A DEEP LEARNING ARTIFICIAL NEURAL NETWORK BASED APPROACH TO AUTOMATED FABRIC FAULT DETECTION

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Abstract

Detection of fabric faults performs a significant part in textile production. Detection of fabric defects is a very challenging task because of the wide variety of defects that occur in fabrics. Due to the defects in the fabric, 45-65% of income are lost by manufacturers. Fabric Defect Detection (FDD) is done by manual inspection method and it is very tedious and consumes more time. An Automated fabric fault identification system, is a specific method mainly designed to focus on finding fabric defects. Such a system is designed to assure quality of the fabrics produced. To identify and classifythe defects in the fabrics, an architecture based on Deep learning Artificial Neural Network is proposed in this paper. Convolutional Neural Network (CNN), with multiple convolution and pooling layers,is proposedto increase the efficiency and accuracy of classification of defects in fabrics.

Keywords : Fabric Defect Detection (FDD), Deep learning, Convolutional Neural Network, Pooling.

I. INTRODUCTION

The objective of the textile industries is to produce competitively-priced and attractive fabrics. The industry focuses on quality of the fabrics at each stage of production,and it becomesthe key factor to preserving itsbusiness in the competitive global market. The task of quality control inspectors isenormous, since they have to identify small defects in a wide area that is moving through their visual field fast. Lack of accuracy and high time consumption are the problems in manual inspection mode since fabric defect detection is a significant phase of quality control. The most vital change that assures accuracy and saves time is a shift from trust on human eye to scan by CMOS/CCD camera[1]. The system records the location, size and image of the defects in a highly automated manner.The comprehensive report gets printed, and the product is categorized according to the severity of faults identified during the inspection. The objective is to save time and energy, as well as to improve the accuracy in the assessment process. Computer-based fabric fault identification systems are thought by many researchers of different countries and those are very useful to resolve these kinds of problems.Revealing of defects and a detailed categorization of faults that occur in the textile industry are major challenges in automated FDD system. In this paper, different techniques are discussed for classifying automated fabric defects,and a deep learning method can be adapted to afford unsupervised mode of classifying defect patterns. This work is expected to be very useful for researchers in the area of computerized fabric fault assessment to understand and evaluate many potential options in this field.

The paper focuses on developing a high-tech fabric defect identification system based on computer vision method and adaptive neural networks. Two broad areas of latest research such as image processing and data mining aremerged in this paper for identification of fabric defects and classification.

II. FABRIC DEFECTS

The occurrence of fabric defects marks the final garment asa defective product. Industry reports reveal that 85% of fabric defects are identified in the production environment. It leads to reduce the value of fabrics from 45% to 65%, and furthermore the fabric is dubbed second grade. Hence it is essential that defects are eliminated by removing the root cause from their very source. Among the large classes of fabric faults, missing yarn, hole, slub, crease mark and spots are the notable ones and they are shown in Figure 1.

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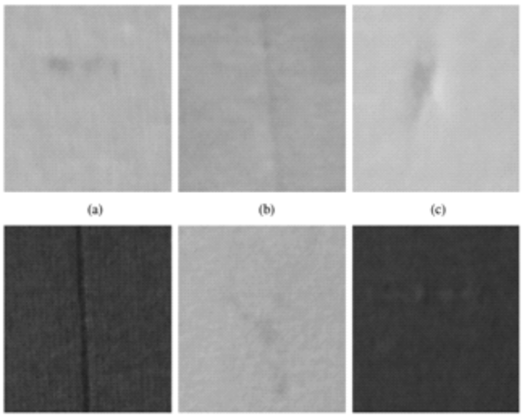

Figure 1: Images showing defects such as color yarn, missing yarn, hole, slub, crease mark and spot.

Fabric defects can also be classified or identified according to the position of defects in the fabric[2]. They can be shown in figure 2 as horizontal, vertical and isolated defects.

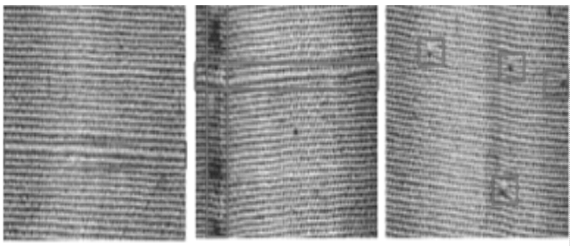

Figure 2: Sample fabric defect images. (a) Horizontal defects. (b) Vertical and horizontal defects. (c) Isolated defects.

III. FABRIC DEFECT INVESTIGATIONPROCESS

An Automated Fabric Defect Detection system involves several stages as depicted in Figure 3. The execution of each step affects the succeeding phases. Each stage has a lot of prominence in the development of a fully automatic system for textile industry. The development of a successive system depends on a strong design and implementation of all phases of the system. Poor design and enactment of a step make the entire system complicated, which results in harder development of the system. In this article, the main focus is given to classification of defects in the automated fabricv inspection system.

Automated Fabric Defect Detection system mostly focuses on detection of defects and only a few systemslay emphasis on classification of defects.

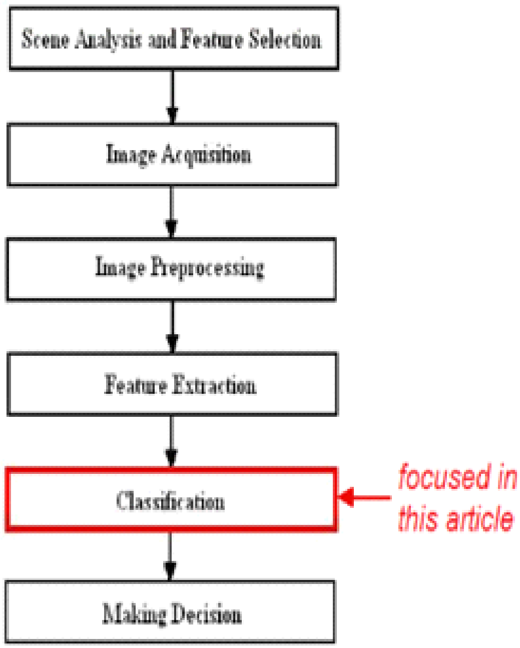

Figure 3: Different stages of an automated fabric defect inspection system.

The defect-recognition procedures that have been used so far are statistical, spectral and model-based[2]. Computer Vision based fabric defect classification uses many methods to recognize the defects. Among them, artificial neural network (ANN), lattice segmentation method, Gabor filters andsupport vector machine (SVM) are most popular. Machine learning is a kind of artificial intelligence method that extracts features out of raw data by using an algorithm. An emerging machine learning method centered on artificial neural networks is Deep Learning.

Fabric defect recognition system based on image processing and deep learning has become an attractive area of research now. It produces more accurate results than human inspection system does. Deep Learning can be applied for de-noising and super-resolution of fabric images[3]. Identification of crease marks in fabrics and also for spotting of holes in fabrics can be done through machine learning methods. Learning methods can be best-suited to identify shrinkage in fabric patterns. Effective restoration and training of fabric dataset using deep neural networks help the system to accurately detect faultsin fabrics.

Neural network architectures based on deep learning acquire features directly from the data without the need for manual feature extraction. Deep learning uses several layers to gradually remove complex-level features from the input fabric image[4].Deep learning architectures force lower layers to recognize the edges of the fabric while the upper layers are trained to identify faults in the fabrics. These mockups are trained by using a large number of hidden layers in the neural network architecture. Convolutional Neural Networks (CNN)use more pre-processing phases when compared to other fabric image classification algorithms. They produce accurate results and are superior to those obtained manually.

IV. NETWORKARCHITECTURE

Convolution Neural Network (CNN) used for fabric defect detection uses seven layers, and is shown in Figure 4. Pairwise Potential Activation Layer (PPAL) is introduced in stage 4 as a dynamic activation layer. To acquire more accurate defect-detection rate the probability map is implemented. CNN architecture uses one input layer and more hidden layers[5].

Here thearchitecture consists of the following layers:

(1) The input layer contains the original fabric image.

(2) Thefirst hidden convolutional layer contains 32×5×5 kernels.

(3) The second hiddenconvolutional layer contains 16×5×5 kernels.

(4) Activation function used in this architecture is PairwisePotential Activation Layer (PPAL). It uses the extracted attributes from the previous convolutional layer and is multiplied by the specified activation map. It uses 3*3 convolutional kernel which uses more pixel properties for inspection.

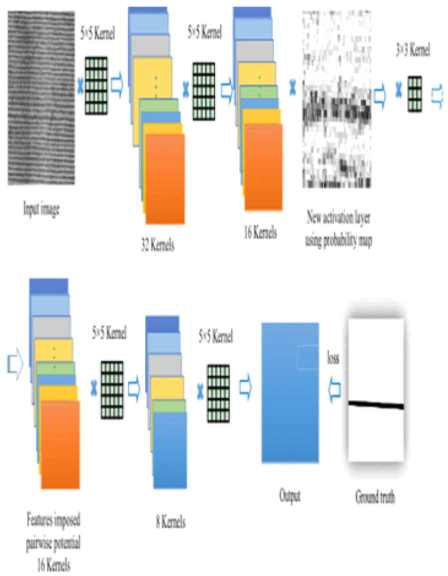

Figure 4: CNN Layers for Defect Detection

(5) The next hidden layer contains 8×5×5 kernels,which add a little complication to the network. This layer also imposes statistical rules to feature maps.

(6) The last hidden layer contains one 5 × 5 kernel which helps to produce an accurate fabric image.

(7) Backpropagationcan be implemented in this network to take more images as references for training the network and produce more accurate results.

Insertion of PPAL in the middle layer eases off the influence of the probability map[6]. If the output layer includes the PPAL then the produced output will be similar to the probability map. It will weaken the convolutional structures.

V. VALUATION OFVARIOUS ACTIVATION FUNCTIONS IN CNN

The most suitable activation function to identify fabric faults is a significant factor to compare the overall performance of FDDs. The four CNNs with the same structure but with different activation functions are considered for comparison. The diverse functions used here are Sigmoid, Tanh, Rectified Linear Unit (ReLU), and PPAL[7].ReLu is treated as a standard activation function for CNN-based fabric defect classification, and it can be applied only for hidden layers. Sigmoid functions, combined with tanh, Softmax and Logistic functions, can be applied in different layers to produce accurate results. It may lead to the disappearance of gradient descent slope.

To overcome the slight difference in the gradientregions of Sigmoidand Tanh activation functions, the cross-entropy loss function is selected. The learning process can be compared with two different learning rates.

VI. CONCLUSION

Robust algorithm depends upon its ability to treat great volume of data having multi-dimensions with unwavering performance, and this holds promise to extend such a classifier to the task of recognizing many more classes of fabric defects.On-line fabric defect inspection system with CNN as the classifier would not only reduce the incidence of defective patches in the fabric but also put the operator on alert to initiate remedial action for earliest restoration so that loss of efficiency on such account can be minimized. Thus, quality as well as quantity of production is set to get enhanced by installing such a system.

A Deep LearningArtificial Neural Network Based Approach for Automated Fabric Fault Detection system is based on two modules, namely learning phase and the testing phase. In the learning phase, the defective fabric images are given as input into the system in the offline mode. Real time defective fabrics are used as input in the testing stage.

The obtained method gives the tradeoff between performance and cost of manual inspection and automated inspection system. It is reasonable since the commondefects that occur in fabrics can be identified easily by using this approach. The minor drawback identified in this system is that small-sized defects are not noted. A high-resolution image inspection system is required to identify such kind of defects.

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