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Research paper

Automatic Detection of Surface Defects in Industrial Materials Based on Image Processing

R.Srividhya[1]*, K.Shanmugapriya[2], K.SindhuPriya[3]

[123] *Assistant Professor, Department of Electronics and Communication Engineering*
Vel Tech High Tech Dr. Rangarajan Dr.Sakunthala Engineering college Avadi, Chennai-600062
**Corresponding author E-mail: vidhyadec09@gmail.com,shanmugapriya@velhightech.com*

Abstract

In the field of industry, corrosion and defects are amongst the most frequent operations. Industrial Materials have periodic defects that are difficult to detect during production even by experienced human inspectors. Defects are difficult to detect during production even by experienced human inspectors. Usually, the colour transfer process contains an image segmentation phase and an image construction phase. Therefore, we introduce an image processing method for automatically detecting the defects in surfaces. We show how barely visible defect can be optically enhanced to improve annual assessment as well as how descriptor-based image processing and machine learning can be used to allow automated detection. Image enhancement is performed by applying manual calculation. We implement this simulation using MATLAB R2013a. Results show that the proposed allows training both tested classifiers with good classification rates around 98.9%.

Keywords: *FCM, SVM, Defect detection*

1. Introduction

Defects on industrial products is a complex problem in production process. The need for quality control and performance testing has become an integral part of production procedure. Defect identification from images is becoming increasingly significant in a variety of applications since quality control plays a prominent role in manufacturing of virtually every product. Defect detection of textured engineered surfaces is one of the major topics to be investigated. Surface inspection and defect detection is a particular case in texture classification, where the algorithm attempts to inspect a surface for possible defects, to classify the input sample as either defective or non defective. Many vision-based inspection approaches have been developed to detect defects on textured surfaces with wide applications such as surface inspection of industrial products that include textile [7,14,20], metal surfaces [18], optical [3],tiles [2], motors[19],railway squats [12] etc. So, we have focused on the machine vision approach to the problem of defect detection of engineered surfaces. The machine vision offers accuracy, consistency and low cost solution to the problem of subjectivity, fatigue and high cost associated with the human inspectors. For humankind, vision is the most important resource of information, hence the most important sense. Among several vision-based activities, object recognition and classification are basic and immediate acts. It would be useful if we could develop an automatic visual pattern recognition system to assist or replace human operator in surface inspection of industrial products. It is important to find the most appropriate visual properties or features of an object that make it distinguishable from others. These properties can be color, shape, edges, texture etc.

2. Preliminaries

2.1. FCM Overview

Image segmentation plays an important role in medical image processing. Fuzzy c-means (FCM) is one of the popular clustering algorithms for medical image segmentation. But FCM is highly vulnerable to noise due to not considering the spatial information in image segmentation. An improved FCM medical image segmentation algorithm based on MMTD which takes some spatial features into account.

2.2. SVM Overview

In many real-life situations we want to be able to assign an object to one of several categories based on some of its characteristics. In computer science such situations are described as classification problems. As a binary classification algorithm, SVM gains increasing popularity because it has shown the outstanding performance in many domains of classification problems such as textile classification [7,14, 20], optical[3],tiles[2],motors[19] and many others. Especially, it tolerates the problem of high dimensions and sparse instance spaces. There has been a recent surge of interest in SVM classifiers in the learning community. SVM provides several salient properties, such as maximization of margin.
The equation to define the hyperplane and the margin are = 0 and = ±1 respectively. Here, is defined as a weight vector and as bias. For better results of SVM, the features that are given as an input to SVM are needed to be reduced. The reduced feature set helps to improve the efficiency of the results produced by the algorithm. To reduce features set, only the useful features are selected from the entire set of features. In feature selection, there is a set of fea-

tures and a method is used to select a subset of features that can perform best under the classification system. The term 'feature selection' refers to the algorithms that gives a subset of feature set which are given as an input to the algorithm [7]. The main three approaches of feature selection are filter, wrapper, and embedded. In Filter methods, high ranked features selected on the basis of a statistical score. In wrapper and embedded methods, the design of a classifier is considered to select the subset of features [8]. The various feature selection or extraction methods like F-score, GA, K-means, Relief and SVM-RFE are discussed in next subsections. These all techniques are helpful to efficiently and easily extract the features for Support Vector Machines.

2.3. Existing Algorithm for Defect Detection

In existing methods, matrix entries and it derives values contrast, homogeneity and energy as feature vector. Gabor filter is used to remove noise from the enhanced image.SVM Algorithm is used for feature extraction. Manual identification is needed. Results show that the existing allows classification rates of up to 94.19%. The disadvantage is that it could not classify the damaged area for the defected surface. It could not implement to all kinds of material surface.Due to this, products and sales will be lost in the industrial applications .The main drawback of this system is manual supervision.

3. Proposed Algorithm for Defect Detection

The algorithm used in this paper is FCM for segmentation process and SVM for Feature extraction. There are 3 stages in this algorithm:
1. Preprocessing stage:
a. Filter selection in noise redution;
b. Threshold in edge detection.
2.Feature extraction stage:
a. Probability of selecting neighboring pixels;
b. Width of the profile;
c.The distance between tracking point and cross point;
d. The number of repeated times;
e. Threshold in binarization;
f. Threshold in spatial reduction
3.Matching stage:
a. Displacement between two templates.

3.1. Preprocessing

Preprocessing techniques are needed on colour, grey-level or binary document images containing text and/or graphics. In character recognition systems most of the applications use grey or binary images since processing colour images is computationally high. Such images may also contain non-uniform background and making it difficult to extract the document text from the image without performing some kind of preprocessing, therefore; the desired result from preprocessing is a binary image containing text only. Thus, to achieve this, several steps are needed, first, some image enhancement techniques to remove noise or correct the contrast in the image, second, thresholding to remove the background containing any scenes, watermarks and/or noise, third, page segmentation to separate graphics from text, fourth, character segmentation to separate characters from each other finally, morphological processing to enhance the characters in cases where thresholding and/or other preprocessing techniques eroded parts of the characters or added pixels to them. The above techniques present few of those which may be used in character recognition systems and in some applications; Feature extraction a type of dimensionality reduction that efficiently represents interesting parts of an image as a compact feature vector.

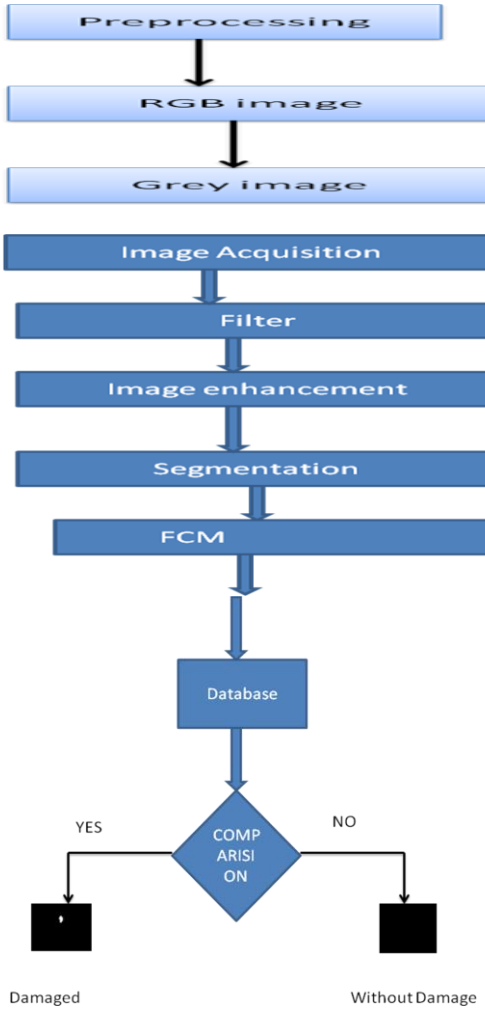
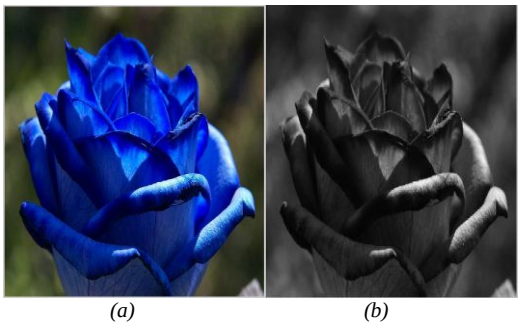


Fig.1: the flow diagram of proposed system

few or some of these techniques or others may be used at different stages of the OCR system. The rest of the chapter will present some of the techniques used during the preprocessing stage of a character recognition system.



(a) *(b)*
Fig.2.(a) RGB image (b)GREY IMAGE

3.2. Feature Extraction

This approach is useful when image sizes are large and a reduced feature representation is required to quickly complete tasks such as image matching and retrieval. Feature detection, feature extraction, and matching are often combined to solve common computer vision problems such as object detection and recognition, content-based image retrieval, face detection and recognition, and texture classification.
The equation to define the hyper plane and the margin are = 0 and = ±1 respectively. Here, is defined as a weight vector and as bias. For better results of SVM, the features that are given as an input to SVM are needed to be reduced. The reduced feature set helps to

improve the efficiency of the results produced by the algorithm. To reduce features set, only the useful features are selected from the entire set of features. In feature selection, there is a set of features and a method is used to select a subset of features that can perform best under the classification system. The term 'feature selection' refers to the algorithms that gives a subset of feature set which are given as an input to the algorithm [7]. The main three approaches of feature selection are filter, wrapper, and embedded. In Filter methods, high ranked features selected on the basis of a statistical score. In wrapper and embedded methods, the design of a classifier is considered to select the subset of features [8]. The various feature selection or extraction methods like F-score, GA, K-means, Relief and SVM-RFE are discussed in next subsections. These all techniques are helpful to efficiently and easily extract the features for Support Vector Machines.

Support Vector Machine (SVM) is the most commonly used classification algorithm for disease prediction. For better results of SVM, the features that are given as an input to SVM need to be reduced. To reduce features set, only the useful features are selected from the entire set of features. This paper gives the comparison of various feature extraction techniques like F-Score, Genetic Algorithm, K-means, Relief and SVM-RFE in terms of accuracy achieved by them in order to predict the tumor in breast diagnosis. SVM-RFE helps to achieve the highest accuracy of 97% and K-means being the simplest method helps to achieve the accuracy of 96%. So, it is beneficial to use any of these two methods in order to extract features for breast cancer diagnosis. Our future work is to study the various enhancements of K-means, and then use the best enhancement, in terms of performance, as feature extraction method.

3.3. Classification

In classification we use SVM as binary classifier we have only two classes representing defective and defect free samples. The process consists of training the SVM and then classifying the unknown image. We also use the simple classification process without SVM. The method counts the number of feature denoting the sample as defect free. If the two or more features have value 1 then we classify the samples as defect free else defective.

4. Results and Discussion

The "Automatic detection for surface defects of industrial materials based on image processing**"** is an improvement in detection of surface defects on industrial materials. Using GSM technology the message about defected area is sent to an appropriate mobile.

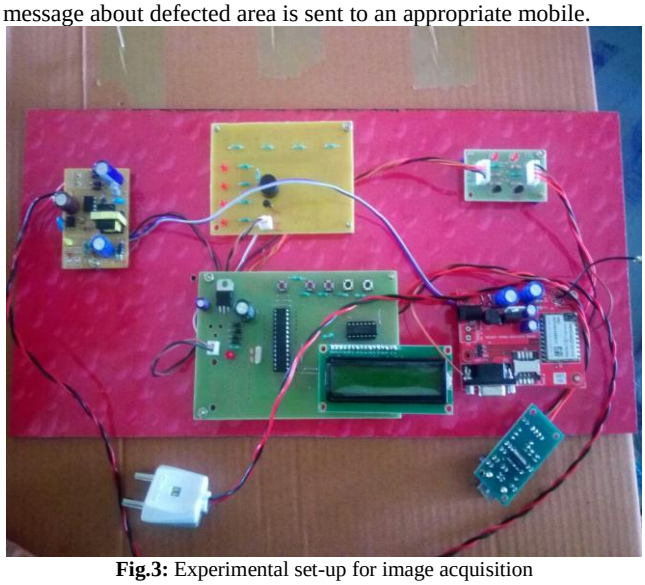


Fig.3: Experimental set-up for image acquisition

We have carried out the experimentation on four surface database including both the fine and coarse surface textures. We computed the three features for all the images based on the proposed algorithm such as FCM segmentation and SVM feature extraction algorithm. After computing the features, we use to classify the images as defective or defect free.50%oth total images of each kind are used for FCM and SVM training. Remaining 50% are tested to classify the defective and defect free images. Note that features are of binary nature and computed as either defective (1) and defect free (0) according to the respective criteria.

Fig.4: Shows the intermediate images after various steps in the algorithm. (a) Original image (b) gray image (c) enhanced image

We compared the results by using various combinations of features. The results can be viewed graphically in Fig. 5. We achieved the overall accuracy of 94.19% with SVM classifier when all three features were used. Instead of training the SVM for individual databases and predicting the class of test image, we also tried to train the SVM by the samples of all the databases collectively. With this we got performance of 91.64%. Also, we tested our heuristics by a simple method of classification without use of SVM. In this method we classified the sample as defect-free if two or more than two features has detected the sample as defect-free otherwise we labeled the sample as defective. This method performs reasonably well and shows 89.73% accurate results. This method works like human brain. Humans are able to find defects without prior knowledge of the defect-free patterns. Similarly, the later process does not require any kind of training for classification. The proposed method is purely based on heuristics and undergoes only simple computational steps such as pre- processing, edge detection, pixel replacements and removals. It finally uses SVM for classification. No computationally expensive method is used in this algorithm. Further as the features are of binary form, few samples are sufficient for training the SVM providing reasonably good classification accuracy.

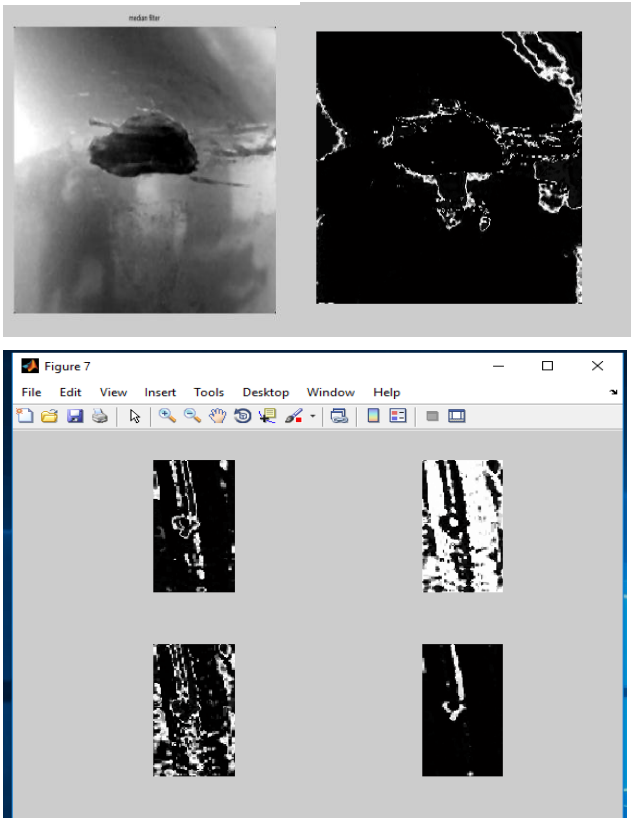


Fig. 5: (a) Binary image with Median Filter (b)Segmented image (c)FCM iterated image

5.Conclusion

This paper provides the collective survey of the different image processing techniques used for the detection of the cracks, scratches and defects in the engineering structures. The main intention of this study was about to study and review the defect detection system based on image processing. Here we have taken many research papers for the review based on the defect detection. The analysis of different methods for defect detection and identification is done.

6. Future Work

An image processing based method for detecting defects (hole, crack and imperfection in diameter) in industrial materials is proposed. In next task the defects will be distinguish according to their size and shape and overall system will be implemented. It will also give the idea about major defect and minor defect. Experimental results will demonstrate the system as effective for dealing with the industrial materials. Our future work will be to focus for implementing this process in small and large scale industries.

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