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Fabric Defect Detection Using Principal Component Analysis

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Abstract

Fabric defect detection is one of the most significant procedures for quality control in textile manufacturing industry. With the development of the integration of global resources, more effective methods of quality testing requirements of unprecedented grow rapidly. The described method represents an effective and accurate approach to automatic defect detection. It is capable of identifying all defects. Because the defect-free fabric has a periodic regular structure, the occurrence of a defect in the fabric breaks the regular structure. Therefore, the fabric defects can be detected by monitoring fabric structure. The regularity of the pixels in the fabric is determined by constructing the PCA model. For the test fabric the PCA model is constructed, component analysis is performed for detecting the defects. Also the percentage as well as location of the defective area is determined by collecting the pixels bellow threshold.

1. Introduction

Fabric defect detection or inspection is a process of identifying and locating defects. In the manufacturing process, if cost and just-in-time delivery corresponds to the two lines of the right angle, the quality should be the hypotenuse that completes the right triangle of the method. That is, in the textile industry, inspection is needed for maintaining the class of the fabric despite of increase in one or both of the other parameters; before any shipments are sent to customers [1]. Fabric, being a extensively used material in daily life, is manufactured with textile fibers. Textile fibers can be made of natural element such as cotton or wool or a composite of different elements such as wool and nylon or polyester. The continually changing fashion of garments has generated a greater product diversity and shorter life cycle for invention. Textile fabrics constitute a large proportion of the total cost of production in garment manufacturing. Since a garment with a textile defect sells with a gigantic discount of 45–65% [2], the garment manufacturing industry faced with increased pressure to become more competitive by increasing yield while reducing costs. Hence, quality control of fabrics before garment manufacturing is essential to guarantee the quality of finished products and to increase the efficiency of the manufacturing process.

An automated defect detection and identification system enhances the product quality at a high production speed and results in improved productivity to meet both customer demands and to reduce the costs [3]. Automated inspection of textile fabrics has attracted a lot of attentions in recent years.

The described method in this report represents an effective and accurate approach to automatic defect detection. It is competent to identify all defects. The fabric defect could be simply defined as a change in or on the fabric construction. Other than classifying a certain appearance of the fabric, registration of the exact location of the defects is important. The advantage for the manufacturer here is to get a warning when a certain amount of defect or imperfection occurs during the production of the fabric so that precautionary measures can be taken before the product hits the market. An automated fabric inspection system can provide reliable results that correlate with the quality control standards of the textile industry.

The objective is to identify whether the fabric is defective or not, if it is defective then display the defective area, to identify the percentage of the defect in the fabric and to analyze the performance using time required for defect detection.

2. Literature Survey

To produce the highest quality fabrics in the shortest amount of time, the modern weaving industry deploys high-speed looms. The utmost priority of all weaving mills is to reduce the presence of weaving defects in the final product at early stages of the production process to insure an optimized economical feasibility [4].Therefore various fabric inspection systems were introduced such as 10 point system, Graniteville, Dallas system and 4 point system [7].

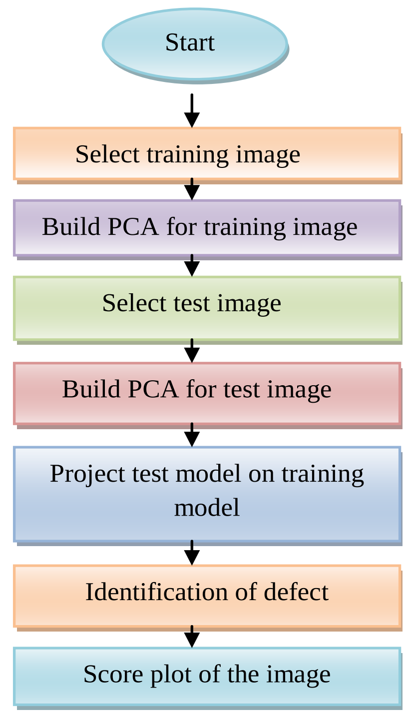
Fabric inspection has two different possibilities. The first is the visual inspection in which the manufactured fabric has to be inspected manually and second is the inspection in which the weaving process is constantly monitored automatically. In visual inspection, trained labours pull the fabric over a table by hand. When the inspector notices a defect on the moving fabric, the machine is stopped by the inspector, the defect and its location is recorded. The visual inspection suffers from many drawbacks. So to overcome these drawbacks; automated fabric inspection systems are used. Automatic inspection systems are designed to increase the accuracy, consistency and speed of defect detection in fabric manufacturing process to reduce labour costs, improve product quality and increase manufacturing efficiency [1]. A number of new and important algorithms have been implemented for automated fabric defect detection in the last years. Several approaches were proposed to address the problem of detecting defects in fabrics, which can be broadly categorized as: structural, statistical, spectral and model based.

3. Principal Component Analysis

Principal Component Analysis or PCA is a statistical procedure concerned with elucidating the covariance structure of a set of variables. In particular it allows identifying the principal directions in which the data varies. The central idea of principal component analysis is to reduce the dimensionality of a data set in which there are a large number of interrelated variables, while retaining as much as possible of the variation present in the data set. This reduction is achieved by transforming to a new set of variables, the principal components, which are uncorrelated, and which are ordered so that the first few retain most of the variation present in all of the original variables. Computation of the principal components reduces to the solution of an eigenvalue-eigenvector problem for a positive-semi definite symmetric matrix [5].

4. Proposed Methodology

The proposed method is shown in figure 1. The aim of the preprocessing step is to gather texture information. The texture information will be taken into account by considering the surrounding pixels to every pixel in the image. A set of images is used that correspond to different fabrics pieces that are consistent with the quality standard for the process. The purpose is to determine whether new pieces are also acceptable or not. These sets of images are considered to represent the Normal Operating Conditions. In Statistical Process Control, it is assumed that a process in a controlled environment behaves in a predictable way. When the behaviour changes; it must be due to some external event. The PCA model build, models these Normal Operating Conditions, and provides operations to detect whether the behaviour differs from the expectations, and quantify the effect. The training and test data is then loaded. A PCA model is created that will capture the variability of the data in an appropriate way. Here cross-validation can be used to find out the optimal number of principal components. Once the model is formed, new samples can be analyzed. This is done by projecting their corresponding test matrices against the model's loadings matrix. Some conclusions about the dependency between the test data and our model can be drawn. It is common to need to isolate the defective area in an image, so a new image can be taken where only the interesting features are displayed. This can be splitted in two logical steps, that is; a common PCA analysis can be performed, where a defective image is used to build the model and then the scores matrix is used to create a mask that isolates the defect, so this mask can be applied to new samples so as to identify the type of feature. A projection of this test image matrix against the PCA model is performed.



"Figure 1: Flowchart of the proposed system"

The score plot provides the discriminative information, regarding how similar the pixels are to one another, taking into account their value and the textural information. So different groupings in this plot to can be expected to represent distinct image objects, such as the background and the defective areas of the same nature.A principal component scores plot is used to identify clusters and unusual observations in the dataset. By using the MATLAB a cloud of points can be drawn that is representing the defect. Then this will give the corresponding binary mask as a result. For new images, there is a need to build the corresponding test matrix, project against the PCA model, and apply the mask image.

5. Fabric defects

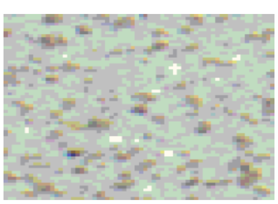
The fabric defect is an abnormality in fabric density and fabric structure. As the fabric is a finished product of many accumulated manufacturing processes starting from the fibre, it can show various kinds of defects. Therefore, the source of the fabric defect has a vital importance. Most defects in fabric occur while it is woven on the loom. Some of these fabric defects are visible, while others are not. However, some fabric defects may be rectified during weaving and after weaving while others are not. The weaving machine is one of the easiest and fastest ways of producing cloth and textile pieces. The weaving process may create a huge number of defects named as weaving defects. Most of these defects appear in the longitudinal direction of the fabric (the warp direction) or in the width-wise direction (the weft direction).The yarn represents the most important reason of these defects, where presence or absence of the yarn causes some defects such as miss-ends or picks, end outs, and broken end or picks. Other defects are due to yarn defects such as slubs, contaminations or waste, becoming trapped in the fabric structure during weaving process. When there is any undesired abnormality inside the fabric construction during the manufacturing process, it results in a mechanical defect. There are more than 50 categories of fabric defects in the fabric industry. Some of the major defects are hole, oil stain, float, coarse-end, coarse-pick, double-end, double-pick, irregular weft density, broken end, and broken pick, scratch, stretch, fly yarn, slub, color bleeding etc. Hence if these defects are not detected properly, these can have a massive effect on the production process [6].

6. Experimental Work

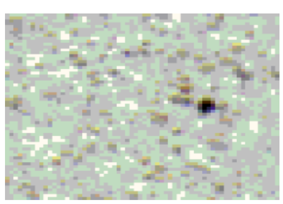
In this study different types of fabrics for training and testing process are used.

TR_1

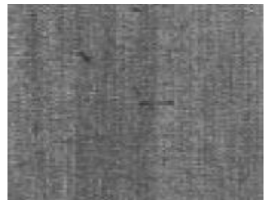
TE_1



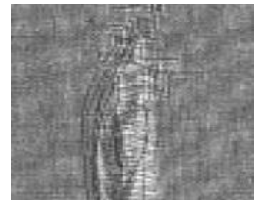
TR_2



TE_2

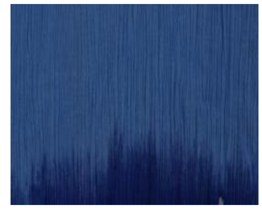


TR_3



TE_3

TR_4

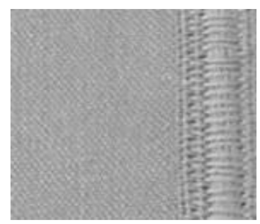


TE_4

TR_5

TE_5

TR_6



TE_6

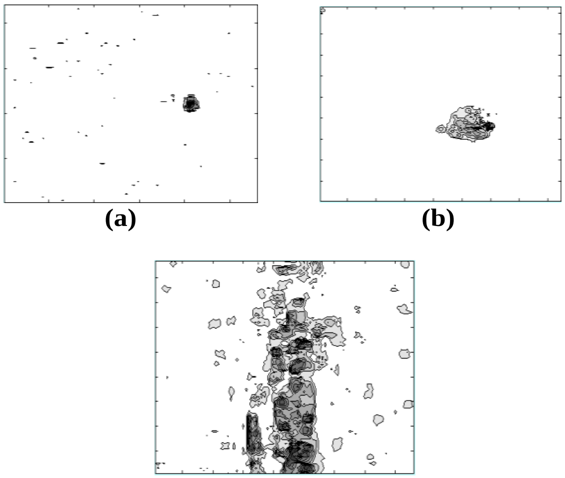
TR_7

TE_7

Figure 2: Different type of fabric samples with defect

Figure 2 shows different training and testing samples.

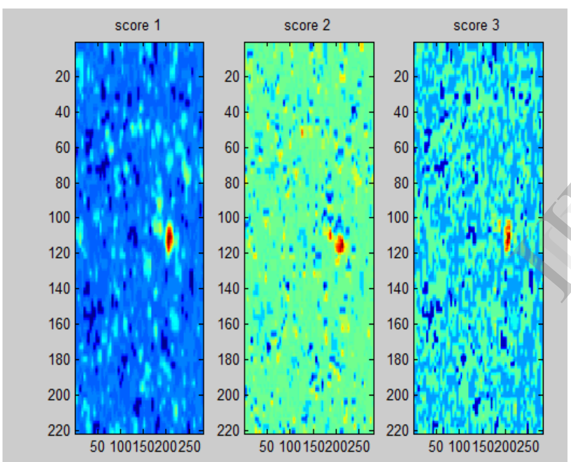
7. Results



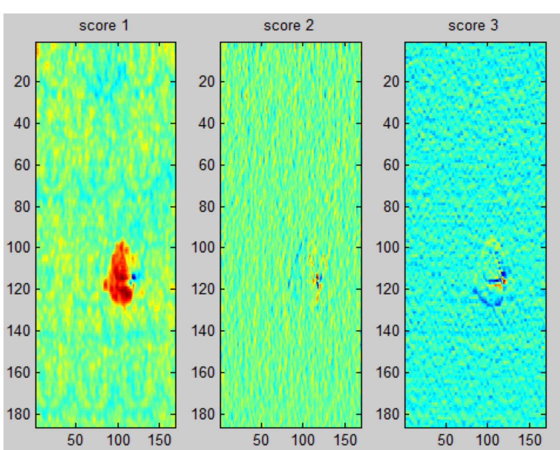
(a) (b)

(c)

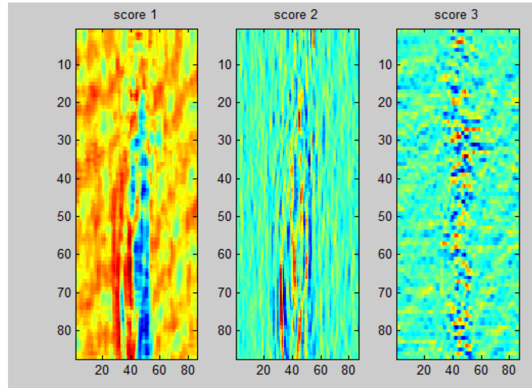
Figure 3: Segmented images



(d)



(e)



(f)

Figure 4: (d),(e),(f)-Score plot highlighting the defective area

Table -1. Experiment Result

Image No.	Detection time	Percentage defect	Image Resolution
1	0.031189	20.3119	444 558
2	0.12999	5.5649	300 400
3	0.068674	12.0345	225 225
4	0.13867	10.7015	300 400
5	0.14109	7.5462	272 400
6	6.8187	6.9163	1944 259
7	0.1564	16.9965	303 425
8	0.05397	23.4382	217 154
9	0.21428	83.6976	336 448

8. Conclusion

An algorithm for fabric defect detection using principal component analysis is implemented. The performance of the proposed defect detection scheme has been widely evaluated by using the database, which consists of a variety of fabric defects including (1) different types, sizes, and shapes of defects, and (2) diverse texture backgrounds. The test results obtained have shown that the method is simple and effective defect detection scheme. Experimental results show that accuracy of developed system is 98%.

9. References

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