Automated Fabric Inspection: Brief Review
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Abstract: In fabric production, the major step for the quality assurance is the inspection of defect. As the manual fault detection systems with trained inspectors undergoes very less percentage of defects detection, automatic system can be used to increase this to a maximum number. Using automated visual inspection, which is a crucial manufacturing step and more economical reduces labor cost, time and less accurate human inspection. Fabric defect detection is defined as the process of identifying and locating the defects. Due to the large number of fabric defect classes, the inspection of fabric defect becomes more challenging. Different techniques had been developed to detect various fabric defects and hence the paper is categorized to define these algorithms. This paper also presents various fundamentals of fabric defect detection and their types.

Key Words: Fabric inspection, defect detection, Principal component analysis

1. INTRODUCTION

Fabric inspection has long been a very labor rigorous process in textile manufacturing. A weaving mill must inspect 100% of the fabric it produces so that it can identify the looms which are beginning to make defects. Inspection is a separate process that takes place after the rolls are detached from the looms. If a part of the cloth is considered too defective, rolls must be reprocessed by removing those defective sections then rerolling to make rolls of First and Second Quality.

A fabric defect is a result of the manufacturing process. In textile manufacturing process, as soon as the defect emerges it becomes important to inspect, detect, assess and rectify defects. Various defects result from machine faults, yarn problems, poor finishing, excessive stretching etc. Due to these defects the price of the fabric is reduced by 45% -65%. Fabric defect detection has been a long-felt need in the textile and apparel industry for maintaining the quality fabric. The nature of traditional manual inspection was repetitive and slow, and defects could be missed due to inspector tiredness, misjudgment and neglect, not mentioning the costs of skilled labour for the task. Automated visual inspection of texture content in digital images plays an important role in detecting textile defects for quality control. A computer based inspection system can be designed to perform 100% defect inspection objectively and consistently that eliminates inspection error due to human infirmity, and saves the costs of skilled inspectors. To detect the defects of the fabric, texture analysis plays vital role in the automated visual inspection of texture images. Surveys carried out early in 1975\cite{1} shows inadequate or inaccurate inspection of fabrics has led to fabric defects being missed, which had great effects on the quality and costs of the fabric finishing and garment manufacturing processes.

An automated defect detection and identification system increases the product quality and results in improved productivity to meet customer demands and reduced costs. Therefore various approaches for fabric defect detection have been proposed to describe the different algorithms that are categorized as structural, statistical, spectral and model based approaches. Ngan, Pang and Yung reviewed automated fabric defect detection methods developed in recent years. They summarized different approaches for texture defect automatic detection, where computer vision and image processing has been the key for success.

A general procedure for an automated inspection system is as shown in Figure 1. The images to be inspected are processed and the features of defects are extracted. Image processing should highlight texture defects, such as the location or extension of the defects using various properties of the textures. A classifier, trained and validated by history data and defect definitions, analyses the features to objectively classify the defects. An industrial automated inspection system must operate in real-time, and produce a low false alarm rate. As computer technology develops, rapid image processing and pattern recognition can be performed.
quickly and inexpensively. It therefore becomes increasingly popular for computer aided feature extraction, defect detection, quality classification and decision in the textile field. Thus, it is the trend that automated image-based inspection replaces human inspection, and improved feature extraction methods will accelerate the process. The region with a defect has a texture different from the background, which has a relatively consistent texture.

2. TYPES OF DEFECTS IN WEAVING

The various types of defects are given below.

2.1 Broken Ends- If a warp is absent in the fabric for a very short or long distance and then this fabric defect is called broken ends.

2.2 Broken Picks- If a warp is absent in the fabric for a very short or long width and then this fabric defect is called broken picks.

2.3 Float- A float is a kind of defect where a warp or weft yarn floats over the fabric surface for a few container lengths due to missing of interlacement of two series of yarns.

2.4 Slugs- When the weft yarn is unclean and contains slugs and its diameter is irregular, then defect is called as slugs.

2.5 Holes- If there are any small holes present in the fabric and then it is a major fabric defect. The occurrence of hole cut or tears which is self explanatory.

2.6 Oil Spot- Oil Spot on the fabric are caused by too much oiling on loom parts from other sources. Oil stains in most fabrics may be removed by scouring process.

2.7 Stitching- A common fabric fault in which the ends and the picks are not interlaced according to the correct order of the pattern. This defect is a result of any undesired motion of the main or auxiliary loom mechanisms such as: shedding, picking etc.

2.8 Dirt-Stains are caused by lubricants and rust. Most of the stains can be traced back to poor maintenance and material handling.

2.9 Knots- A fabric place where two ends of yarn have been tied together and the tails of the knot are protruding from the surface. It is caused by tying spools of yarn ends together.

3. LITERATURE SURVEY

3.1 Structural Method

Structural approaches represent texture by well-defined primitives (micro texture) and a hierarchy of spatial arrangements (macro texture) of those primitives. These primitives can be as simple as individual pixels, a region with uniform gray levels, or line segments. To describe the texture, one must first define the primitives and then the placement rules. The choice of a primitive (from a set of primitives) and the probability of the chosen primitive to be placed at a particular location can be a function of location or the primitives near the location. The advantage of the structural approach is that it provides a good symbolic description of the image. This method is not successful on fabric defect detection, mainly due to the stochastic variations in the fabric structure (due to elasticity of yarns, fabric motion, fiber heap, noise,) which poses severe problems in the extraction of texture primitives from the real fabric samples [2, 3].
3.2 Statistical Method

Statistical approaches measures the spatial distribution of pixel values [2]. The main object is to separate the image of the inspected fabric into the regions of distinct statistical behaviour. This technique is one of the first methods in machine vision [4]. By computing local features at each position in the image and deriving a set of statistics from the distributions of the local features, statistical methods can be used to analyze the spatial distribution of gray values. Based on the number of pixels defining the local features, these approaches can be classified into first order, second order and higher order statistics. The first order statistics estimate properties like the average and variance of individual pixel values, second and higher order statistics estimate properties of two or more pixel values occurring at specific locations relative to each other.

3.3 Spectral Method

Spectral approaches occupy a big part of the latest computer vision research work. It simulates the human vision system where the psychophysical research has indicated that human visual system analyzes the textured images in the spatial frequency domain. Spectral approaches require a high degree of periodicity and hence it is applied only for computer vision of uniform textured materials like fabrics. For automated defect detection, such approaches are developed to overcome the efficiency drawbacks of many low-level statistical methods. The primary objectives [3] of these approaches are firstly to extract texture primitives, and secondly to model or generalize the spatial placement rules.

3.4 Model based Method

Model-based texture analysis methods try to capture the process that generated the texture. Model based texture analysis such as Fractal model and Markov are based on the construction of an image that can be used for describing texture and synthesizing it. Model-based approaches are suitable for fabric inspection when the statistical and spectral approaches have not yet shown their utility. This task is very difficult and computationally intensive if the models are complex and if a large number of models must be considered.

3.5 Algorithms

3.5.1 Fabric defect detection using bitplane decomposition

Instead of highlighting gray level images, highlighting the contribution made to total image appearance by specific bits is examined in this method. As bit-plane images are binary images, they are highly suited for morphological image processing. Bit planes 0 and 1 contain the most significant information regarding the location and shape of the fabric defect. The higher order bit planes contain a majority of visually significant data while the lower order ones contribute to more subtle details in an image. On examining the eight bit planes of the image, the lower order bit planes are found to carry significant information regarding the location and shape of the fabric defect in the image. This method is simple, efficient and accurate [5].

3.5.2 Fabric defect detection using artificial neural network

In this method the recognizer acquires digital fabric images by image acquisition device and converts that image into binary image by restoration and threshold techniques. The output of the processed image is used as an input to the Neural Network (NN) which uses back propagation algorithm to calculate the weighted factors and generates the desired classification of defects as an output. This method is feasible and applicable in textile production factories for defect detection and classification. It has a comparatively high prediction error in one or two cases due to the insufficient information about the particular defect from the coefficients of that defect. Furferi and Governi [6] described an artificial vision inspection system for real-time detection and classification of raw material defects. This system based on an artificial neural network approach with 90% detection reliability and an adequate computational time [8].

3.5.3 Fabric defect detection using Gray level thresholding method

These approaches are direct and simple mean to detect high contrast fabric defects. The principle depends on the signal variation due to the presence of high contrast defect. It compares the gray level of each image area with a reference threshold. If its gray level is greater than the threshold, this area has a defect and
otherwise, it is a defect-free one. The advantage of this method is its ease of implementation. The drawback is it fails to detect the defects which appear without altering mean gray level in defect-free areas.

3.5.4 Fabric defect detection using local linear transforms method

This method gives a statistical reason for the extraction of texture properties by means of convolution operators. These masks may be considered as local detectors of simple structures such as defects. Several popular bi-dimensional transforms such as Discrete Cosine Transform, Discrete Sine Transform, and Discrete Hadamard Transform can be used for the extraction of local texture properties. Unser [7] proposed a method that gives an access to higher order statistical information by means of simple histogram or moment computation along selected axes in the space of pixel values in a specified neighbourhood. An optimal and sub-optimal linear operator for texture analysis and classification was derived.

4. PROPOSED METHOD

4.1 Principal Component Analysis

Principal component analysis is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. The number of principal components is less than or equal to the number of original variables. This transformation is defined in such a way that the first principal component has the largest possible variance and each succeeding component has the highest variance possible under the constraint that it be orthogonal to (i.e., uncorrelated with) the preceding components. PCA is sensitive to the relative scaling of the original variables. PCA can be done by eigenvalue decomposition of a data covariance or correlation matrix or singular value decomposition of a data matrix, usually after mean centering the data matrix for each attribute. PCA is the simplest of the true eigenvector-based multivariate analyses.

4.2 Methodology

A set of RGB images is used that correspond to different fabrics pieces that are consistent with the quality standard for the process. The objective is to determine whether new pieces are also acceptable or not. First it is necessary need to load the data. The training and test data is then loaded. The next step is to create a PCA model 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 to include, and let the algorithm auto center and
scale (flags autoCenter and autoScale) the input data. 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 split in two logical steps.

- A common PCA analysis can be performed, where a defective image will be used to build the model.
- 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. The score plot provides with discriminative information, regarding how similar the pixels are to one another, taking into account their value (graylevel, RGB, or up to as many channels as desired), and the textural information (using the area that surrounds it). So different groupings in this plot to represent distinct image objects are done, such as the background and the defective areas of the same nature can be expected. By using the MATLAB a polygon can be drawn that contains the cloud of points that is representing the defect. Then this function will give the corresponding binary mask as a result. Usually it is more convenient to select the background’s score points, to then invert the selection. For new images, there is a need to build the corresponding test matrix, project against the PCA model, and apply the mask image.

5. CONCLUSION

Review of automatic fabric inspection methodologies using image processing techniques gives possible trend of this application area. The research on visual inspection is diverse and ever-changing. In order to realize the formation and nature of the defects, it is important to be able to accurately focus the defective regions rather than classifying the surface as a whole. This can provide possibilities of classifying the defects and further studies of the characteristics of the defects.

REFERENCES