Artificial Neural Network approach to Fabric Defect Identification system

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Abstract

Textile industry is one of the revenue generating industry to India. In textile industry the detection of defect in fabric is a major threat. Woven fabrics produced by weaving. Weaving is a process of interlacing two distinct yarns namely warps and wefts. A fabric fault is any abnormality in the fabric that hinders its acceptability by the user. The price of the fabric is affected by the defects in fabric. At present, the fault detection is done manually after production of a sufficient amount of fabric. The nature of work is very dull and repetitive. This is uneconomical because, possibility of human errors with high inspection time. This paper proposed a computer based inspection system for identification of defects in the woven fabrics using image processing and Artificial Neural Network (ANN) technique with benefits of low cost and high detection rate. The inspection system first acquires high quality vibration free images of the fabric using digital camera. The acquired images are first preprocessed and normalized using image processing techniques. The preprocessed image converted into binary image by taking intensity as thresholding. Six statistical features extracted from the binary image. These extracted features given as input to the Artificial Neural Network (ANN), which uses radial basis function network to identify the defects. The ANN trained by using 125 defect free and defected images and tested with 75 images.

Keywords: Artificial Neural Network (ANN), Back Propagation Algorithm, Defect Identification, Feature Extraction, Image processing, Statistical features.

1. Introduction

Quality control means conducting observations, tests and inspections so that making decisions, which improve its performance. A fabric is a flat structure. Woven fabrics produced by weaving, which is the textile art in which two distinct sets of yarns or threads – called the warp and weft – are interlaced with each other at right angles to form a fabric or cloth. The warp represents the threads placed in the fabric longitudinal direction, while the weft represents the threads placed in the width-wise direction. The weave pattern periodically repeated throughout the whole fabric area with the exception of edges. The plain weave is the most made weave in the world, it is relatively inexpensive, easy to weave and easy to finish. First quality fabric plays the main role to insure survival in a competitive marketplace in a weaving plant. This introduces stress on the weaving industry to work towards low cost first quality products as well as just in time delivery. Second quality fabric may contain a few major defects and/or minor several structural or surface defects. Online system provides images from current production and is located directly on or in the production line, while offline system is located after the production line. Until now the fabric inspection is still undertaken offline and manually by skilled staff with a minimum accuracy and high inspection time. The dream of textile manufacturers is to achieve optimum potential benefits such as quality, cost, comfort, accuracy, precision and speed. Computer based system requires very high resolution imaging to enable defects as small as a single missed thread, a fine hole or stain to be detected. Plain fabric inspection systems still a challenge due to the variable nature of the weave.

The fabric defect is a change in or on the fabric construction. The weaving process may create a huge number of defects named as weaving defects. These defects appear in the longitudinal direction of the fabric (warp direction) or in the width direction (weft direction). Presence or absence of the yarn causes defects such as miss-ends or picks, end outs, and broken end or picks. Some defects are due to yarn defects and additional defects due to machine related and appeared as structural failures. Automatic
fabric inspection systems designed to increase the accuracy, consistency and speed of defect detection in fabric manufacturing process to reduce labor costs, improve product quality and increase manufacturing efficiency. Image processing pays a vital role in defect detection. The resolution of an image can be referred either by the size of one pixel or by the number of pixels per inch. The lower the image resolution, the less information is saved and higher resolution means more information is saved but larger memory size is required to store.

Celik H.I., Dulger et al.[1][3] proposed a machine vision system for fabric inspection based on wavelet transform, double thresholding binarization and morphological operations where they detected the defective and defect free regions of an accuracy of 93.4 % and the defects are classified with 96.3 % accuracy rate. Zhou, J., Semenovich, et al.[2] proposed a dictionary-learning framework for fabric defect detection by simply measuring the similarity between the original and its approximation which is able to efficiently discriminate defective samples from normal. They used a recently developed novelty detection algorithm, the support vector data description for handling classification task. Their results show that the proposed algorithm can control both false alarm rate and missing detection rate within 5%.


2. Material

In this paper, we focus on 100% cotton plain-woven fabric with defect free and defected image. The images, taken by using digital camera, begins from 300 dpi resolution and will increase by a step of 100 dpi because human vision is approximately 300 dpi at maximum contrast. The suitable resolution, which provides higher detection rate, is 1000 dpi. The optimal size, based on percentage of identification and CPU time, which produce high identification rate with minimum time is 512x512, which is shown in fig.(1).
3. Methods

The most important parameter used in the image acquisition is the resolution. The resolution of an image can be referred either by the size of one pixel or by the number of pixels per inch. The lower the image resolution, the less information saved and higher resolution means more information saved but larger memory size is required to store. The scanning of fabric images begins from 300 dpi resolution because human vision is approximately 300 dpi at maximum contrast. The scanned image is stored in ‘tif’ format and grayscale image. A camera used to capture various plain fabric samples containing different types of defects. Initially the resolution level is set to 300 dpi and then gradually increased by step of 100 dpi until 1200 dpi as a maximum resolution. Different types of camera like CCD (Charged Coupled Device) perform the image acquisition, CMOS (Complementary Metal Oxide Semiconductor), digital camera etc., the images are stored in matrices of size 512x512 pixels. After acquiring the image, the image is normalized using interpolation method. The normalized image converted into binary image taking intensity values as threshold, and then from the binary image the features extracted.

4. Feature Extraction

The texture of an image region described by the way the gray levels distributed over the pixels in that region. The features are described the properties of an image region by exploiting space relations underlying the gray level distribution of a given image. Statistical approaches compute different properties. Based on the number of pixels defining the local features the statistical approach can be classifying as first-order (one pixel), second-order (two pixels) and higher-order (three or more pixels) statistics. The difference between first-order and higher-order statistics is that first-order statistics estimate properties of individual pixels, and do not consider pixel neighborhood relationships, whereas second and higher-order statistics estimate properties of two or more pixel values occurring at specific locations relative to each other. Higher order statistics not considered for implementation due to interpretation difficulty and calculation time. The following first and second order statistics are consider among the available statistics as texture features in representing images. First order statistics texture measures calculated from the original image intensity values. They do not consider the relationship with
neighborhood pixel. Features derived from this approach include moments such as mean, standard deviation, energy, entropy, skewness and kurtosis

\[
\text{mean} (\mu_i) = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} I(i,j)}{M \times N}
\]  \hspace{1cm} (1)

\[
\text{standard deviation} (\sigma_i) = \sqrt{\frac{\sum_{i=1}^{M} \sum_{j=1}^{N} (I(i,j) - \mu)^2}{M \times N}}
\]  \hspace{1cm} (2)

\[
\text{energy} (e_i) = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} I(i,j)^2
\]  \hspace{1cm} (3)

\[
\text{entropy} = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} [I(i,j) - \ln(I(i,j))]
\]  \hspace{1cm} (4)

\[
\text{skewness} = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} (I(i,j) - \mu)^3}{M \times N \times \sigma^3}
\]  \hspace{1cm} (5)

\[
\text{kurtosis} = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} (I(i,j) - \mu)^4}{M \times N \times \sigma^4}
\]  \hspace{1cm} (6)

5. Artificial Neural Networks

The Artificial Neural Networks (ANN) is inspired by the way biological nervous system works, such as brain processes an information. ANN mimics models of biological system, which uses numeric and associative processing. In two aspects, it resembles the human brain. 1. It acquired knowledge from its environment through a learning process. 2. Synaptic weights, used to store the acquired knowledge, which is interneuron connection strength. There are three classes of neural networks, namely single layer, multilayer feed forward networks and recurrent networks.

In this paper, multilayer feed forward network used in which the processing elements are arranged in three layers called input layer, hidden layer and output layer. During the training phase, the training data fed into to the input layer. The data is propagated to the hidden layer and then to the output layer. This is called as the forward pass of the back propagation algorithm. In forward pass, each node in hidden layer gets input from all the nodes from input layer, which multiplied with appropriate weights and then summed. The output of the hidden node is the nonlinear transformation of the resulting sum. Similarly, each node in output layer gets input from all the nodes from hidden layer, which multiplied with appropriate weights and then summed. The output of this node is the non-linear transformation of the resulting sum.

The output values of the output layer compared with the target output values. The target output values are those that we attempt to teach our network. The error between actual output values and target output values is calculated and propagated back toward hidden layer. This is called as the backward pass of the back propagation algorithm. The error used to update the connection strengths between nodes, i.e. weight matrices between input-hidden layers and hidden-output layers updated. During the testing phase, no learning takes place i.e., weight matrices are not changed. Each test vector fed into the input layer. The feed forward of the testing data is similar to the feed forward of the training data. The back propagation algorithm used to calculate the gradient error function using chain rule of differentiation. After the initial computation, the error propagated backward from the output units, so it is called as back propagation. The algorithm for back propagation is as follows.

1. Apply feature vector \( x_n \) to artificial neural network and forward propagate through network using

\[
a_i = \sum w_{ij} x_i \quad \text{and} \quad x_j = h(a_j)
\]  \hspace{1cm} (7)
2. Evaluate $\delta_k$ for all output using
\[
\delta_k = y_k f'_k
\]  
(8)

3. Back propagate the $\delta$s using
\[
\delta_j = h'(a_j) \sum w_{kj} \delta_k
\]
(9)
\[
\text{use } \frac{\partial E}{\partial w_{ji}} = \delta_j a_i
\]
(10)

to evaluate required derivative. The back propagation algorithm has higher learning accuracy and faster.

Its aim is adapting the weights to minimize the mean square error.

6. Results and Discussions

The inspection system captures fabric images by acquisition device (digital camera) and passes the image to the computer. Initially the inspection systems normalize the image using interpolation methods. The normalized image filtered with adaptive median filtering. Taking the intensity value as threshold the image converted into binary image. The six first order statistics values calculated from the binary image. These calculated statistics values used as feature vector to the multilayer feed forward network. The input layer consists of 6 neurons, hidden layer consists of 5 neurons and output layer consists of 1 neurons. The neural network uses Levenberg-Marquardt function as training function. The output layer is to produce target outputs as 1 for defect images and 0 for defect free images. The neural network trained with 225 images and tested with 175 images. The performance of the system is evaluated by using 75 different fabric images. There are 25 defect free images and 50 images of various types of defect. The network trained by more than 180 defect and defect free images.

Figure 2. (a) Defect free input image                                                    (b) Defected input image

Figure 3. (a) Defect free normalized image                                      (b) Defected normalized image
Figure 4. (a) Defect free filtered image  
(b) Defected filtered image

Figure 5. (a) Defect free resultant image  
(b) Defected resultant image

Figure 6. (a) Defect free image output  
(b) Defected image output

Figure 7. (a) Performance of Neural Networks  
(b) Training of Neural Networks
Our system produces 98.86% accurate results identifying defects. Artificial Neural network simulates the input set after calculating input set and identify defect of image as an actual output. Therefore, this system is simple and successfully minimizes inspection time, produces high accuracy than manual inspection system.

Figure 8. Identification accuracy of various methods

Figure 9. Regression of Neural Networks

7. Conclusion

In this paper, a fabric defect identification system based on statistical features and back propagation was presented. Firstly images acquired, preprocessed then GLCM is formed and statistical features are extracted. The extracted features are input to BPN classifier for further matching process. Four types of fabric defects were identified. We achieved total success rate of fabric identification is 98.86%. The results obtained by our proposed system indicate that a reliable computer based fabric inspection system for textile industries can be created and it can produce high accuracy than manual inspection system.
8. References


Biography

Dr. G. M. Nasira received M.C.A. and M.Phil degree in the year 1995 and 2002 respectively and the Doctorate degree from Mother Teresa Women’s University, Kodaikanal in the year 2008. She is having around 15 years of teaching experience in College. Her area of interest includes Artificial Neural Networks, Fuzzy Logic, Genetic Algorithm, Simulation and Modelling. She has presented 38 technical papers in various Seminars / Conferences. She has presented 5 technical papers in International Conference. She has published 15 articles in International Journal. She is a member of Indian Society for Technical Education (ISTE).
B. Nagarajan received MCA degree from Madras University, India in 1997 and M.Phil. degree in Computer Science from Manonmaniam Sundaranar University, India in 2002. Currently he is pursuing the Ph.D. His area of interest in research includes Image Processing and Neural Networks. He has published eleven papers in National/International Conferences of repute and five papers in International Journals. He has worked as a Co-Investigator in a research project funded by DRDO, Nowdelhi, India during 2003 and 2005. He is a Life member of Indian Society of Technical Education (ISTE) and Association of Computer Electronics and Electrical Engineers (ACEEE).

P. Banumathi received BE, MCA, M.Phil and MBA in the year 1994, 2004, 2007 and 2008. She is having 13 Years of teaching experience and 5 years of Industrial experience. Her area of interest is Artificial Neural Networks and Image Processing. She has presented 15 technical papers in various Seminars / National Conferences. She has presented 3 technical papers in International Conference. She has published 5 articles in International Journal. She is a member of Indian Society for Technical Education (ISTE) and Computer Society of India (CSI).