

Improved Fabric Defect Detection and Pattern Classification using Radon Transform

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ABSTRACT: Fabric defect detection plays an important role in maintaining the quality of fabric in textile industry. There are many methods available for detecting defects in patternless fabrics. Defect detection in patterned fabrics is a tedious task. In this paper a new method is proposed for the detection of defects in patterned fabrics. Also classification of fabric patterns is done with a technique combining Radon Signature and DWT which is assisted by multiclass svm. This proposed method helps to recognize fabric patterns and fabric defects with minimum cost and time which is very useful in largescale textile production units. This method can be used for fabrics having patterns like Plaid, Striped, Irregular as well as patternless. Comparison of features and defect detection is done using Speeded Up Robust Features(SURF) which gives faster and better results.

KEYWORDS: Pattern classification , Statistical descriptor (DWT),SURF, Radon transform, types of defects, multiclass svm.

I. INTRODUCTION

Defects are common in all manmade things. But the aim is to find out a suitable remedy to avoid this or to lower its amount to an acceptable level. Similarly there are chances for defects to occur in fabrics produced by large manufacturing units. Since large quantity of production is done at a faster rate the probability of occurrence of defects is also higher. Due to this quality reduction manufactures doesn't get much profit. Also it will result in production of low grade products. Inorder to maintain the quality of fabrics produced it is very much important to detect these defects. That is the ultimate aim is to reduce the defects and to produce high quality textiles within short period of time. During early days these defects were detected manually. As a result there is need for extra labourer and the process is time consuming. Since the work is done manually accuracy will also be very low. This results in introduction of new methods of defect detection. It includes methods like semi-automatic and fully-automatic defect detections. Generally fully automatic defect detection is preferred since it is faster and produce better results. Almost all fully automatic defect detection methods are based on image processing.

II. RELATED WORK

Defect detection of fabrics using digital image processing gained its popularity since 1980's. Texture analysis is important among them. Fabric pattern recognition and defect detection is a challenging aim due to the presence of many clothing patterns and its colours with too much intraclass variations. The methods of texture analysis existing mainly give importance to textures with comparable changes in orientation, scaling and viewpoint. It doesn't focus on intensity variations and intraclass patterns. While considering the case of clothing pattern recognition reasonable accuracy cannot be obtained using existing traditional texture analysis methods [1], [2], [3], [4]. In this paper an extension is given to [5], that is here clothes with complex patterns can be used and also it recognize clothing patterns into four categories.

Gabor filter scheme was proposed by Navneet Kaur [6]. It applied optimized 2-D Gabor filters to the textile defect detection problem and provided a further support of their suitability for this task. The textural abnormality inspection

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techniques are discussed in four categories by Xie Xianghua [7]. It includes structural approaches, statistical approaches, model based approaches and filter based approaches. This paper also uses image processing methods for vision based surface inspection. Priya [8] used separate digital images into its bit planes for texture analysis. The contribution made to total image appearance by specific bits is considered here for analysis. Clothing defect detection using image restoration and threshold techniques[9] is done in J Patel.Graylevel texture features extracted from co-occurrence matrix [10], autocorrelation of sub-images [11], Karhunen- Loeve (KL) transform [12], mean and standard deviations of sub-blocks [13] are used in statistical approaches.

III. PROPOSED METHOD

In this proposed paper radon transform based Radon signature is used to extract the global features of the clothing pattern while statistical features are computed using statistical descriptors at different resolutions. Almost all algorithms present today are computationally intensive with less accuracy. Also most of the techniques works only in patternless fabrics. But the proposed method can handle both patterned and patternless fabrics with very large intraclass variations. Here pattern classification and defect detection are done with same inputs which also reduces the computational time and increases productivity of textile industries.

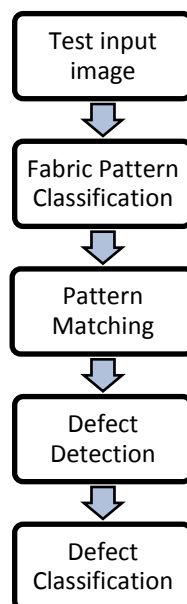


Fig.1.Proposed method flowchart

In the case of defect detection most of the works were done on patternless fabrics. Because it is comparably easy for detecting defects in patternless fabrics with common image processing applications. The proposed method can be applied not only to patternless fabrics but also to patterned fabrics with complex patterns. This approach is based on the result obtained from the pattern classification stage. Since pattern classification is done prior to pattern matching it reduces computational time for matching stage upto four times. Further the matching stage is done with Speeded Up Robust Feature extractor which is speeded version of SIFT. Due to this computational time further reduces and result is obtained much faster. The detailed flowchart of entire method is as show in fig.1.

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IV. PATTERN CLASSIFICATION

Large intraclass variations can be found out in fabric images along with interclass variations. This is the major challenge in classification of clothing patterns. But clothing patterns show more consistency in directionality in different categories of images. This is desirable since this property can be used for differentiating different fabric patterns. Here both the local features and global features are used for classification. In this paper clothing patterns are basically classified into four namely plaid, striped, irregular and patternless. Structural information of repetitive primitives can be extracted from the local features while directionality and statistical properties of clothing patterns are extracted from the global features. These features are extracted using Radon Signature and DWT based statistical descriptor (STA). The basic block diagram for the proposed pattern classification is as shown in fig.2.

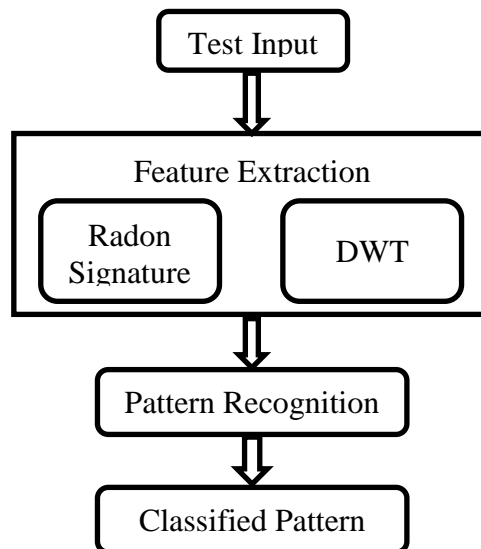


Fig.2. Pattern classification schematic flow chart

1. RADON SIGNATURE

It is a type of signature obtained from the manipulation of Radon transform. Radon transform is used in two dimensions commonly but can be generalized to higher dimensions also. Radon transform is a type of integral transform. It consists of the integral of a function over straight lines. Due to this property it can be used to detect the principle orientation of an image. Rotation invariance is achieved by rotating the image in dominant direction. If $f(x, y)$ is a 2D function then its radon transform is given by,

$$R(r, \theta) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(x, y) \delta(r - x \cos \theta - y \sin \theta) dx dy \quad (1)$$

where r is the perpendicular distance of a projection line to the origin and θ is the angle of the projection line. Clothing patterns in same category also have different color and intensity levels. In order to decrease the intensity variations $f(x, y)$ is taken as the gradient map of the Sobel operator. Radon transform based on the maximum disk area is calculated instead of the entire image to retain consistency of Radon transform for different projection orientations. The orientation of the image is given by the variances of 'r' under a certain projection direction θ_i ,

$$Var(r, \theta_i) = \sum_{j=0}^{N-1} (R(r_j, \theta_i) - \mu(r, \theta_i))^2 \quad (2)$$

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$$\mu(r, \theta_i) = \frac{1}{N} \sum_{j=0}^{N-1} (R(r_j, \theta_i))^2 \quad (3)$$

where $R(r_j, \theta_i)$ is the projection value at perpendicular distance of r_j and projection direction of θ_i , $\mu(r, \theta_i)$ the expected value of $R(r, \theta_i)$; N is the number of sampling bins in each projection line. Variances of 'r' under all sampling projection directions forms the Radon signature.

$$[Var(r, \theta_0), Var(r, \theta_1), \dots, Var(r, \theta_{T-1})]$$

where T indicates the number of sampling projection directions. Then RadonSig feature vector is normalized to L2-norm since it is a nonspare representation. The dominant peaks in the RadonSig represents principle directions of the image.

Now the patterns are classified based on number of peaks in radon signature and thresholding them. The Radon Sig of striped clothes have one principle orientation and plaid clothes have two principle orientations. The irregular and patternless clothes do not have any dominant principle orientation in any direction. They can be differentiated from each other by value of variance. That is irregular patterns have very large variations than patternless images.

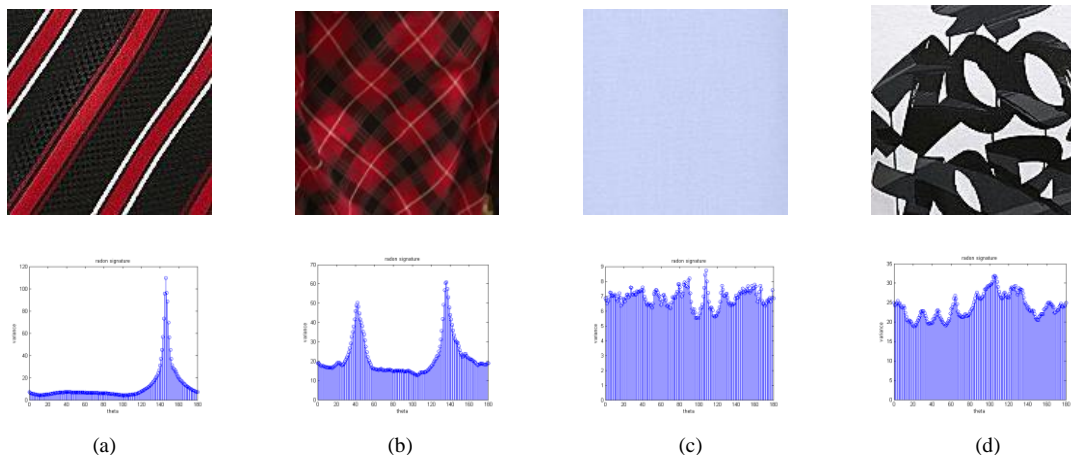


Fig.3. Radon Signatures of different fabric patterns:a)Plaid b)Striped c)Patternless d)Irregular

2. STATISTICAL DESCRIPTOR

In order to analyze the images which have very few background noises and uniform statistical properties it is advantageous to use statistical features. Discrete Wavelet Transform (DWT) is a good spectral analysis tool for extracting the statistical features. By using dwt images can be analyzed at multilevel resolution. The DWT can be used to decompose an image I into low-frequency channel $D_j(I)$ under a coarser scale and multiple high-frequency channels under multiple scales $W_{k,j}(I)$; $k = 1, 2, 3$; $j = 1, 2, \dots, J$, where J is the number of scaling levels. Every scaling level produces four wavelet subbands. It includes one low-frequency channel $D_j(I)$ and three high-frequency channels $W_{k,j}(I)$. The three high frequency channels extracts information in horizontal, vertical, and diagonal directions. Here $J=3$ scaling level is used for decomposition.

In this statistical descriptor four statistical feature values are extracted. It includes variance, energy, uniformity, and entropy of all wavelet subbands. These statistical values calculated are concatenated to form the final descriptor. So it has a dimension of 48. The statistical values are calculated by using the following equations.

$$Variance = \sum_{i=0}^{L-1} (z_i - m)^2 p(z_i) / (L - 1)^2 \quad (4)$$

$$Energy = \sum_{i=0}^{L-1} (z_i - m)^3 p(z_i) / (L - 1)^2 \quad (5)$$

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$$\text{Uniformity} = \sum_{i=0}^{L-1} (p^2(z_i)) \tag{6}$$

$$\text{Entropy} = \sum_{i=0}^{L-1} (p(z_i) \log p(z_i)) \tag{7}$$

where z_i and $p(z_i)$, $i = 0, 1, 2, \dots, L - 1$ is the intensity level and corresponding histogram; L is the number of intensity levels; $m = \sum_{i=0}^{L-1} (z_i p(z_i))$ is the average intensity level.

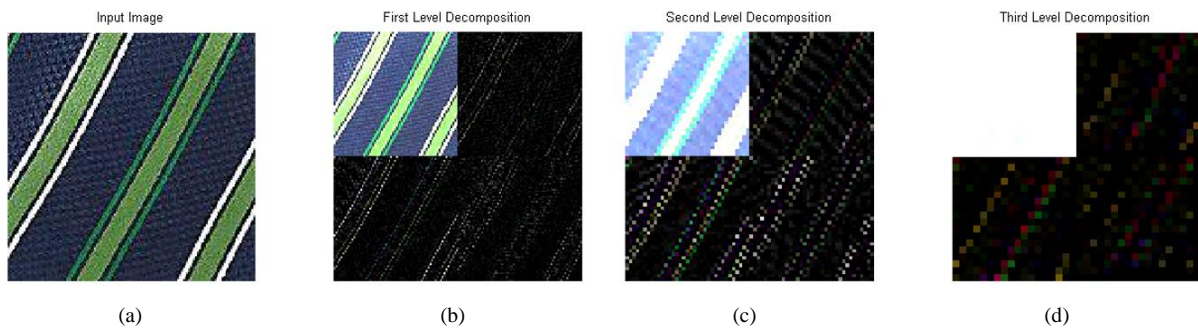


Fig.4.DWT decomposition: a)input image b)first level decomposition c)second level decomposition d) third level decomposition

The three level wavelet decomposition of the given input image is as shown in fig.4. The fig.4.(a) is the input image and fig.4.(b),(c),(d) are the first,second and third level decomposition of the first image respectively.

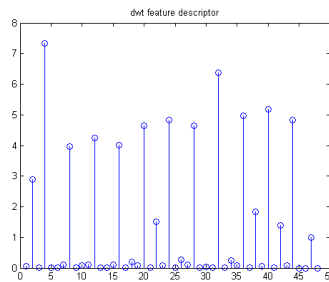


Fig.5.STA descriptor of dimension 48

The statistical descriptor obtained using the input image shown in fig.4.(a). is given above in fig.5. This statistical descriptor has a dimension of 48 which is formed by the concatenation of variance, energy, uniformity and entropy values at three levels.

3. SVM CLASSIFIER

Support vector machines are basically binary classifiers. But they can be used for multiclass classifications if some modifications were done on basic binary classifier. They belong to a family of generalized linear classifiers and can be interpreted as an extension of the perceptron. A hyperplane or set of hyperplanes is constructed by svm for classification and regression. The separation is said to be good if the hyperplane has the largest distance to the nearest training-data point of any class which is termed as functional margin. As the margin is increased generalization error will be decreased.

Here in this paper multiclass svm is used for the classification of patterns. In multiclass svm labels are taken from a set of elements for the purpose of assigning labels to the instances. There are many approaches available for doing so. Here in this paper single multiclass problem is reduced to multiple binary classification problem. At first the svm is trained

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using available set of features of known pattern. Then testing is done using another set of data. Reasonable results are obtained using least number of training data. Better results are obtained adding some more training data.

V. PATTERN MATCHING

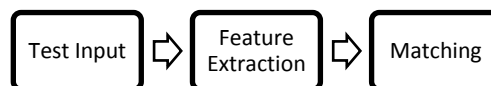


Fig.6.Flowchart of pattern matching

The schematic flow chart of pattern matching stage is as shown in fig.6. In this paper SURF is used for pattern matching. For this purpose we use the result obtained from the previous stage i.e., the output of pattern classification. Based on the output of pattern classification there is only need to check the data from corresponding database. By using the SURF algorithm the feature are extracted and best match from the corresponding database is selected.

1. SPEEDED UP ROBUST FEATURE

SURF is advanced version of SIFT (Scale Invariant Feature Transform). It is about three times faster than SIFT. It is a local feature detector and descriptor which is widely used in object recognition applications. It is an advanced scale and rotation invariant descriptor. It is also invariant to illumination and changes in viewpoint. Here integral image which is the intermediate representation of the sum of gray scale pixel values of image is used. Also Laplacian of Gaussian is approximated with Difference of Gaussian in SIFT whereas in SURF LoG is approximated with a box filter. As a result of this SURF gives faster output than SIFT.

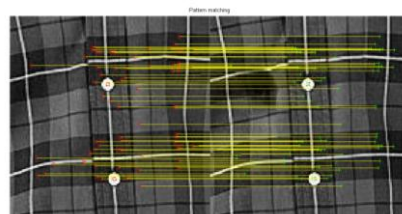


Fig.7.Pattern matching using SURF

The matched output for a defective cloth from the database is as shown in the fig.7. Here a defective image is as the input. Then by using the SURF algorithm interested key points and feature vectors are calculated for both the input defective image and images from the corresponding database of the previous pattern classification stage. Then these features are compared with each other features of input image and matched pattern is found out for further process in the next stage.

VI. DEFECT DETECTION

DEFECTS

Fabric defects refers to set of defects occur in fabrics which is undesirable. Also these defects are equally seen in cotton, silk, wool fabrics. These defects may be widely classified into two namely Yarn defects and Weaving defects.

Yarn defects

These are the defects originated during spinning stage or winding stage of fabric production. Broken Filaments occurs when the individual filaments constituting the main yarn are broken. Knots occurs when broken threads are pieced together by knotting in improper way. Slub occurs as a bunch of fibres having less twist or no twist and has a wider diameter compared to normal spun yarn.

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Weaving defects

These defects are originated during the weaving process. Float is the improper interlacement of warp and weft threads in the fabric over a certain area in the woven fabric. Stains are spot defects of oil, rust, and grease seen in the fabric. Gout is a foreign matter usually lint or waste accidentally woven into the fabric. Holes may be caused due bad needle, take down mechanism too tight, high tension on yarn, bad yarn needle too tight in their slots, dial height too low or too high, badly tied knots, improper stitch setting.

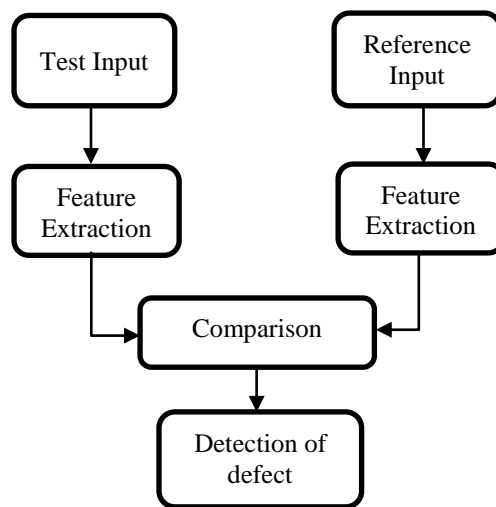


Fig.8.Flowchart of Defect detection

After founding out a suitable match from the database in the pattern matching stage, defect detection is done. This is done by comparison of features of test input with the features of the matched reference input from the database. The schematic flow chart for defect detection is as shown in fig.8.

VII. EXPERIMENTAL RESULTS

The experiments are done using the images obtained from a digital camera. The dataset for reference is kept in the particular folder for the purpose of easiness. Then the images of defective clothes are given as input. The given input images are classified into corresponding patterns such as plaid, striped, patternless and irregular. Then pattern matching is done using speeded up robust feature descriptor which gives faster result when compared with SIFT like descriptor which is shown in fig.7.Since pattern classification is done prior to the pattern matching it also saves much time.

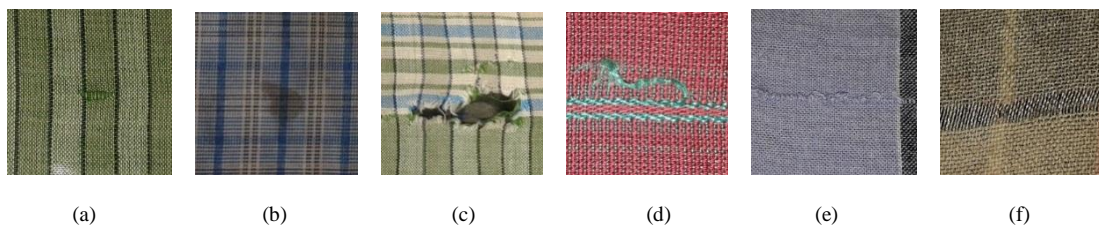


Fig.9.Detected Defects a) Gout b) Stain c) Hole d) Broken Filaments e) Float f)Drop Stitches

After pattern matching the features of corresponding input image and reference image are compared which result in detection of defects. The detected defects using the proposed method is shown in fig.9.The detected defects include Gout, Stain , Hole , Broken Filaments, Float and Drop Stitches as shown in fig.9.(a),(b),(c),(d),(e) and (f) respectively.

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VIII. CONCLUSION

The fabrics are classified into four categories successfully. This method gives fast results compared with exiting state of art methods. The classification of patterns doesn't involve much lengthy algorithms and also it is simple to implement. Since the fabrics are classified prior to matching stage it also further improved the speed of matching stage. Thus the total time consumption is reduced very much and the defects are detected with very high accuracy rate. The most important achievement is that this method can be applied not only to patternless fabrics but also to patterned fabrics of different types. Overall performance of the proposed method implies that this can be adopted in the textile manufacturing units by combining with control and automation using microcontrollers.

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BIOGRAPHY



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