. Therefore, automatic fabric defect inspection is required to reduce the cost and time waste caused by defects. Studies have been carried out in this area, where in different inspection systems for detection of defects and properties of fibers, yarns and fabrics have been looked upon. The purpose of this paper is to categorize and describe the same. In this paper an attempt has been made to present the survey on these different inspection systems for detection of defects and properties in various areas of textiles and its role in the overall quality control.

Keywords: Automatic Fabric Defect Inspection, Fabric Defect, Quality, Quality Control

I. INTRODUCTION

With the tremendous growth of the textile industries it is very important to sustain competition. Companies must reexamine and fine-tune their business processes to deliver high quality goods at very low costs and companies must simultaneously ensure speed and quality while responding rapidly to changing customer tastes. The competition enhancement depends mainly on productivity and quality of the fabrics produced by each industry. In textile sector, there have been a large amount of losses due to faulty fabrics. Presently, much of the fabric inspection is performed manually by human inspectors and using off-line stations.

The work of inspectors is very tedious and time consuming. They have to detect small details that can be located in a wide area that is moving through their visual field. Many defects are missed, and the inspection is inconsistent, with its outcome depending on the training and the skill level of the personnel. The identification rate is about 70%. In addition, the effectiveness of visual inspection decreases quickly with fatigue. In textile sectors, different types of faults are available i.e. hole, scratch, stretch, fly yarn, dirty spot, slab, cracked point, color bleeding etc; if not detected properly these faults can affect the production process massively. Wastage reduction through accurate and early detection of defects is an important aspect of quality assurance.

With visual fabric inspection, a trained person inspects all types of fabrics and identifies all defects and then divides them into the corresponding grades, which is very tedious and required highest level of concentration, which can be maintained only for about 20 to 30 minutes. Even in a well-run operation, the reproducibility of a visual inspection will rarely be over 50 %. The introduction of automated inspection gives more reliable results which are free from the subjective deficiencies of the manual fabric inspection.

To increase the quality and homogeneity of fabrics, an automated visual inspection system is needed for better productivity. Existing commercial quality control systems comprises of visual inspection systems detect common defects like thin areas, thick areas, missing ends, picks, holes, lines, coating defects, contamination, etc. some systems correlate the results of the visual inspection systems for grading/performance assessment of these categories of fabrics mostly for apparels and they are too expensive for small companies. Studies have been carried out in different areas of textiles by using PC-based real time inspection systems which gives the benefits of low cost and high detection rate.

The next section is an attempt to study the existing commercial inspection systems and also the other proposed inspection systems used in different areas of textiles. The said study would identify the different methods for detection of faults, their assessment and influence on quality control.

II. COMMERCIAL AUTOMATIC FABRIC DEFECTS DETECTION / INSPECTION SYSTEMS [7]

A. Uster FABRICSAN (Fig. 1):

   – It is one of the earliest commercially available fabric inspection system designed by M/s. Uster Technologies.
- It can inspect fabric at speeds up to 120 metres per minute (Off-line) and can detect defects down to a resolution of 0.3 millimetres.
- Fabriscan is a software alongwith the device for classifying faults in a matrix called Uster Fabriclass, which is similar to the well-known Uster Classimat system for yarns.
- The cost for Fabriscan starts at $200,000.

![Uster FABRISCAN Inspection System](image1.png)

**B. Barco Vision’s Cyclops (M/s. Barco) (Fig. 2):**
- It has a traveling scanning head and can be deployed on the weaving machine itself.
- It prevents the production of off-quality fabric by stopping the weaving process if it detects a serious or running defect.
- Cyclops is designed to be used with Barco's QualiMaster system, all defect information, pick and time stamped, is sent to a fabric quality database.
- The Cyclops scanning head includes a camera and illumination system.
- The Cyclops scanners cost $ 5,000 each and can be used for fabric widths up to 280 centimetres.
- For double panel looms (up to maximum 560 cm), Cyclops comes with a double camera based image acquisition head.

![Barco Cyclops installed on Loom](image2.png)

**C. Elbit Vision System’s I-TEX (Fig. 3):**
- It is capable of inspection speeds up to 300 metres per minute and can handle fabric widths up to 5 metres.
- The system's proprietary software algorithms have been designed to imitate the human visual system.
- The I-TEX system cost is dependent on a number of factors such as the fabric application, desired speed and fabric width.
- The system sells for between $ 1,00,000 and $ 6,50,000.
- Currently four product lines have been designed to address the quality monitoring needs of different sectors within the fabric manufacturing industry:
  - I-Tex, for the visual inspection and quality monitoring of woven and knitted fabrics;
  - PRIN-TEX, for the detection of printing defects on fabric;
  - Broken Filaments Analyzer, for the detection of filament defects in glass fabrics;
  - Shade Variation Analyzer, for the detection of shade inconsistencies in dyed fabric.
They have also adapted their visual interpretation technologies for other applications, like the nonwoven fabric and printing industries.

Potential applications in the nonwoven industry include air filtration media, diapers, surgical dressings.

Some of the other commercially available systems for nonwovens include SMASH WEB of ISRA VISION, NIS200 of Lenzing Instruments and FLAWSCANTM 1000 of i2S. These systems detect the common defects but cannot effectively treat the visual uniformity grading of fabrics.

III. PC/VISION BASED REAL TIME DETECTION OF STRUCTURAL VARIABILITY IN TEXTILES

As discussed earlier the human assessment of the severity of a defect is based on experience and the general maximum detection efficiency is about 80%. Automated visual inspection systems have been a good response to the shortcomings exhibited by human inspectors. But these kinds of systems commercially available (as discussed above) are very expensive. Therefore a need of a system, which offers a scalable open architecture and can be manufactured at relatively low cost using off-the-shelf components, was required. Thus this type of inspection systems would give the benefits of low cost and high detection rate. Many researchers have been working on this. Ongoing through many of the papers in said area it has been found that the use of real time vision based/ image recognition or processing has been an effective tool for detection of variation in textiles. The approaches after the detection of the defects for effective quality control of textiles.

A. Detection of Structural Variability in Fibres:
A paper by Assessing Cotton Fiber Maturity and Fineness [3] by Image Ghith, Fayala & Abdeljelil proposes a maturity analysis of fibres by image analysis, where structural variability is studied for analysing maturity and fineness. Image analysis is an attractive alternative to existing systems for investigating some quantitative fiber characteristics. It is quick, reliable and unbiased technique which is used to evaluate fiber maturity and fineness.

B. Detection of Structural Variability in Woven Fabrics:
Initial studies in this area had been done in the area of woven fabrics in 1999, wherein a vision based fabric inspection system accomplishing on loom inspection of the fabric was done [1]. It was described in terms of its image acquisition subsystem and its defect segmentation algorithm. The image acquisition subsystem was used to capture high-resolution vibration-free images of the fabric under construction. A prototype system was used to acquire and to analyze more than 3700 images of fabrics that were constructed with two different types of yarn and in each case; the performance of the system was evaluated as an operator introduced defects from 26 categories into the weaving process. The overall detection rate of the presented approach was found to be 89% with a localization accuracy of 0.2 in and a false alarm rate of 2.5%. It uses a novel defect segmentation technique and gave high detection rate and accuracy. The technique gives a solution at considerable low rates so as to apply the solutions for small scale industries.

An automated vision system for localizing structural defects [2] was developed by Ahmed & Hazem. Paper suggests an automated vision system for localized structural defects. An automated visual inspection system was used and a fault detection algorithm was proposed. The performance of system was evaluated on plain fabrics with different types of faults. The modules were divided into pre-processing and processing modules. The system offered computational ease and simplicity. Good performance was obtained in identifying the faults which have high variability in physical dimension. The detection algorithm is quite simple in terms of statistical features to suit the real-time application. Simple texture features like mean, variance, and median were utilized. The detection rate of the system is less as it detects flaws which vary drastically in dimensions. Other types
of defects other than structural defects remain to be explored. Also there is a scope of further study for classification of this structural variability for defect analysis.

A Textile Defect recognition system [4] used the local threshold technique without the decision tree process. An image acquisition device captures the images of fabrics. The RGB images were then converted to binary images by restoration process and local threshold techniques and four types of faults (holes, scratch, no fault and other fault). The recognizer deals with different types of faults and fabrics and therefore it cannot be considered for a general approach. A large percentage of misclassifications were obtained by the used algorithm. The system gave good performance for scratch faults and holes and could detect few amounts of multi-colored defect fabrics.

Another study in 2005[5] proposed a real-time fabric inspection algorithm for industrial application. The cost was reduced by using PC-based system instead of the professional DSP board, and double buffer memory for a parallel process and was designed to extract a minimal size of defect without classifying the kinds of defects because of the speed. After the processing of the images using imaging software, the size and position of defects were determined and displayed on the monitor. The proposed inspection system was designed to extract a minimal size of defect by lines and not the type of defect. It was designed to find defects over 1 mm in width and length. The perfect recognition rates were obtained for oily spot and spot with a large difference of illumination amongst the five representative defects (warp float, broken pick, hole, oil spot, and spot) considered, while low recognition rates were obtained for warp and pick float with small difference of illumination. The fabric inspection algorithm proved quite useful to extract a minimal size of defect by lines and not by nature of defect. It could detect variability where there is large difference of illumination and considerably good recognition rates as compared with the manual method. Cost was the limitation factor here for more speedy and exact inspection.

Gabor filters have also been used for textile defect detection. Studies in 2011 [6] carried out by Junfeng & Huanhuan. A new method has been suggested here. About 5 kinds of defects for woven fabrics have been considered here. The experimental results obtained confirmed the satisfied performance and the low computational requirement and the performance of algorithm. The method was not suitable for all textile flaws. As the method was not suitable for all textile flaws, and so gave scope for further work to be done in the area.

C. Detection of Structural Variability in Non-Woven Fabrics:
Studies [10] have been proposed by S. Hariharan, S. A. Sathyakumar, P. Ganesan on measuring of fibre orientation in nonwovens using image processing but not on detection of the faults and their classification. Paper describes the application of image processing techniques for measuring the fibre orientation in nonwovens. Spatial uniformity of fibrous structures have been described statistically by using index of dispersion. Results show the technique is capable to identify variation in geometrical dimensions of very small textile objects. Studies propose measuring of fibre orientation in nonwovens using image processing but not on detection of the faults and their classification. By elaborating the digitization algorithm along with numerical methods would give solutions for obtaining characteristics of nonwovens and thus improving the quality.

Studies by Jianli and Baoqi [9] on comparision of neural network for visual uniformity recognition of nonwovens shows novel approach for defect identification and classification. The authors proposed the Gaussian density (GGD) model, LVQ and Bayesian neural network. However, its recognition rate has to be improved. The paper describes all the aspects of the proposed research in it. Introduction of neural networks increases the complexity in the study and therefore increases computation time to improve the recognition rate. The paper proposes comparison of neural networks rather than going for simple classification of the faults in nonwovens as required by industrial point of view and therefore the study is limited to validation from the point of view of experiments. The paper is mainly focused on uniformity recognitions of nonwovens. So the objectives of research should be centered on the quality of nonwovens only. But here in this article it is related to mere comparison of complex techniques to be used for finding uniformity of nonwovens rather than finding out some other simple solutions which may be useful in the industry. The paper suggests method which is valid from point of view of experiments, the problem regarding detection and grading of faults in nonwovens still remains for the industrial applications to be explored in future. Also only one variety of nonwovens has been considered here and solutions for other types of nonwovens/functional fabrics are required to be developed.

D. A General Review on different Methods for defect detection in Textiles:
A paper [8] by Henry, Grantham & Nelson provides a review of automated fabric defect detection methods developed in recent years. A different approach used in detection of faults has been discussed and a comparative study between them has been done. Review has been done for different methods used for different types of fabrics, motifs, fabric faults, etc. Qualitative analysis including detection success rate for every method has been discussed Defect detection can be affected by factors such as illumination and quality of acquired images. As per the review, a perfect detection success rate is almost impossible to achieve as the quantity and type of patterned images for evaluation increase. The method to be chosen depends on the type of application. Paper gives a good survey of different defect detection methods and describes their characteristics, strengths and weaknesses. It employs a wider classification of methods and a good comparative study across these methods. The insights, synergy and future research directions are discussed which would be beneficial to researchers and practitioners in image processing and computer vision fields in understanding the characteristics of the different defect detection approaches.
IV. SUMMARY

The survey of the papers gives an idea of the different approaches that have been considered in designing quality control systems in the area of textiles. The commercial available systems are quite expensive. PC/vision based systems show reliability in detecting structural variability in woven structures while there is a scope for defect detection of nonwovens. With the increase in number of applications of this segment of textiles in different areas during the days to come, it becomes necessary to have this kind of system to check the quality of such varieties of fabrics in much shorter time and with utmost accuracy.

REFERENCES