Classification of knitted fabric defect detection using Artificial Neural Networks

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***Abstract----*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. The 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 colour 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 error back–propagation 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 no of training data samples, it was found that the best evaluation performance was obtained as 83.3%**.

Keyword—classification, netting, Artificial Neural Networks, Back propagation, computer vision.

I. INTRODUCTION

The researchers have been working on computer vision based knitted fabric defect detection system in recent past. The system is replacing manual inspection to find the defect and classify its categories. Automated knitted fabric inspection system faces two main problems namely defect detection and defect classification in knitted fabrics. There are three 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. The manual system having two main drawbacks: time consuming and high accuracy of defect detection is not achieved [1]. The researcher in [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 defects where occurring on the fabric.

The authors in [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 [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.

In [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 in [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 researchers applied multilayer perceptrons models to classify the defects and achieved better classification accuracy. Zhiqiang Kang, et al, [9] applied the wavelet transform and neural networks to detect defect on the surface of the fabric. The organisation of the paper as follows. Section II describes the proposed approach. In section III presented the experiments conducted. In section IV results and discussion are discussed. The summarization and future scope of the work is discussed in section V.

II. 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. 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 below in Fig. 1.

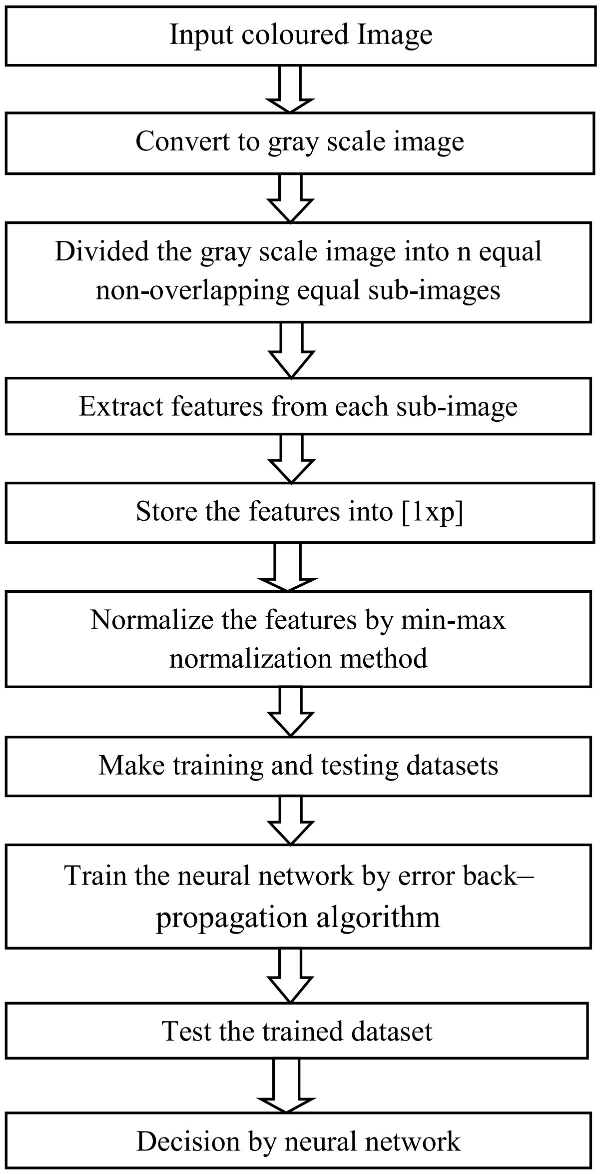

Fig.1 The flow chart of proposed work.

III. EXPERIMENTS CONDUCTED

A high resolution camera was applied to capture the high quality images of the samples offline. The images were transferred to computer system to make an image database. The samples of knitted fabrics were obtained from Department of Textile Technology of our Institution. The MATLAB software [10] was selected to develop the code for this work. A computer system having Intel(R) core(TM) i7-7700HQ CPU@ 2.80GHZ, 8 GB RAM machine. Holes and thick places were the two types of defects selected from knitted fabric for the experimental purpose. Some of the images with defects such as holes and thick place were shown in fig.2.

Fig. 2 (a): Sample of hole images.

Fig. 2 (b): Sample thick places images.

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 defective sample image was divided by non-overlapping four sub-images of equal size 64 x 64. Hence there were four sub-images. From each sub-image four type of features mean, standard deviation, kurtosis and skewness were extracted. Hence from image size 128 x 128, there were 16 features were calculated. These features were stored in [1 x 16] as a feature vector in a database. The same process was repeated for all the sample images. And feature vectors were obtained for each individual sample.

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 neural networks architecture. The hidden and output neurons are 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 1respectively. The weights were updated after each iteration of processing by training rules. The details about neural network architecture and learning rules can be found in [12-14]. The classification accuracy of the test samples were calculated in test phase and same has been represented below [4]:

Performance index

$$= \frac{no.of\ correct\ classification}{Total\ no.of\ \ patterns\ presented} x100$$

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. All the images were 128x128 in size for the experiments.

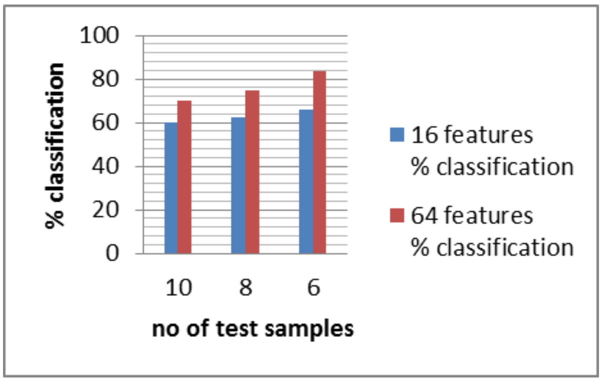

Fig. 3: A defect classification comparison by feed forward neural networks on varying test dataset.

IV. RESULTS

The structure of neural networks were having two hidden layers apart from input layer and output layer respectively. The neurons in hidden layers and output layer were nonlinear sigmoidal functions. The neural networks were trained on training samples of 10, 12 and 14 nos. respectively. The test phase was carried on 10, 8 and 6 nos. test samples. 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 in experiment 2. A comparative classification results on two different datasets by feed forward neural networks was shown in the Fig.4. 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, as no of features increased from 16 to 64. 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 no of 64 features provides better representation of the object in an image which yields better classification results. A large number of experiments were carried out and after successful training of the on the neural classifiers to predict correct classification. The experiments offered best classification accuracy were reported here.

Table 1: Classification Results in %.

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

V. 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 the proper training set applied to the 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 movements, 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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