List of publications

1. Jayanta K. Chandra, Pradipta K. Banerjee, Asit K. Datta, “Neural Network Trained Morphological Processing for the Detection of Defects in Woven Fabric”, The Journal of the Textile Institute, Taylor and Francis, vol.- 101, no.- 8, pp- 699- 706, 2009.

2. Jayanta K Chandra, Asit K Datta, “Detection of defects in fabrics using sub image based singular value decomposition”, The Journal of the Textile Institute, Taylor and Francis, vol.- 104, issue- 3, pp- 295-304, 2013.

3. Jayanta K. Chandra, Pradipta K. Banerjee, Asit K. Datta, “Morphological Reconstruction Operation for the Detection of Defects in Woven Fabric”, IEEE Region 10 Colloquium and the Third ICIIS, I.I.T. Kharagpur, India December 8-10, 2008.

4. Jayanta K Chandra, Pradipta K Banerjee, Asit K Datta, “Singular value decomposition method for the detection of defects in woven fabric refined by morphological operation”, IEEE Recent Advances in Intelligent Computational Systems (RATICS), pp- 541- 544, Trivandrum, India, 2011

5. Jayanta K Chandra, Pradipta K Banerjee, Asit K Datta, “PCA Based ANN Trained Morphological Process for the Detection and Classification of Defects in Woven Fabric”, International Conference on Soft Computing and Engineering Applications (SEA- 2011), pp-26- 32, Kolkata, India, 2011.

6. Jayanta K Chandra, Pradipta K Banerjee, Asit K Datta, “Modular eigenfabrics based classifier for the detection of defects in woven fabric”, IEEE International Conference on Recent Trends in Information Systems, Kolkata, pp- 223- 228, India, 2011.

7. Anushree Basu, Jayanta K Chandra, Pradipta K Banerjee, Asit K Datta, “Sub image based eigenfabrics method using multiclass SVM classifier for the detection and classification of defects in woven fabric”, IEEE International Conference on Computing Communication & Networking Technologies (ICCCNT), pp-1-6, Coimbatore, Tamilnadu, 2012.

Book chapter:

- Asit K Datta, Jayanta K Chandra, “Detection of defects in fabric by Morphological image processing”, chapter-11, pp- 217-233, Woven Fabric Engineering, SCIYO Publication, 2010.

Replies to viva- voce questions:

1. ***Why are the diagonal orders (first and third quadrant) in Figs 6.5(c) & 6.4 (c) missing?***

   Reply: Diagonal orders in the Fourier spectra of Figs 6.5(c) & 6.4 (c) are not missing. Since the amplitudes of higher order sinc function are small compared to the central amplitude, these are not visible in the spectral image. Moreover, all amplitudes of the 3D sinc function would have appeared symmetrically even in the diagonals, if and only if the basic grating structures is absolutely square. It can be seen from Figs 6.5(a) & 6.4 (a) that the grating structure is rectangular, therefore even the first orders of the Fourier spectra in both the figures are rectangular instead of square.

2. ***Processed image in Fig. 6.2 (i) shows the detected object black (dark) while processed images in Figs. 6.4 (f) & 6.5 (f) show it bright, why?***

   Reply: In Figs. 6.2 (i) & 6.4 (f), the reconstructed fabric images in spatial domain after frequency domain filtering are shown. Since the respective fabric images in spatial domain, shown in Figs. 6.2(c) and 6.4(a) contain a dark and a bright defect, so these images after filtered in frequency domain and reconstructed back to spatial domain give the interlaced grating structure removed images of defects in its original intensity values.

   However the, binary image of defect, appeared as bright in Fig. 6.5 (f) is obtained by the filtering of the fabric image shown in Fig 6.5(b) followed by its energy thresholding.

3. ***It is mentioned on page 129, top line 'From Fig. 6.4 (e) - (f) it may be observed that the energy of noise is small'. Explain.***

   Reply: Fig. 6.4 (e) & 6.4 (f) are filtered reconstructed fabric frames of 3D fabric images shown in Fig. 6.4 (a) & 6.4 (b) as the input frames. As the filtering in this case is done to suppress the interlaced grating structure of the fabric, shown in Fig. 6.4 (e) and 6.4 (f), the energy of the noise representing interlaced grating structure of fabric become small when compared to those for the defective fabric portions considered as region of interest. .

4. ***Is equation (3.31) dimensionally correct?***

   Reply: Equation (3.31) as given by $POS_i(t+1) = POS_i(t) + v_i(t+1)$ is dimensionally correct. This is due to the fact that POS_i and v_i, representing position and velocity of i- th particle of the swarm have dimension 2 (as in the problem 2 parameters are to be optimized). Iterations do not change the dimensions.

5. ***It is readily seen that the reconstructed images approach the original image with increasing number of basis elements. P. 35. Explain***.

   Reply: The basis elements represent the energies associated with singular values of a fabric image, the manipulation of which by left and right singular vectors reconstructs the fabric image again as per equation (2.3). From figure 2.1 it is also observed that the first few singular values are dominant parameters than the others. Hence it is possible to reconstruct the fabric image, up to a certain similarity by considering these dominant singular values. Though small, the non dominant singular values also carry some fabric information. Therefore, if all singular values are considered the reconstructed fabric image becomes identical to the original one.

Errata:

1. **All the typographical errors are corrected in this copy as suggested by examiner**.

P. 5, line 3 from bottom: *insure* is changed to *ensure*.

P. 9, line 4 from bottom: *in this review* is changed to *in this thesis.*

P. 48, para 1, line 6: *statics* is changed to *statistics*.

P. 56, in line above eq. 3.10 and the paragraph after this: *is* changed to *are*.

P. 57 2nd line above eq. 3.14: *principle* is changed to *principal*.

P. 59, line 4 from bottom: *at* is changed to *to*.

P. 69, line 4 from bottom: *principle* is changed to *principal*.

P. 153, line 12 from bottom: *tutored the aspects of* is deleted.

2. **All references are corrected in this copy as suggested by examiner.**
   a. Inconsistencies in writing the references are corrected. Page numbers are designated as pp. and volume and issue are designated as volume (issue) throughout.
   b. In reference 154: *Kenedy* is changed to *Kennedy*.
   c. In reference 163: place and country are incorporated.
   d. In reference 190: required information is given.
   e. In reference 193: volume of the reference is given.

Title of the Thesis

Some Studies on Image Analysis Techniques for the Detection and Classification of Defects in Woven Fabrics

Abstract

The objective of the thesis is to develop efficient and simple defect detection techniques with higher defect detection accuracy. The techniques which are yet to be tried or tried in limited way in the field of defect detection on woven fabric are mainly explored. The work in Chapter 2 is focused on the technique of sub image based singular value decomposition (SVD) for defect detection in fabric. Chapter 3 deals with fabric space management for achieving reduced coefficient fabric space, required for fabric defect detection in an efficient way. A rough set based approach is undertaken for fabric classification in Chapter 4. Optimum number of parameters representing a fabric class is obtained using rough set theory. Once the optimum parameters are known, the trained ANN provides the parameters required for binarization and morphological opening based reconstruction operation of a certain fabric class and class of fabric defect for fabric defect detection (Chapter 5). For classification purpose Euclidian distance classifier, multi class support vector machine (SVM) and K- nearest neighbor (KNN) classifiers are used. Lastly in Chapter 6, an altogether different approach is explored using three dimensional Fourier transform. A three dimensional cylindrical filtering is used to detect the defects in fabric. The radius of the filter along with the energy threshold value, required for noise elimination is obtained by particle swarm optimization (PSO) technique. All the proposed methods are tested on a standard fabric database TILDA for their validity and satisfactory results are obtained in almost all cases. In Chapter 7, it is concluded that no single method can fulfill all the required criteria simultaneously and hence a numbers of off line methods are studied in this thesis in the field of defect detection in woven fabric to evaluate their efficacy.

Jayanta Kumar Chandra.