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Defect detection in textiles using back propagation neural classifier

ABSTRACT

The textile products are affected by the defects during the manufacturing processes. It is also waste of the resources used for the production and in turn it affects the business. The manual inspection in defect detections is not encouraged these days in manufacturing process. The computer vision with machine learning algorithms in automated quality control system plays an important role in detecting defects in manufacturing process as well as analyzing the quality of products. Classification of defects in knitted fabric is an active area of research around the globe. This paper presents a classification method to detect defects such as holes and thick places in knitted fabric by applying artificial neural network algorithm. The artificial neural network algorithms learn from the input data after successful training process, it predicts the nature of the unknown samples in very fast and accurate way. The proposed work has been carried out in two phases. In the first phase the images of the defective samples of two classes were collected by a high-resolution camera. The color images of the samples were converted into grey scale images. The features were extracted from each grey scale image and stored in a database. In the second phase a neural classifier was trained with back–propagation neural Network (BPNN) algorithm on the training dataset. After successful training of the neural network on train dataset, the performance of the trained neural network was evaluated on the test dataset. Different experiments were carried out by increasing the number of training data samples; it was found that the best evaluation performance was obtained as 83.3%.

***Keywords**: Classification of defects, holes, thick places, artificial neural network, features, knitted fabrics.*

1. INTRODUCTION

The researchers have been working on computer vision based knitted fabric defect detection system in recent past. It is expected that machine-based vision system to detect the faults in knitted fabric may replace the ongoing manual defect detection process gradually. Automated knitted fabric inspection system faces two main problems namely defect detection and defect classification in knitted fabrics. There are few problems faced by humans working manually on quality control systems: fatigue and tediousness. Also this process is time consuming. A potential solution for this problem is to club computer based vision system with artificial intelligence (AI) techniques.

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The manual system having two main drawbacks: time consuming and high accuracy of defect detection is not achieved [1]. The researchers [2] used neural network with General Delta Rule learning algorithm for training by selecting small subset of pixels from the image as input. They found out fabric defect successfully and also identified the type of defects occurring on the fabric.

The authors [3] extracted the features by using 7x7 mask from the texture surface of fabric with and without defects and the dimensionality of the feature vector was reduced by using Principal Component Analysis (PCA). A three layer neural network and support vector machine (SVM) was applied to detect defects. In another study [4], the researcher has reported a feed forward neural network based approach for fabric defect segmentation. The method proposed by the author has reduced the computational requirements and gave successful results.

During an investigation [5], the authors transform the images into H-image. Applied discrete cosine transform (DCT) to the H-image and extracted the energy features from the image. These energy features were used to train back-propagation network of fabric defect. In test phase a high average accuracy was achieved. The authors in [6] implemented a computer based vision system for detecting and classifying fabric defects. Two types of features were extracted: tonal features and texture features. Two types of system were used for classification work. The first system was fuzzy c-means clustering (FCM) and second was Adaptive Neural- Fuzzy Inference System (ANFIS). A high degree of detection and classification of defects was achieved by using each one system.

The researchers extracted features from the fabric corresponding to statistics of colour intensity of defect [`1] and trained the neural network on the features for fabric defect classifications. They evaluated the performance of neural network on the test dataset. A high level of classification accuracy was achieved in fabric defects. The deep learning method is machine learning method. This method was used by the authors [7] to detect the defects in woven fabrics.

An automated vision system was presented to detect and classify surface defects in leather fabric [8]. The authors extracted GLCM features from the samples and artificial neural network was trained. The researchers applied multilayer perceptron models to classify the defects and achieved better classification accuracy. In an investigation [9], the authors designed a SVM based defect classification method of woven fabrics based on GLCM and Gabor features. They obtained a very high success of defect prediction.

A good review paper based on feature extractions and defect detection algorithms can be found in the literature [10]. In a study, authors [11] applied the wavelet transform and neural networks to detect defect on the surface of the fabric. A method was designed [12] based on GLCM features to detect the defect in fabrics and with Gabor filter method. They found that GLCM based method provides a better method compared to Gabor Based method. A neural architecture-based fabric defect detection work was carried out by the authors [13].

A survey paper on defect detection of fabric by different types of neural classifiers is reported [14]. In one of the recent studies [15], extracted statistical features from knitted fabric in RBG color components and trained the two hidden layers of ANN. The network predicted good result on the test samples of the knitted fabrics. In another investigation [16], the authors applied Multi-Layer Convolutional Neural Network based on Histogram back propagation algorithm for fast fabric defect detection and obtained better prediction rate. The authors [17] applied a computer -based defect detection using shearlet transform. The method was implemented on a circular knitted fabric and high defect detection was achieved.

The acquiring image and transporting into the processing system for analysis is complex process. Also, the patterns on the knitted fabrics makes the quality inspection of textiles difficult. A method was designed to solve this problem was by the periodic distance of the pattern and the self-adaptive segmentation to identify the defect image blocks. The feature matching and defect localization of the defect image blocks were carried out by the researchers [18] with high dress of success.

The researchers applied digital image processing and artificial intelligent techniques on the fabric defect detection. They found that multi-scale convolution neural network is more suitable for the task compared to the other methods. The digital image processing and computer vision-based technology applied in textile industry to find out the fabric defect detection.

The automated system based on the above-mentioned technology is efficient and effective in detecting defect detection of knitted fabrics. A survey paper published by the investigators [19] presents a wide range of research works carried out by the scientists in this regard. A review on the fabric defect detection was published by the researchers [20] on defect detection in manufactured product in textile industry. A large number of works by the researchers were reported in the published article.

In the present investigation an attempt has been made to use an automated method for defect detection in knitted fabric using back propagation artificial neural classifier.

2. PROPOSED APPROACH

The proposed methodology is consisting of two parts: first part is to calculate the features from the sample images having defects and stored the features in a database. The feature database is divided into two parts training and testing. A neural network trained with error back-propagation algorithm was considered for training on the feature dataset. After successful training of neural network on feature dataset, the network was tested on test feature dataset and the classification accuracy was calculated. A coloured image of size M x M of knitted fabric is considered. The image is converted into grey scale image of size M x M. The grey scale image is divided into n non-overlapping equal sub images. Four features were used mean, standard deviation; kurtosis and skewness were computed from each sub image and stored in a form [1 x p] to form a feature vector from one image. The above process was repeated to all the image samples to get feature vectors from knitted fabric with and without defects. A database was constituted with feature vectors. This database is divided into two parts: training and testing.

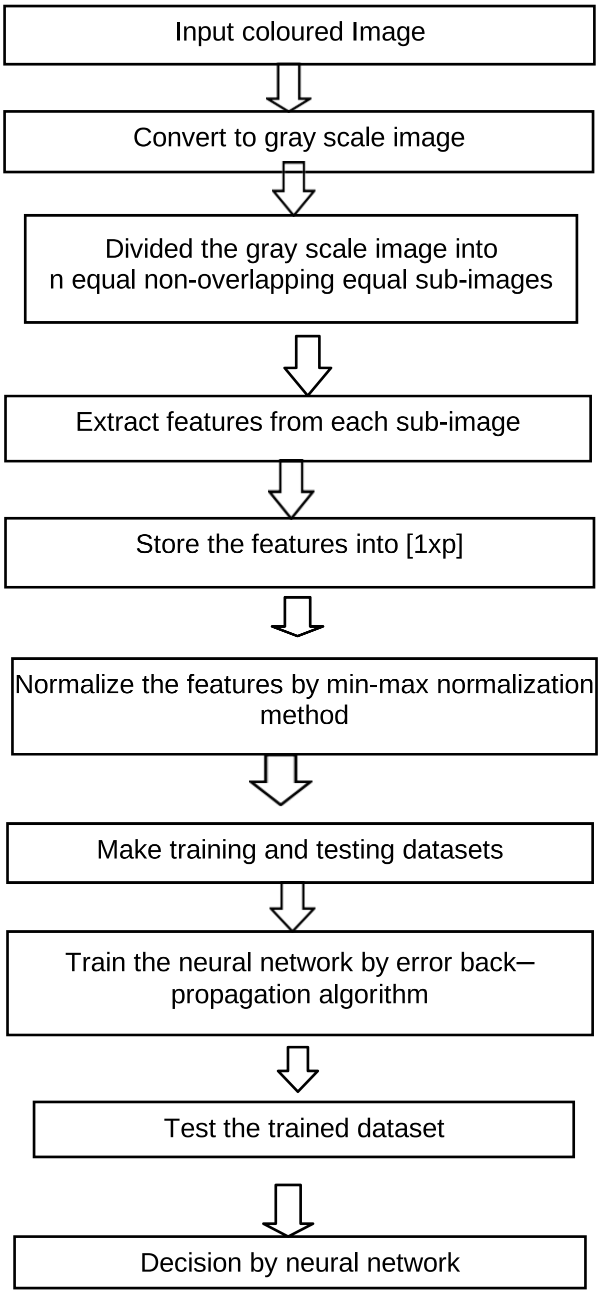

Figure 1. The flow chart diagram of the proposed work

Slika 1. Dijagram toka predloženog rada

The training database was divided into three subgroups with increasing number of training samples. A feed forward neural network was considered for training with error back propagation algorithm. The neural network was trained properly on training datasets with predefined goal. The unseen test dataset was presented to neural network after training for classification purpose. The performance analysis of a neural network was evaluated on the three different test datasets. The complete flow chart diagram of the proposed system was given in Figure 1.

3. EXPERIMENTS CONDUCTED

A high-resolution camera was applied to capture the high quality images of the knitted fabric samples offline. The images were transferred to computer system to make an image database. The samples of knitted fabrics were obtained from the Sky Cotex India Private Limited, Tirupur, Tamil Nadu, India. The MATLAB software [21] was selected to develop the code for the work proposed. A computer system having Intel(R) core(TM) i7-7700HQ CPU@ 2.80GHZ,8GB RAM machine was used for the simulation studies. Holes and thick places were the two types of defects selected from knitted fabric for the experimental purpose. Some of the images with defects as holes and thick place were shown in Figure 2a and Figure 2b.

Figure 2a. Sample of hole in images

Slika 2a. Uzorak rupe na slikama

The images were resized to 128 x 128. Two different experiments were carried out on different feature vectors obtained from the sample images. In experiment 1 the sample image was divided by non-overlapping four sub-images of equal size 64 x 64. From each sub-image four type of features mean, standard deviation, kurtosis and skewness were extracted. Hence, total number of 16 features were extracted from each image of 128 x 128 size. These features were stored in [1 x 16] as a feature vectorin a database. The same process was repeated for all the images used for experiment and feature vectors were obtained for each individual sample image.

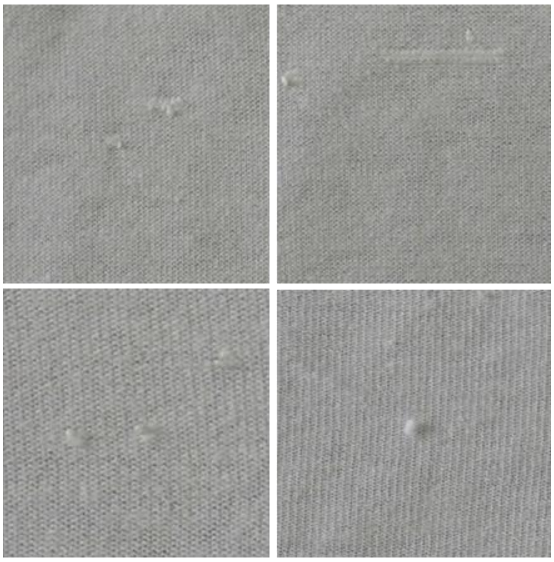

Figure 2b. Sample thick places in images

Slika 2b. Uzorak debelih mesta na slikama

In the second experiment the image was divided into sixteen non overlapping sub-images of equal size 32 x 32. From each sub-image four features were extracted as mentioned above. There were 64 features obtained per image and stored in [1x64] as feature vector from one image. The same process was repeated for all the images and a database of features was created. The dataset was divided into training and test datasets for the further processing by artificial neural network. There were two hidden layers and one output layer apart from input layer in the artificial neural network's architecture. The hidden and output neurons used nonlinear sigmoid functions.

At the start of the experiments, the weights values were in the range of range of± 0.25 and the learning and momentum rate coefficients was varied in between 0 to 1, respectively. The weights were updated after each iteration of processing by training rules. The details about neural network architecture and learning rules are discussed in the literature [21,22]. The classification accuracy of the test samples was calculated in test phase and same has been represented below [4]:

*Performance index = (No. of Correct Classification / Total No. of test pattern presented) * 100.*

The number of input neurons in input layer depends on the feature vector length. The output layer neurons depend on the number of defect classification. The hidden layer neurons were fixed by trial-and-error methods.

Table 1 presents the performance of the proposed methods on varying features test datasets.

Figure 3 depicts a comparative result of neural networks performance on different test datasets.

Table 1: Classification Results

Tabela 1. Rezultati klasifikacije

Sl. No.	No of features per sample	No of training samples	No of testing samples	Defect detection (%)
1		10	10	60
2	16	12	8	62.5
3		14	6	66
4		10	10	70
5	64	12	8	75
6		14	6	83.3

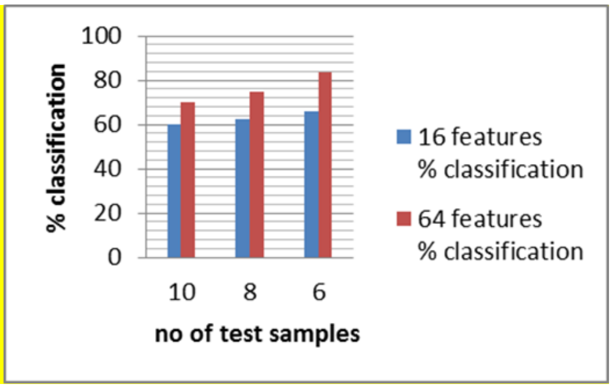

Figure 3. A defect classification comparison by feed forward neural networks on varying test dataset

Slika 3. Poređenje klasifikacije defekata pomoću neuralnog prenosa mreže na različitim skupovima testnih podataka

4. RESULTS AND DISCUSSION

The neural networks having two hidden layers apart from one input layer and output layer, respectively, were considered for the experiments. The nonlinear sigmoidal functions were applied at each hidden layers and output layer neurons. The neural networks were trained on training samples of 10, 12 and 14 nos., respectively. 10, 8 and 6 numbers test samples were considered test phase. In experiment 1, a classification accuracy of 60%, 62.5% and 66% were obtained, respectively by properly trained neural networks. The classification accuracies of 70%, 75% and 83.3% were obtained respectively in experiment 2. A comparative classification results on two different datasets by feed forward neural networks is shown in the Table 1. It is observed from the experiments that classification accuracy increases as the dimensionality of feature vector length increases. Hence the appropriate length of the feature vector from the image samples plays an important role in proper training the neural classifier. In our case, the number of features increased from 16 to 64 in training and test phase. The probable reason is that appropriate features extracted in beginning of the experiments play an important role to represent the object in an image. It is noted that the number of 64 features provides better representation of the object in an image compared to 16 features which yields better classification results. The proper training data set is also important. In the experiments the number of training sets were increased to get better classification results as mentioned in the classification accuracies. A large number of experiments were carried out and after successful training of the neural classifiers; it was possible to predict correct classification. The experiments offered best classification accuracy were reported here.

5. CONCLUSION

A method for defect classification using artificial neural networks was presented in this work. The images of defective knitted fabrics were obtained using high resolution camera. The features were extracted with varying dimensionality describing the property of the image. It was observed that classification accuracy increased with increasing the dimensionality of the data and the proper training set applied to the artificial neural network. The further studies on this area will be carried out by exploring large no of image samples with other defects in the knitted fabrics. Other features such as moments, texture, etc. may be extracted and network will be trained and tested. The performance of other types of neural network: resilient neural network, probabilistic neural network may also be considered for the classification purpose. The method proposed may be applied for other areas of classification with or without changes also.

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IZVOD

Detekcija defekta u tekstilu korišćenjem neuronskog klasifikatora sa povratnim širenjem

Tekstilni proizvodi su pogođeni defektima tokom procesa proizvodnje. To je, takođe, rasipanje resursa koji se koriste za proizvodnju i zauzvrat utiče na poslovanje. Ručna inspekcija u otkrivanju kvarova se danas ne podstiče u proizvodnom procesu. Kompjuterski vid sa algoritmima mašinskog učenja u automatizovanom sistemu kontrole kvaliteta igra važnu ulogu u otkrivanju nedostataka u proizvodnom procesu, kao i analizi kvaliteta proizvoda. Klasifikacija nedostataka pletene tkanine je aktivna oblast istraživanja širom sveta. Ovaj rad predstavlja metod klasifikacije za otkrivanje nedostataka kao što su rupe i debela mesta na pletenini primenom algoritma veštačke neuronske mreže. Algoritmi veštačke neuronske mreže uče iz ulaznih podataka nakon uspešnog procesa obuke, predviđa prirodu nepoznatih uzoraka na veoma brz i precizan način. Predloženi radovi se odvijaju u dve faze. U prvoj fazi su slike neispravnih uzoraka dve klase prikupljene kamerom visoke rezolucije. Slike uzoraka u boji su pretvorene u slike u sivoj skali. Karakteristike su izvučene iz svake slike u sivoj skali i uskladištene u bazi podataka. U drugoj fazi je obučen neuronski klasifikator sa algoritmom neuronske mreže sa povratnom propagacijom (BPNN) na skupu podataka za obuku. Nakon uspešne obuke neuronske mreže na skupu podataka o vozu, performanse obučene neuronske mreže su procenjene na test skupu podataka. Različiti eksperimenti su sprovedeni povećanjem broja uzoraka podataka za obuku; utvrđeno je da je najbolji učinak ocenjivanja dobijen sa 83,3%.

Ključne reči: *Klasifikacija defekata, rupe, debela mesta, veštačka neuronska mreža, karakteristike, pletenine*

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