Artificial Intelligence
Applications on Bioinformatics and Textile Industry

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Abstract: AI techniques have been successfully used in many fields of engineering. A brief description of possible applications of AI in engineering are dated with future prospects. This study reviews two different experimental systems; bioinformatics and textile engineering. The experimental systems are described. Different databases are used and their implementation results are also presented by using AI methods; like ANN and PSO-NN. Implementation accuracies are given with tables for their use in these cases.

1 INTRODUCTION

Artificial Intelligence (AI) in engineering applications is continuously increasing. Systems are used for design, planning, classification and intelligent control and other expert applications. Different real world problems were solved.

Biometric authentication is critically important to provide personal identification and verification. ANN's have also been used for solving variety of problems including pattern classification and recognition in biometric. Complex and nonlinear characteristics can be effectively modelled by using ANN's rather than traditional methods. These applications are seen in biometric as; speech, handwritten character, fingerprint and signature recognition system and real-time target identification for security applications. Biometric authentication must be highly reliable conforming high degree of security. Improvements and contributions on biometric technologies are yielded to solve this problem (Daş, 2008). Daş et al., 2009 have studied system performance statistically. Bhattacharyya et al, 2009 have presented a survey on biometric authentication on the past, present and future views. Daş et al. 2012 have designed an optomechatronic device for biometric authentication especially for document base.

Defect detection is an important problem in fabric quality control. Many attempts have been performed to solve this problem in textile industry. Textile industry is also very concerned with quality. Fabric defects are responsible for nearly 85% of the defects found by the garment industry. It is imperative therefore to detect, to identify, and to prevent these defects from reoccurring. Currently, the quality of the fabric is evaluated by the human vision in most of the weaving factory and even with the most highly trained inspectors only about 60% of the defects is being detected. The inspection speed of a fabric even woven with an efficiency of 97% is observed as 30 m/min. A prototype intelligent system for woven fabric defect detection is developed and operated in real time using AI techniques. The defects are detected with image processing methods and classified with AI by using neural networks. (Çelik, 2013)

This paper is organized with two case studies as signature verification and fabric defect detection using NN's. Implementation results are given with numerical and statistical figures. Experimental studies are performed at Gaziantep University, Department of Mechanical Engineering and Textile Engineering Laboratories as PhD. research projects. Studies are successively completed at present, but the improvements in AI algorithms are still continuing.

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2 STUDIES USING ARTIFICIAL INTELLIGENCE (AI)

Artificial intelligence techniques such as Artificial Neural Network (ANN), Fuzzy Logic (FL) and Genetic Algorithm (GA) are used for many unlimited applications including bio-informatics, biomedical etc. providing an ideal platform in engineering. Majority of recent engineering applications are still being performed on heuristics since reliable results are obtained.

This study is analysed any base for bioinformatics and textile engineering as signature verification and fabric defect detection with classification. During the procedure similar steps are performed. The texture features of the fabric samples are extracted and these features are used as input. AI system learns the texture features and distinguishes them into categories. NN's are classified with their connections or architectures used to represent a neuron and the learning rule as a single layer or multi-layer perception.

2.1 Signature Verification with Neural Networks (NN)

Sabourin and Drouhard, 1992 have described a handwritten SV system. The directional probability density function (PDF) and feed forward NN with back-propagation (BP) learning are applied to random signatures in verification process. NN algorithm is described by See and Seng, 1993 to analyse and obtain the optimal values of factors such as learning rates, skilled forgeries and pre-processing of images which affect the performance and also accuracy of a SV system. Drouhard et al.,1994 have improved PDF and BP-NN by using the global classification error in memorization and generalization. Pottier et al., 1994 have used multi-layer perceptron for identification and authentication of handwritten signatures. Murshed et al., 1995 have been presented a Fuzzy Artmap NN trained genuine signatures based on off-line SV system. Zhou and Quek, 1996 have developed an automatic fuzzy NN driven SV system. Dehghan and Fathi, 1997 have presented multiple multi-layer perceptron NN modules trained with global features cooperating in taking an off-line SV. Huang and Yan, 1997 have studied on off-line SV based on geometric feature extraction and NN classification.

Sabourin, et al. 1996-1997 have studied on local granulometric size distributions. A signature was centred on to a grid of rectangular retinas, which were excited 36 by the signature's trajectory pixels at that location. Baltzakis and Papamarkos, 2001 have used a two stage NN for off-line SV. Santos et al., 2004 have proposed to reduce the number of signature samples required by each writer in the training phase of off-line SV. Jose et al., 2003 have studied on a new robust technique for the off-line signature verification The technique was based on the use of compression NN's, and in the automatic generation of the trained set from only one signature for each writer. Marinai and Gori, 2005 have studied on the survey of ANN applications on off-line document image processing. Daş, 2008 have performed statistical figures for the application success in this thesis. Daş and Dülger, 2009 have studied on signature verification by using a universal data base with PSO-NN with significant success.

2.2 Fabric Defect Detection with Neural Networks (NN)

Off-line defect detection is initially studied by using Wavelength analysis and Gabor functions. Their classification is then performed by using an interface with NN's (Çelik, 2013). Huang and Chen, 2001 have presented a method with FL and BP learning algorithm using NN's with nine categories of defects including normal fabrics and eight fabric defects: missing end, missing pick, double ends, double picks, hole, light filling bar, cobweb, and oil stain. Tilocca et al, 2002 have presented a method using a different optical image acquisition system and ANN to analyze the acquired data by using different light sources. A three layered FFNN with sigmoidal activation function and BP were used. Four defects; large knot, slub, broken thread and knot were classified by the presented system with success of 92%. Kumar, 2003 has presented an approach for local textile defects using FFN and fast web inspection method using LNN. A twill weave fabric sample with defect miss pick was tested by using FFN method. Fabric inspection image with the defects slack-end, dirty-yarn, miss pick and thin bar were tested by LNN method. Kuo and Su, 2003 have made fabric defect classification by using GLCM and NN methods. GLCM of the fabric sample images were obtained. The features such as energy, entropy, contrast and dissimilarity were extracted. The defect types were introduced to NN, tested and trained by using four fabric defect images; warp lacking, weft lacking, oil stain and hole. Kuo and Lee, 2003 have classified the defects as; warp lacking, weft lacking, hole and oil stain defects by training a three layer BPNN with plain weave white fabric. The fabric samples were acquired via an area scan camera with 512 x 512 resolutions. The classification was achieved with high recognition for all types of defects. Islam et al., 2006 have developed an automated textile defect detection system based on adaptive NN.

This is based on to combine thresholding techniques and ANN for defect classification with a performance of 77%. Liu et al., 2008 have studied on fabric defect classification by applying PSO-BPNN. PSO algorithm was introduced into BPNN training to determine NN connection weight and threshold values reasonably. Suyi et al, 2008 have presented a study by using sub-images of DB3 wavelet transform function. These features were used as input to PSO-BP NN for classification of five types of defects; warp direction, weft direction, particle, hole and oil stain. Suyi et al., 2009 have proposed a defect detection algorithm by combining cellular automata theory and fuzzy theory. Jianli et al., 2007 have proposed a method of Gray Level Co-occurrence Matrix (GLCM), Principle Component Analysis (PCA) and NN. GLCM of the image was obtained and 13 different features of the matrix were extracted by using Haralick method. The features vectors were prepared for NN input. NN was trained for four types of fabric defects; warp lacking, weft lacking, oil stain and hole with success.

3 CASE STUDIES

Two case studies are highlighted applications of AI especially on biometric field and textile industry in everyday life in the following. A study on signature verification based on PSO-NN is presented (Daş M.T., 2008). A study for denim fabric defect detection is then presented and classified using NN's (Çelik İ.H, 2013).

3.1 Case Study I

This device is built at Gaziantep University, Department of Mech. Eng., and Dynamic Systems Laboratory. The parts of the device are the frame, the X-Y table (two stepper motors), a camera & filter wheel and light sources (IR, UV, Daylight-Figure 1). Figure 2 shows details of lights available in the system. A Graphical User Interface (GUI) program, IMPQD (Image Processing for Questioned Document) software is prepared. Signature Verification (SV) toolbox is also included. Menu options are shown in Table 1.

Addition to classical menu toolbox, image processing applications, SV toolbox, a camera control and a position control of X-Y table are performed with IMPQD in Figure 1.

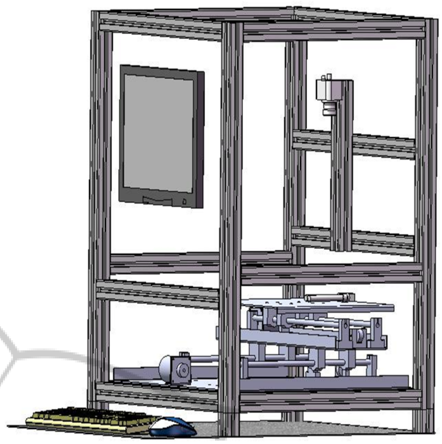


Figure 1: Designed Device.

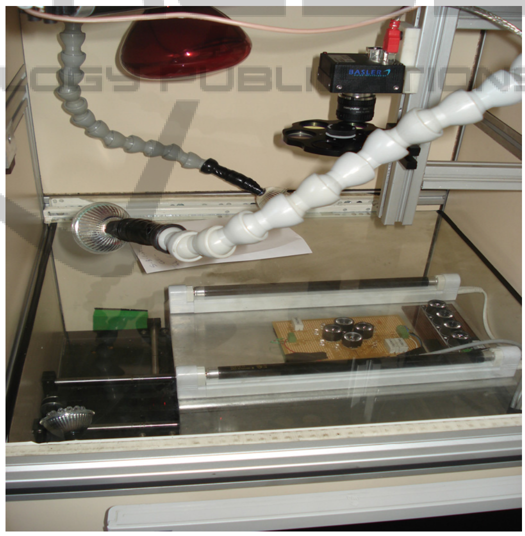


Figure 2: Illumination Details.

The software is designed either examining the questioned document and/or signature verification with PSO-NN algorithm. Satisfaction is obtained at the end. A universal signature database is used for this purpose. Parameters of the proposed method PSO-NN are the number of particles, the number of dimensions, the number of parameters and the constants for PSO and NN for training process.

After training, weights of the network are obtained in data file used in test part of the algorithm. During application, 25 sets of 54 different signatures have been used. Numbers of 24 genuine and 30 forgery signatures have been performed for each set. Different number of inputs have been generated and tried for verification process.

Table 1: IMPQD with Image Processing Units (8 Dialog boxes).

File	**New, Open, Save, Save As, Print, Send, Exit**
Image	Mirror, Flip, Negative, Rotate Left, Rotate, Right, Skew, Resample
Image 2	Grey Scale, Negative, Dither
Image 3	Lighten, Darken, Contrast, Erode, Dilate
Image 4	Blur, Gaussian, Median, Soften, Sharpen, Edge, Emboss, Threshold, Noise, Jitter, Pinch, Bathroom, Swirl, Punch
Mat + C	Neural Network and Signature Verification Toolbox
Table Control	X-Y table and Camera controller

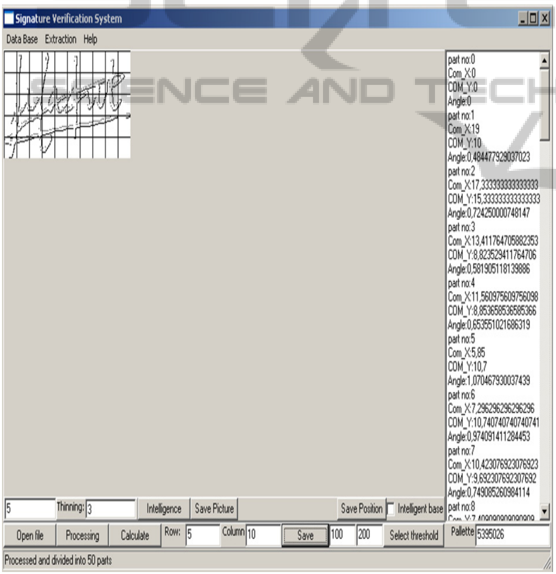


Figure 3: Signature Processing Window.

In this study two different division techniques can be applied onto the signature. The same signatures set are tried with 3, 6, 9, 12, and 20 parts. Numbers of divisions are chosen randomly, in order to compare small and large parts. One of the set is divided vertically with equal size. The other one is divided with square constant sizes such as (3x1, 3x2, 3x3, 4x3, and 5x4). Different number of particles (25, 30, 40, 50) and iterations (1000, 2000, 5000, 10000) are also applied onto the same signatures. The number of particles and iterations are adjusted with trial and error method. (Daş M.T., 2008) Genuine 15 signatures and 16 forgery signatures are trained for NN training. PSO-NN algorithm has been performed with 40 particles and 5000 iterations. Input nodes (18) are adapted for each input set and hidden layer (32) nodes adapted system with trials in the training section. Parameters of the network have been used with 0.8 learning rate and λ is 1. Table 2 presents verification results of database.

Table 2: Verification Results.

	Skilled forgery	*Genuine signatures*
Tested signatures	350	225
Accepted	94	186
Rejected	256	39
Results(%)	26.85 FAR	17.33 FRR

3.2 Case Study II

A fabric inspection system is built to recognize fabric defects then a classification is performed afterwards (Çelik İ.H., 2013). An industrial fabric inspection machine is the main body. It is being modified by a camera system, camera attachment equipment, an additional lightening unit, a rotary encoder and PC. CCD line-scan camera, frame grabber card, lens and camera link cable are included in camera system. This system is available at Gaziantep University, Textile Engineering Department Laboratory in Turkey. The system architecture is given in Figure 4. The experimental system is shown in Figure 5.

Off-line and real-time fabric defect detection processes are carried out by using three different algorithms. A defect database is prepared for off-line applications. The database consists of five kinds of fabric defects such as warp lacking, weft lacking, hole, soiled yarn and knot and defect-free fabric samples. Defect detection algorithms; Double Thresholding (DT), Wavelet Analysis (WA), and Gabor Filter (GF) methods are applied both off-line on the database images and real-time by using the experimental set-up. Classification is then performed with neural networks on denim fabric. (Çelik İ.H.et al 2013)

Different interfaces are prepared. An interface is used for defect detection as *'Exit'*, *'Fabric identification', 'Start Camera', 'Trigger'* and *'Stop camera'* (Figure 6.a) The *Fabric Identification* button is used to calculate thresholding limits.

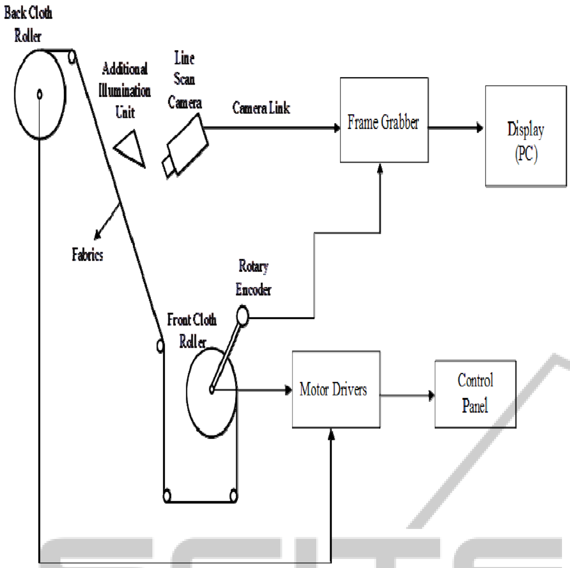


Figure 4: Schematics of Defect Detection System.

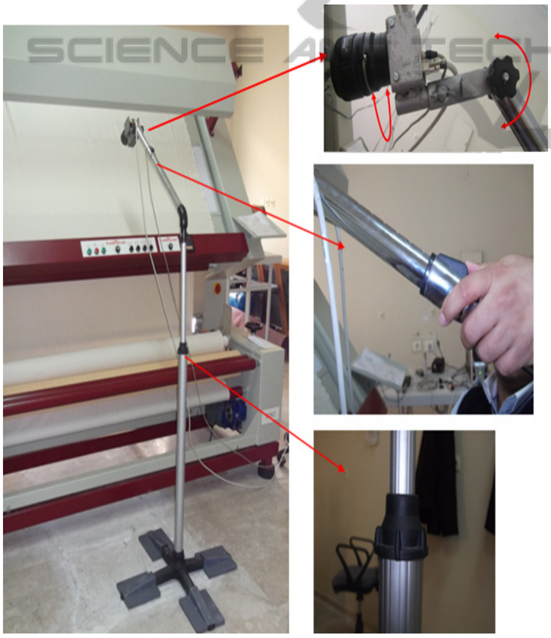
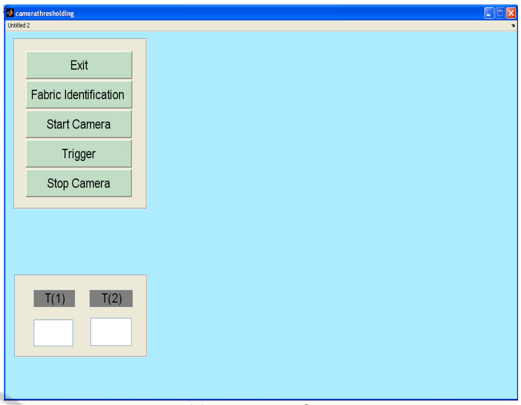
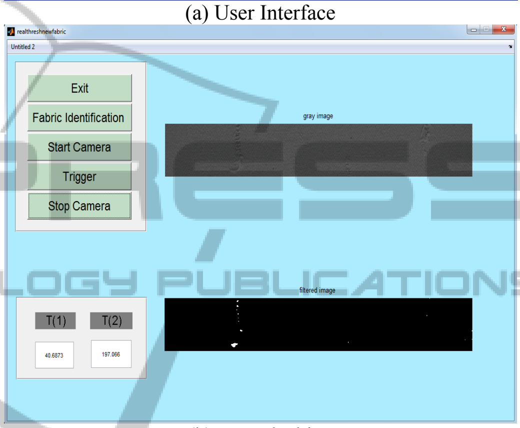


Figure 5: The Experimental System.

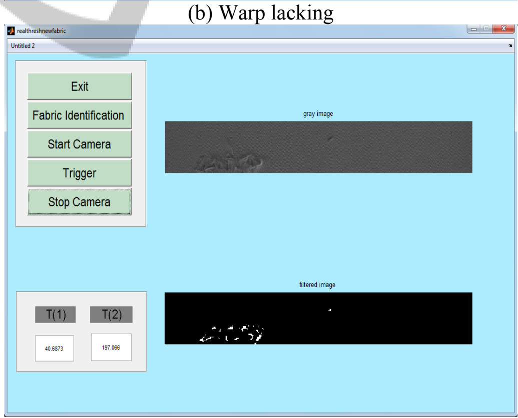
The average of lower limits and upper limits is calculated and displayed on the screen as T(1) and T(2) respectively. The camera is started again by using *Start Camera* button. *Trigger* button is pressed by starting the defect detection process. *Stop Camera button* stops the image acquisition by the fabric winding stop. The second interface is automatically used to determine the defect type of a selected defective image. The user interface consists of three buttons as; *'Exit'*, *'Reset Data'* and *'Load Defective Image'* as in Figure 6.f.



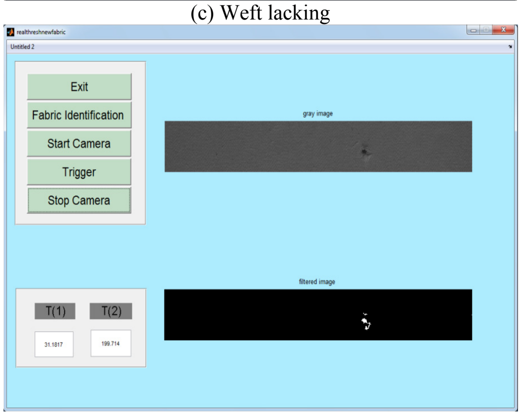
(a) User Interface



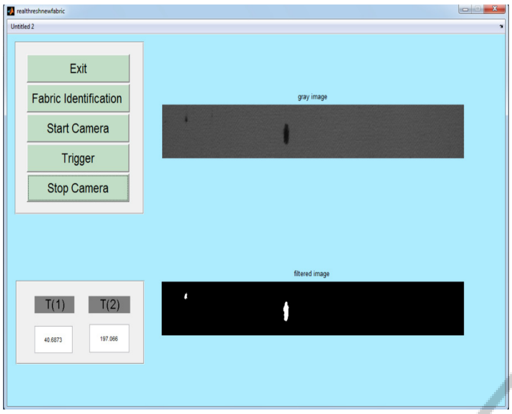
(b) Warp lacking



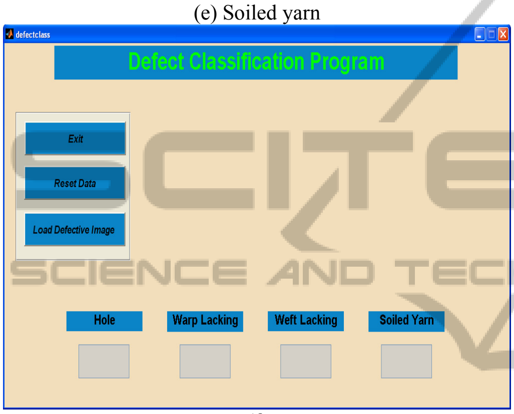
(c) Weft lacking



(d) Hole



(e) Soiled yarn



(f)

Figure 6: Defect detection and classification program user interface.

The defective fabric images are stored and then used for network training and testing. The features of the 25 defective fabric images are extracted for each defect type and the input matrix of the network is formed. Having trained NN successfully, 20 samples of each type of defects are used to test the network classification accuracy. Table 3 shows defect classification accuracy rates. Studies are continuing on the subject.

Table 3: Defect classification accuracy rates.

Defect type	**Hole**	**Warp Lacking**	**Weft Lacking**	**Soiled Yarn**
Hole	20	0	1	0
Warp Lacking	0	19	0	1
Weft Lacking	0	1	19	0
Soiled yarn	0	0	0	0
Samples	20	20	20	20
Accuracy (%)	100	95	95	95

4 CONCLUSIONS

Since biometric application is quite common in our daily lives, signature verification is mostly used as forms of identification. Off-line signature verification (SV) with PSO-NN is performed; handwritten signatures are collected from an available database with preparation of SV toolbox. An improved verification method; PSO-NN is adopted and applied on the signatures. PSO is used to train neural network system. The performance of the method is successfully tried on a different database in many applications.

A prototype intelligent system is developed for woven fabric defect detection and operated it in real time using AI (Artificial Intelligence) techniques. The prototype system consists of the fabric unwinding and rewinding machine, lighting system, image processing hardware, and software. Meantime four types of defects; hole, warp lacking, weft lacking and soiled yarn were classified on the fabric using NN's. A user interface was prepared for this application. The upper and lower threshold limits T_1 and T_2 were measured by using defect-free fabric frames when determining fabric defects.

Two case studies are presented here to show applications of AI in different fields of engineering. Both studies are performed experimentally and supported by the theory. Satisfaction in the results is definitely seen.

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