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Various Defect Detection Approaches in Fabric Images - A Review

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ABSTRACT

Fabric defect detection is a necessary and essential step of quality control in the textile manufacturing industry. This paper has been reviewed the various fabric defect detection methods of statistical, spectral, model based and structural approaches. This paper has been presented the survey on types of defects, detection accuracy, performance metric and inference from recent publications. This paper shall benefit researchers and practitioners in image processing and computer vision fields in understanding the characteristics of the different defect detection approaches.The conclusion from this paper suggest that the pulse coupled neural network (PCNN) approach is better detection accuracy than the other methods and is suggested for further research.
Keywords: Quality control; fabric Inspection; Automated Defect Detection;

I. INTRODUCTION

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. Fabrics are textile materials which are made through weaving, knitting, braiding and bonding of fibers. Defect means a flaw on the fabric surface as a result of the manufacturing process. Fabric defect detection is a quality control process aimed at identifying and locating defects. Traditionally, human inspection, carried out in wooden board, is the only means to assure quality. It helps instant correction of small defects, but human error occurs due to fatigue, and fine defects are often undetected. Hence automated inspection becomes a natural way forward to improve fabric quality and reduce labor costs. Fabric inspection plays a significant role in quality control of textile materials.

Fabric defects are defined as distortions which occur on fabric pattern. Distortions cause to changing in Warp and Weft yarns, density of yarns or in spaces between Warp and Weft yarns. The automated fabric defect detection systems detect the extraordinary changes and decide the asset of defects and their places. Fabric manufacturing occurs in many stages, which start from manufacturing of yarns. In yarns manufacturing, fibers are processing for composing yarns. However, natural structure of the fibers or spinning operations may cause thinning, thickening, rupturing on fibers, these structural changes cause defects on fabric patterns.

After yarn manufacturing, weaving process composing fabrics with using yarns. The yarns are weaving by using looms. Sharpness parts of looms, abnormal motions of machines are also cause for defect reasons. All the defects that occur during these processes are named woven fabric defects. Fabrics are produced after passing many processing. Different machines and techniques are used during processing stages. So, fabrics are exposed to forces and stresses which cause defects. According to their forms and directions, defects take different names has been extensively applied to various tasks and this method was reviewed in serial no of [1], [2], [4] in table 1.

B. Spectral approaches

The primary objectives of these approaches are firstly to extract texture primitives, and secondly

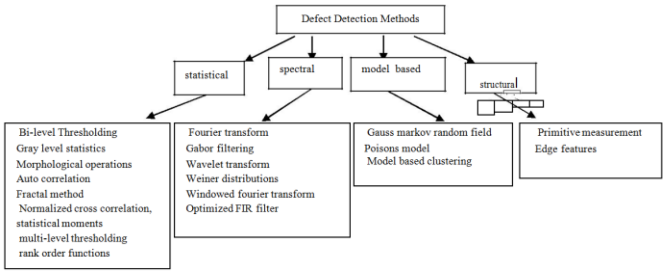

Fig. 1 Different defect detection methods

II. DIFFERENT APPROACHES OF FABRIC DEFECT DETECTION

A. Statistical approaches

Statistical method is a method of analyzing or representing statistical data. In fabric inspection, the main objective is to separate the image of the inspected fabric into the regions of distinct statistical behavior. Based on the number of pixels defining the local features, these approaches classified into higher order and lower order statistics. Higher order statistics (HOS) used the term skeweness and kurtosis whereas the low order statistics used the term mean and variance. Due to the higher powers, HOS are significantly less robust than lower order statistics. Clearly, the use of statistical approaches is well distinguished in the field of computer vision and to model or generalize the spatial placement rules. Spectral approaches require a high degree of periodicity thus, it is recommended to be applied only for computer vision of uniform textured materials like fabrics. For automated defect detection. Spectral approaches occupy a big part of the latest computer vision research work. This method was used for image quality enhancement, noise reduction, feature extraction and it was reviewed in serial no [3], [7], [8] in table 1.

B. Model-based approaches

In this approach, the texture is regarded as a complex pictorial pattern and can be defined by a deterministic model. Model-based texture analysis methods try to generate the texture. Here model the texture by determining the parameters of a pre-defined model. Particularly, model-based approaches are suitable for fabric inspection when the statistical and spectral approaches have not yet shown their utility. The advantage of the modeling is that it can produce textures that can match the observed textures. Model based approaches are particularly suitable for fabric images with stochastic surface variations and this method was reviewed in serial no of [5], [9] in table 1.

C. Structural approaches

In structural approaches, texture is characterized by texture primitives or texture elements, and the spatial arrangement of these primitives. These primitives can be as simple as individual pixels, a region with uniform gray levels, or line segments. Consequently, the main objects of these approaches are firstly to extract texture primitives, and secondly to model or generalize the spatial placement rules. The Placement rules can be obtained through modeling geometric relationships between Primitives or learning statistical properties from texture primitives. However, these approaches were not successful on fabric defect detection, mainly due to the stochastic variations in the fabric structure and this method was reviewed in serial no [6], [10] in table 1.

TABLE 1
COMPARISON OF VARIOUS DEFECT DETECTION TECHNIQUES

S.No	Technique	Input image	Types of defects detected	Detection accuracy	Performance parameter	Inference
1	Fisher Criterion basedDeep Learning, Fisher Criterion Denoising Auto encoding(FCSDA) (Yundong le et al. 2016)	Plain, Twill fabric	Broken end, Hole, Netting multiple, Thick bar, Thin bar	98%	Learning rate, Scaling factor, Network depth, Number of hidden layer units	High detection accuracy was provided by this method even the negative samples are insufficient . Training process is time consuming.
2	Genetic Algorithm (Y.Kumbhar et al. 2016)	Textile color fabric	Threading defect, oil spot, color fading	90%	Homogeneity, contrast, Correlation, Hue, Saturation,	This method used to detect the defects for a sample of a very large number of high quality images.
3	Kernel Principal Component Analysis (KPCA) (Junfeng Jing et al. 2016)	Uniform & Structur ed fabric	Hole, Oil spot, Thread error, Objects on the surfaces	96%	Detection success rate specificity and sensitivity	High true detection rate and a low cost for online fabric inspection is achieved
4	Pulse Coupled Neural Network (PCNN) (Yundong Li et al. 2016)	Warp-Knitted fabric	broken ends, loom fly, thin bar	98.6%	Mean, standard deviation	This hybrid method is suitable to run on an embedded system because of the low computation. The system is applied to defect inspection for warp knitting machine.
5	GIMP Retinex filtering, (Amelio Carolina Sparavigana et al. 2016)	Textile woven fabric	Mispick	92%	Image size, scale division, dynamic slider	This method is used to help human vision for instance detecting tiny flaws of the fabric.
6	Feature extraction technique, graphbased	Color fabric	Needle cutting, oil	89%	Form factor, rectangularity	This method gives multipurpose without requiring any adjustment and finding the

	segmentation, (prasad dakhole et al. 2016)	image	stain		factor, location, orientation, intensity based features, moment based features	better accuracy and less time consumption in the industry.
7	2D Fast Fourier transforms (George bardi et al. 2016)	Woven fabric	Hole, excessive margin	78%	Yarn distance, energy distribution parameter, maximum energy parameter, displacement, speed	This method determines the yarn paths even in highly draped border regions of the surface. So the influence of different experimental settings on fiber orientation can be easily evaluated.
8	Small Scale Over Completed Dictionary Of Sparse Coding (SSOCD), Hardware Acceleration (Feng et al. 2016)	Twill fabric	Mispick, Broken pick, Buckling,Tom selvedge, Rough selvedge, Fuzzy ball, Bore, Yarn, Double flat, Yarn evenness, Pulled in selvedge, oil warp	93.7%	Reconstruction error, Sum of the absolute value of projection, largest absolute value of projection, distance between the image, average of trained samples, Size of image patches	Algorithm's serial time consumption is reduced. This system reached a state with a good parallel speedup ration and parallel efficiency. The algorithm run with high parallel efficiency and the detection speed meets the requirements of Industrial Inspection. the detection result will easily be affected by noise through, illumination changing, fabric grain fluctuating, etc.
9	Back propagation Algorithm (Akshay V.Nalawade et al. 2016)	Textile woven fabric	Oil spot, horizontal defect, vertical defect	88%	Entropy, homogeneity, contrast, wavelets, fractals	This method is reliable for fabric inspection system in textile Industries.
10	Artificial Neural Network back propagation pattern recoganization technique, series of filter operation (Gangandeep singh et al. 2016)	Woven fabric	3 types of defects	93.3%	5 features	The efficiency of this model is enough reliable to find the defects in fabrics. However this algorithm is not appropriate for all types of defects

III. CONCLUSION

Comparative studies in the literature that evaluate texture analysis methods in application to defect detection. In this paper FCSDA provide 98% accuracy and 2D fast Fourier transform provide 78% accuracy. It must be noted that different studies use different datasets and possible different parameter settings. The resolution of the images used for Various methods of defect detection of fabrics and quality and quantity metrics are reviewed in table1. There are several the detection process also important. Here the size of the image also affects the efficiency of the algorithm devised. Although a solid conclusion cannot be drawn to determine the best method for defect detection, statistical and filter based methods have been more popularly applied for fabric Inspection.

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