Review of Back-propagation Algorithms for Defect Elimination with proposed DMASIC Methodology

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Abstract*— In India textile industry holds an irreplaceable self-sustains position. The aptness of apparel organizations are based on numerous aspects like reliability, durability and increase in demand for good quality products with less number of defects. In our paper we have discovered hundred defects which are responsible for the degradation in cloth quality for textile industries. This paper also attempts to review and present the detail study of fabric defects occurring at each level of textile manufacturing process starting from the raw material to the end product and its elimination using proposed DMASIC methodology. To reduce these defects at each level of textile manufacturing process with DMAIC methodology (Define, Measure, Analyze, Improve, and Control) we introduce one more phase in it i.e. SORT phase after the analyses step resulting the DMASIC methodology. This phase of sorting categorizes the defects into three levels: minor, major and critical defects. After DMASIC Sort process we use automatic defect detection and classification process using artificial neural networks to get the various defects under knitted, woven, dyeing and finished category. To obtain the best results for neural networks we compare the four back-propagation training algorithm i.e. Simple Back Propagation, Levenberg-Marquardt, Conjugate Gradient, and Resilient Back Propagation. These algorithms are compared based on their speed, accuracy, convergence, implement complexity, and memory requirement. It has been observed that RPROP can be most efficient algorithm along with proposed DMASIC for defect detection and classification due to its high rate of convergence and robustness.

Keywords: Six Sigma; DMAIC; DMASIC SORT process; Levenberg Marquard; Conjugate Gradient; Resilient back propagation.

I. INTRODUCTION

The manufacturing of textiles requires five basic steps for garment confection i.e.

- Processing of raw material like cotton.
- Spinning of yarn.
- Weaving of knitted and woven fabrics (shown in Fig 1)
- Colourless greige material full of impurities.
- Dyeing and finishing of products

The quality of garment industry is calculated in terms of strength of yarn, standard of fibers, fabric manufacturing, color fastness, basic design of cloth, less defect and quality of cloth [5].

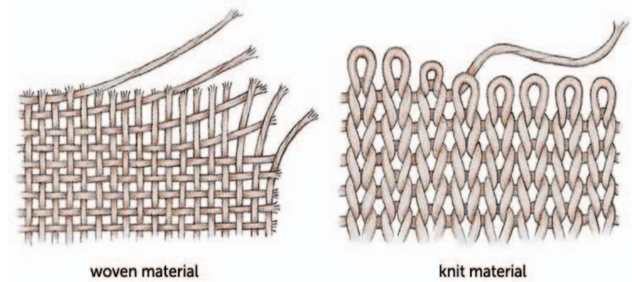

Fig 1. Woven and Knitted Fabric [7]

It has been found and observed that price of textile cloth is reduced by 60% to 80% due to defects present in them [2]. A fabric defect is any irregularity or abnormality present in the fabric that hinders its acceptability by the buyer. All textile industries aim to produce competitive fabrics which are based on the productivity and quality of the fabrics produced by each industry. Minimization of defects at each level of fabric production is the prerequisite for the quality improvement. This paper critically analyses the DMAIC [43] Methodology of Six Sigma for overall process of a selected garment factory and proposes new approach of DMASIC.

Six-Sigma is a highly organized, disciplined, customer-oriented and profit-driven methodology that emphasizes on reducing the defects at each level and improving the performance level of product. It is based on a rigorous process and data-driven methodology [40, 43] [45-49].

Six-Sigma minimizes the defect in fabric through five phases of DMAIC methodology namely Define, Measure, Analyze, Improve and Control [1]. It is process improvement method based on the integration of four elements (customer, process, manpower and strategy) to provide management innovation [6]. Six Sigma helps us to improve the quality of process outputs by recognizing and removing the causes of errors and letting the process operate at a 90-95% efficiency level [10]. It include disadvantage of existing DMAIC approach which motivates us to add SORT process in it after analyze phase.

In this research paper we hereby propose to add one more phase with DMAIC i.e. SORT phase to identify the defect level. After identifying the defect we use automatic defect detection and classification process to categorize the defects under various classes like knitted, woven, dyeing, finished product. Numerous approaches have been proposed for automatic defect detection and classification using neural networks. This paper also employs the comparison of four back propagation algorithm to provide a solid basis for the emergent theory development for best training algorithm for defect classification.

The basic computation steps used in back propagation algorithm and basic architecture of neuron [20] is given below in Fig 2.

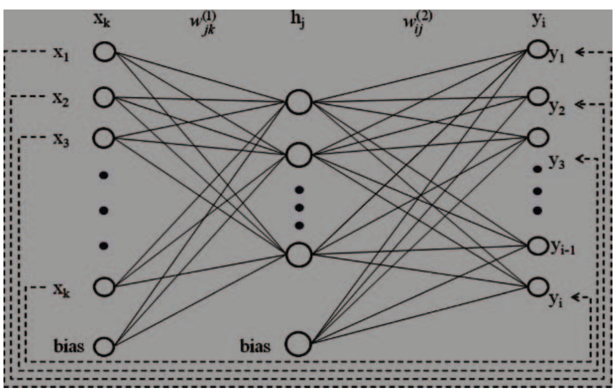

Fig 2: Basic Architecture of Neuron [20]

Error Signal for neuron j is

$$\delta_j = -\frac{\partial E}{\partial net_j} \quad (1)$$

The gradient for weight w_{ij}

$$\Delta w_{ij} = -\frac{\partial E}{\partial net_i}\frac{\partial net_i}{\partial w_{ij}} \quad (2)$$

$$\frac{\partial net_i}{\partial w_{ij}} = \frac{\partial}{\partial w_{ij}} \Sigma w_{ik} y_k = y_j \quad (3)$$

Putting equation 2 and 3 together we get

$$\Delta w_{ij} = \delta_i \ y_j \quad (4)$$

In back propagation algorithm we apply the chain rule [21] to compute the influence of each weight in the network with respect to an arbitrary error function. The equation for chain rule is given by:

$$\frac{\partial E}{\partial w_{ij}} = \frac{\partial E}{\partial net_i}\frac{\partial net_i}{\partial y_i}\frac{\partial y_i}{\partial w_{ij}} \quad (5)$$

Where w_{ij} is the weight from neuron j to neuron i; net_i; is the output; and y_i is the weighted sum of the inputs of neuron i. Four different types of back--propagation algorithms Levenberg-Marquardt [33], Conjugate Gradient [34], Simple Back Propagation [35] and Resilient back-propagation [21] are being compared based on speed, accuracy, convergence, implement complexity, learning paradigm and memory requirement. The best algorithm identified can be further used for the automatic defect detection and classification system. Neural networks and decision tree classifiers [22] are used for building real-time applications due to their non-linear, parallel-processing capability. .

The remaining sections of this paper are organized as follows. Section II describes relevant previous efforts in the fields, of Six-Sigma DMAIC quality improvement process and various types of back-propagation algorithms. Section III focuses on motivation and research approach for DMASIC method. Section IV describes the textile manufacturing process and the defects present at each level. To minimize the defects at each stage DMASIC method is used. Section V gives the pseudo code or flowchart of the various neural network training algorithms for comparison. Section VI discusses the various phases required for neural network training model and gives the comparison between various algorithms. Section VII concludes with some remarks and plausible future research lines.

II. LITERATURE REVIEW

Textile mill manufacturing operations are of course exceedingly complex [7]. There are many variable processes available at the spinning and fabric forming stages [8]. In textile industry there have been an enlarge amount of losses due to the defects at each level of processing [9, 11] and these defects can harm the production cost massively.

Due to defects there are heavy losses incur in organization. This paper makes an attempt to identify around hundred defects at each level of textile manufacturing process. To reduce the defect percentage at each stage of textile manufacture process the DMAIC (define, measure, analyze, improve and control) methodology of Six Sigma is used [1-2, 38]. DMAIC is a problem solving technique used to analyze the process data and lastly it helps to identify the root causes behind the defects produced in the fabrics [2, 3]. The objective of Six Sigma method was to reduce the number of defects to as low as 3.4 parts per million opportunities [12-14]. The basic drawback of Six Sigma DMAIC methods is that it eliminates defects but do not address how to optimize the process flow [57]. DMAIC cannot classify the defects as major, minor and critical. Textile defect detection and classification through digital inspection images has received significant concentration during the past ten years and numerous approaches have been proposed in the literature [18]. Computer vision technology with artificial neural network have been applying on textured samples over the past few years for developing automated defect detection and classification systems[18]. The ANN deploys the back-propagation algorithm for classification of defects. It has been observed from the literature review that no work has been done to utilize the input-output capability of Levenberg-Marquardt, conjugate gradient and resilient back propagation neural network training algorithm in the textile defect detection [23]. Neural networks are considered as the best classifiers to classify the defects due to their non-parametric nature and ability to describe complex decision regions.

According to neuron model given by Warren Mc.Culloh and the logician Walter Pris [24]artificial neuron is a main processing entity with many inputs and outputs based on the network used by the individual. The result is obtained by the weight associated with each interconnected neuron at input, hidden and output layer [25]. The various reasons which help us to use neural networks for defect detection and classification purposes are mentioned below [26]:

- It provides a flexible network
- It helps in analysing the data from the network even if data is imperfect or vague.
- It has capability of adaptive learning
- It has fault tolerant model.
- It has ability to detect the complex relationship between dependent and independent variables.

Manufacturing processes become costly due to inefficiencies present in them [27]. The automation of the visual inspection system requires lot of interaction among various system components. The architecture of the typical automated textile defect detection and classification is shown in fig 3 [18].

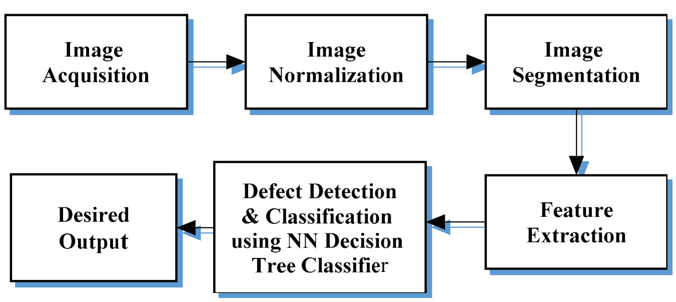

Fig 3: Block Diagram of Automatic Defect Detection & Classification System

Artificial Neural Networks are used widely in automated visual system for fabric defect detection in last decade [29]. The main aim of this comparison of these four algorithms is to reduce the global error E defined as [23, 27].

$$E = \frac{1}{P}\sum_{p=1}^{P} E_p \tag{6}$$

Where
P=Training pattern counts
Ep=Error in each training pattern

The value of Ep is given by the formula

$$E_p = \frac{1}{2}\sum_{i=1}^{N}(O_i - T_i)^2 \tag{7}$$

Where N= Number of Output Nodes

O_i=Output at i^{th} node

T_i =Target output at the i^{th} output node

III. MOTIVATION

Six-Sigma is a systematic, highly disciplined, customer-oriented methodology for minimizing the defects [19, 39-40, 45-49]. Six-Sigma has been defined as the arithmetical unit of measurement, that measures the profitability, increases satisfaction market, through share statistical and process to achieve a defect free performance [18, 40]. Sometimes Six Sigma may create rigidity and bureaucracy that can generate delays and may reject the higher defect rate [37]. When these performance targets are not met, quality managers begin a performance-improvement process using the DMAIC approach [1-2, 43]. DMAIC and DMADV methodology of Six Sigma are both inspired by Deming's Plan- Do-Check-Act Cycle [50]. DMAIC [1-2] is aimed at improving the current business scenario while DMADV is aimed to develop a new business product or design [51, 42]. The DMAIC technology with Lean Sigma technique has given a better results in most of the cases but unable to provide the greater quality product as per the customer satisfaction [44]. The limitations of the DMAIC method are that it can eliminate the defects through its five phases but it cannot categorize the defect level as minor, major and critical. In this paper we will implement this new phase in DMAIC i.e. SORT Phase for classification of defects. The feed forward architecture and support vector machines used for defect segmentation are computationally costly, but advantage of SVM is that it does not suffer from the problem of local minima [52, 53]. A novel method using genetic algorithm and neural network has been proposed to classify the type of defects in the cloth [54]. NN using back-propagation algorithms is mainly used as classifier due to their non-parametric nature and ability to describe complex decision regions [52, 55, 56, 53, and 18].

IV. Textile Manufacture Process Defects and Six Sigma Technology

A. Fabric Defects

This section explains the various defects occur at each level of the textile making process. The process flowchart of textile manufacturing is given in fig 4 which signifies the five stages of garment manufacturing and defects at each stage. The main characteristics of the cloth that need to be taken into consideration are as [5, 16]:

- Appearance of overall garment.
- Garment pattern and creation
- Feel and fall of the fabric.
- Physical properties.
- Dyeing properties of the finished garment
- Presentation and packaging of the final product.
- Color fastness of the garment.

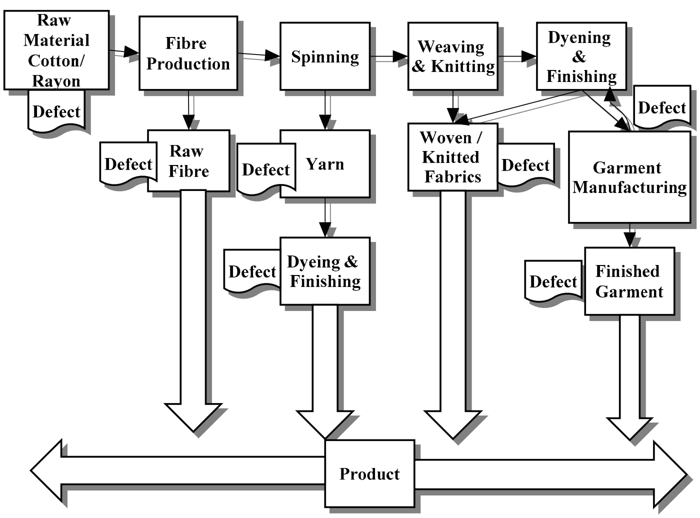

Fig 4. Textile Manufacture Process Flowchart and Defects at each Level

Table I presents the around 100 types of defects present at each level of textile making process.

Due to defects present in textile cloth it reduces the price by 50-70% [28-29]. The identification rate of detecting defects is only about 70-80% [29]. So, early and accurate detection of defects in fabrics is an important aspect for product and quality improvement.

B. DMAIC Methodology of Six Sigma

The DMAIC is an improvement system process for existing processes falling below specification and looking for incremental improvement [17]. The meaning of five letters in DMAIC is given below in fig 5. DMAIC [1-2, 43] tool is a data driven approach use to drive management decision and actions across an organization. The following subsection illustrates the the DMAIC process.

Define Phase: The main motive of this phase is to describe the problem and goal of the project that needs to be improved and modified**.**
Aim: The apparel industry is suffering from high rate of cloth rejection due to defects present at each level of textile manufacturing process.

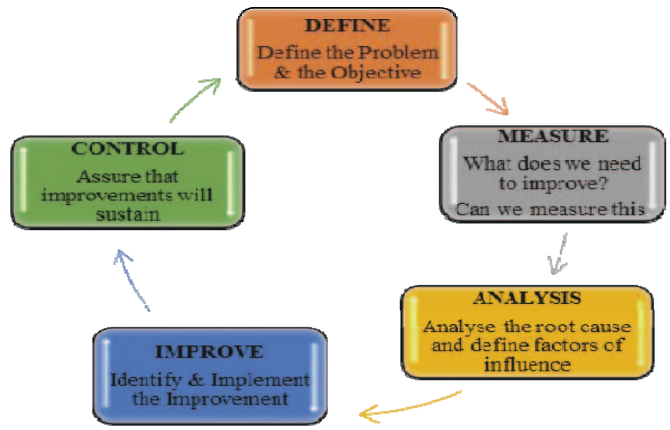

Fig 5. DMAIC Methodology of Six Sigma

Goal: To reduce the defect rate in the textile industry will reduce the cost of the product and will help in improving the quality of the product. This can be achieved by forming a team of people and using tools like process map etc.

Measure Phase: In this phase the data is collected and frequency of defects is inspected. It executes a systematic data collection plan. The tools used in this phase are pareto chart, data collection plan etc. These tools will help us to identify all the defects present in the process and the percentage occurrence of each defect will be calculated. Six-Sigma is a measurement-based strategy to improve the defect elimination process [15]. This task is accomplished with the help of DMAIC [43] process.

Analyze Phase: In this phase the data is analyzed and the root causes between the current performances and goals is identified [4]. In this the data analysis tools and process analysis techniques are used to identify and verify the original causes of the problem by the project team. The target of this phase is to identify the major reason behind the defects [2]. The exhaustive training sessions are conducted to identify the potential causes of the defects in presence of following members like factory manager, industrial engineer, line supervisor, machine operators etc. Based on the discussion with them the cause effect diagram is created. The cause effect diagram developed for all defects is given below in figure 6:

TABLE I. VARIOUS TYPE OF FABRIC DEFECTS AT EACH PROCESS OF TEXTILE MANUFACTURING [1-2, 7]

Raw Material Defects	**Man-Made Fiber Defects**	**Yarn Defects**	**Woven Defects**	**Knitted Defects**	**Dyeing & Finished Defects**	**Sewing Defects**	**Finished Product Defects**
This type of defect occurs due to raw material like cotton, rayon etc.	*The defects originated from the fiber made up of raw material*	*The defects originating from the spinning*	*The defects which originate during the process of weaving*	*The defects which occurs during knitting of cloth*	*The defect which occurs during the dyeing of textile products*	*The defects which occur during the sewing of product*	*The defect occurs when product is ready to deliver*
Badly stained or discoloured cotton	Denier	Broken Filaments	Broken Ends	Drop Stitches	Shade Variation	Open Seams	Unwanted marks on fabric
Dead Cotton	Filament Count	Knots	Float	Yarn Streaks	Crease Mark	Wrong / Broken Stitching	Decolorized patch on fabric
Wet cotton or rayon	Twist	Slub	Gout	Barriness	Pin Hole Damage	Broken Ends	Pin holes
Accidental mixing of cotton with other foreign particles	Cross Section	Fabric press off	Hole, Cut or Tear	Fabric press off	Dye Spots	Holes	Sanforize Picker
Water stains on cotton	Luster	Broken ends	Oil Stain	Broken Ends	Wrong Slitting	Inoperative Zipper	Bowing
Badly stained or discoloured cotton	Tensile strength and elongation	Thick places	Slub	Spirality	Band Line	Missing Buttons	Pilling
	Broken Filaments	Thin places	Missing end	Slub	Dust	Needle Cuts	Water Spots
	Degraded Cellulose	Rolling or Crossed Warp ends	Missing Picks	Pin Hole	Dead Cotton on Dyed Cotton	Dropped Stitches	Cut or Nicks
	Finished & Surfaced Deposits	Reed	Reed Mark	Broken Needle	White Stains	Loose Yarn	Seam Tears
	Dyeing Characteristics	Damage by Shuttle	Color Bleeding	Cracks or Holes	Broken Stitches	Zipper too short	Soil
		Drop Wires	Warp Streaks	Shrinkage	Unravelling Seams	Stains	Streaks
		Stretched Yarn	Rippled Defects	Thick & Thin Places	Difference in Luster	Cutting Defect	Inadequate pressing
		Selvages	Floating ends	Fly Contamination	Blue Specs	Pattern Defect	Pressing Producing Shine on Fabric
		Broken Picks	Broken Selvages	Sinker Mark	Uneven Shades	Run or Ladder	Loose Threads
			Cut Filling	Fabric Press off	Warp Streaks	Needle Lines	Bias
			Foreign Matter	Lycra out	Careless Selection of Dye Stuff	Sagging or Rolling Pockets	Folding Defects
			Greenish stains	Skewing		Skipped Stitches	

Improve Phase: The main motto of this step is to find a solution that will reduce the cause of problems and helps to prevent a problem from recurring [15]. For this the project team needs to implement and test the solutions to measure the accuracy of the results.

Control Phase: Once the results are documented in the improve phase they are used frequently to measure the performance of the process. To withstand the progress the control plan is need to be made. The control plan should include:

- Continuous training should be organized for supervisors, line inspectors, and employees to improve the production.
- Proper quality management team should be build.
- The organization should use good quality machine storage places, threads and other garment accessories.
- The preventing defects are at higher priority as compared to correcting defects.

The limitation of DMAIC approach is that we can eliminate the defects but cannot classify them as major, minor and critical defect. In this paper we will be introducing this new phase in the DMAIC methodology after the analyse step. So the new DMAIC will be DMASIC sort process where S stands for SORT or classify the defects into three levels shown in Fig 7 i.e:

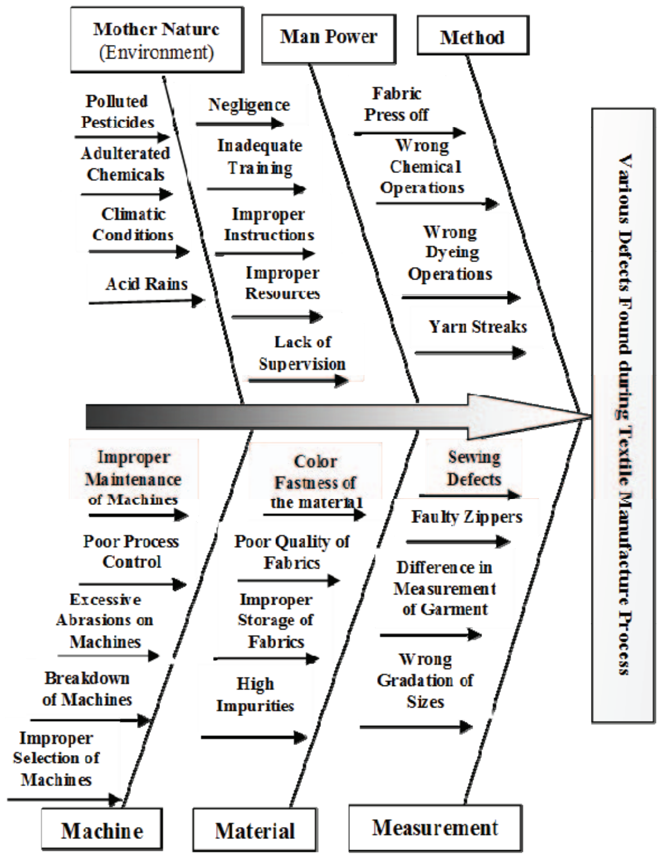

Fig 6. Cause and Effect Diagram for all Major Defects at each Level

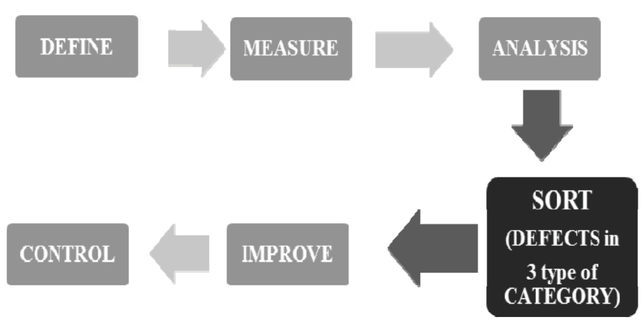

Fig 7. DMASIC SORT Process for Classifying Defects

- **Critical Defects:** Defects which are unsafe and cause hazard to the health of the individuals.
- **Major Defects:** Defects which affects the purchase and productivity of the product.
- **Minor Defects:** Defects which have no effects on the purchase of the product.

Textile industry plays a major role in everyone's life. Quality inspection is an important aspects of all industries while producing the quality product. There are lot of problems faced by the apparel industries such as:

- Inline Inspection in the textile industry
- Fabric Shrinkage
- Estimation of the porosity of textile fabrics.
- Measuring of thread densities
- Unavailability of quality monitoring tools.
- Inferior quality of raw materials
- Operations in a critical zone of the garment.
- Sewing on bias cut.
- **Defect Detection and Classification.**

The DMASIC technology suggests some potential solutions to minimize the above problems through cause effect diagram etc. Among all defect detection and classification plays a very significant role in producing quality product at spinning, weaving, knitting, dyeing and processing side [18].

V. Comparison of Various Back-Propagation Algorithms

In this paper, a new approach for defect detection and classification based on neural network decision tree classifier is presented. Based on the research, the proposed system uses neural network for classifying the defects. To obtain the best algorithm we have compared the four types of back propagation algorithm. All the four algorithms are described in following sections.

A. The Basic Back-Propagation Algorithm

This is the most basic algorithm used for training the data in the neural networks. It adjusted the weights and biases according to the activation functions calculated by the synapse and back propagated by the backward mechanism [25]. The pseudo code of the algorithm is given below [30-31]:

1. Start the process
2. Assign all networks with inputs and outputs
3. Initialize all inputs with small weights between +1 and -1
4. Give input to the network i.e. network patterns and architecture
5. Repeat
    a. For feed forward process. Calculate: Weight Sum of the Input Neuron; Add threshold sum; Activation function.
       // For propagating error backwards
    b. Error signal is calculated for the output layer.

c. For every hidden layer in the network calculate node's signal error and update weight's for each neuron in the network
d. Calculate the global error function

6. Train the network for the maximum iteration and for all patterns till (maximum number of iterations < than specified) AND (Mean Square Error Function is < than specified) and network has converged.
7. Display system output and store the results for future use.
8. Stop the process.

B. Levenberg-Marquadt Algorithm

The LM algorithm is the combination of Error back-propagation and Gaussian Newton Algorithm. It is very simple and good method for approximating function. The LM is defined as the sum of non-linear valued functions [25]. It depends on the correct and the current solution [32]. The algorithm behaves like a steepest descent when the current explanation is far from correct one. If the situation is vice-versa it acts like a Gaussian Newton method. The algorithm for the LM is given below:

1. Compute the Jacobian matrix J. It is a first order partial derivative matrix of a vector valued function [33].
2. Calculate error gradient
   i. $g=J^T E$
   E-Error Vector containing the output used for training the network.
3. Compute the Hessian approximation using cross product of Jacobian matrix
   i. $H=J^T J$
4. Compute $g = (H+\lambda I)\delta$ to find δ.
   Where λ= Damping Factor (It effects the convergence of algorithm)
   I=Inverse Matrix
5. Update the network weight w using δ and recomputed the mean square error (MSE) with updated weights.
6. If MSE has not decreased. Discard new weight and increase λ using v (adjustment factor) and go to step 4.
7. Else decrease λ using v and stop. This process goes on until error decreases.
   a. (If λ is need to be increased multiply with v. And divide by v if it is need to be decreased)

C. Conjugate Descent Algorithm

The pseudo code for the algorithm is given below:

1. Initialize search direction and decide weight vector w_o [34]. To determine the best distance along the existing search direction a line search is performed.
2. To determine the step size search is made along the conjugate direction. Step size is adjusted during each iteration.
3. Search direction is compared to determine whether it is conjugate to previous search direction or not.
4. The new search direction is found by combining the new steepest descent direction with previous search direction.
5. Compute the comparison ratio.
6. If comparison ratio is less than or greater than the given ratios than adjust weights else leave weights unchanged.
7. Choose new direction and repeat the steps until the weights are unchanged.

This algorithm produces the fast convergence [36].

D. Resilient Back-Propagation Algorithm

As the input gets larger the sigmoid function used by the back-propagation algorithm reaches zero. This causes change in the weights and biases of the network [23]. To save the network from these harmful effects RPROP is used. Instead of using the magnitude of the back-propagation it uses the sign of the back-propagation gradient to change the biases/weights [25]. It maintains separate weight deltas for each weight and bias and adapts these during training [35]. The algorithm for RPROP is given below in fig 8:

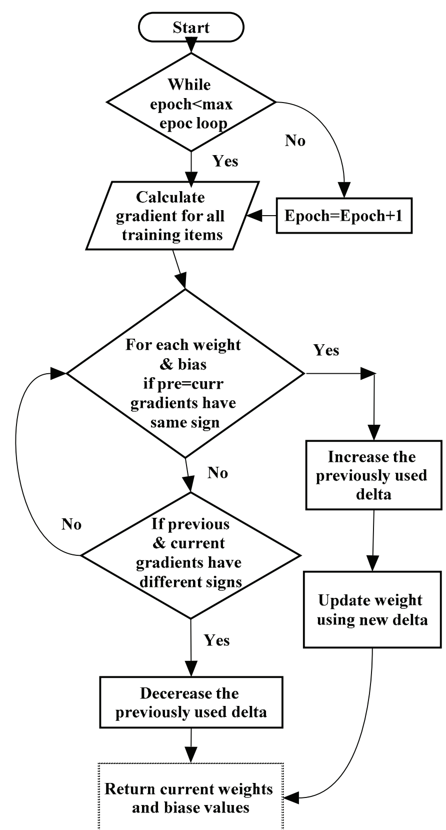

Fig 8: Flow chart for Resilient Back-Propagation Algorithm

VI. Discussion and Observations

Minimizing defects is very important for textile industries to ensure the quality of the products. The DMAIC [43] methodology suggest some solutions to reduce the defects through brain storming, cause effect diagram, control plan etc. With the help of these tools the most of the defects were identified which are responsible for cloth rejection. DMAIC eliminates the defects but does not classify the level of defects. For detecting the defects and classify them we have introduce the new phase SORT phase in the DMASIC process. The data obtained from the DMASIC is given to the decision tree classifier to categorize the defects under raw material, knitted, woven, dyeing and finished defects. To obtain optimal solution and increase the performance of the system we compare four types of back-propagation algorithms and compared based on various parameters. The following are the phases for modelling the Neural Network System [36].

Phase I: Training of Neural Network:

The suggested strategy is to build neural network model syatem starting from a single variable and gradually increasing the variable and test the performances [36]. Once the network architecture is decided we need to train the network. The training algorithm is decided by the number of input, output and hidden layer neurons. The pseudo code for training the network is given below:

1. Start the process and load the data
2. Select and set the number of neurons in each input, output and hidden layer
3. Select the transfer activation function and learning parameter.
4. Generate the network, initialize weights and biases to neuron and set epoch=1.
5. Calculate the output values
6. Calculate the MSE (mean square error).
7. if (MSE<=MSEmm)

```
 stop training
 else
     if (Epoch>=Epochmax)
         stop training
      else
         Update weights and biases
    Epoch=Epoch+1
```

8. Go to step 6 and repeat the process

Phase II: Comparison Criteria

The comparison of these four algorithms are based on the various parameters. The below mentioned table II depicts the comparison of Backpropagation. Levenberg Marquadt, Conjugate Gradient and Resilient Algorithm.

TABLE II. Comparison Criteria Of Various back propagation Algorithms [23-26]

Techniques / Parameters	Back-Propagation	Levenberg Marquadt	Conjugate Gradient	Resilient Back-Propagation
Computational Speed	Poor	Excellent	High Speed	Medium High
Implementation	Low	Medium	Low	Low
Memory	Small	Large	Large	Medium Small
Convergence Factor	Weak	High	Fast	High
Stability	Stable	Stable	Stable & Efficient	Stable & Efficient
Type of Process	Iterative	Iterative	Iterative	Iterative
Accuracy	Low	Medium	Medium	Best
Learning Paradigm	Supervise	Supervise	Supervise	Supervise

VII. Conclusion

Good Quality fabric is ultimately a question of customer satisfaction. In our paper we have presented hundred of defects at each level of textile manufaturing process and at the same time we have also given the Six Sigma DMAIC technique to eliminate those defects. The novel DMASIC SORT process has been proposed in this paper to sort the defects into three levels minor, major and critical which will surely enhance the elimination and classification for fabric texture defects in textile industry.Ofcourse this needs to be experimented to support this theory. At the same time we present critical analysis of various back-propagation training algorithm to obtain the optimal result.

It is very difficult to know which training algorithm will perform the best for a network. It depends on lot of factors as mentioned in table II. With due consideration of all parameters it is observed that RPROP is considered to be the best algorithm measured in terms of convergence, speed, accuracy and robustness with respect to training parameter. This algorithm does not require any learning rate parameter like back propagation. This paper suggests the best possible training algorithm for textile defect detection and classification using neural network as decision tree classifiers.

References

[1] Syed Misbah Uddin, Rashidul Hasan, Md. Saddam Hosen, “Defects minimization through DMAIC methodology of Six Sigma”, International Conference on Mechanical, Industrial and Energy Engineering, Khulna-Bangladesh, 2014, December 26-27.

[2] Uddin S.M., Rahman C.M.L. “Minimization of defects in the sewing section of a garment factory through DMAIC methodology of Six Sigma”, Research Journal of Engineering Sciences, September 21-26, 2014, ISSN 2278 – 9472 Vol. 3(9).

[3] Dr. Anupama Prashar, "Right-first-time dyeing in textile using Six Sigma methods", International Journal of Scientific & Engineering Research, Volume 4, Issue 8, August-2013, 1517, ISSN 2229-5518.
[4] Neha Gupta. "An application of DMAIC methodology for increasing the yarn quality in textile industry", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Issue 1 (Mar - Apr 2013), e-ISSN: 2278-1684 Volume 6, pp 50-65.
[5] http://www.fibre2fashion.com/industry-article/3092/defects-in-garments?page=1#sthash.KYzIb8Hq.dpuf.
[6] Zuhaib Hassan, "Six Sigma in textile industry", Istanbul Technical University, Istanbul, Turkey.
[7] J.D. Goldberg, "Fabric defects: Fabric defects case histories of imperfections in woven cotton and rayon fabrics", Fellow Director, J.P Stevens & Co. INC.
[8] https://en.wikipedia.org/wiki/Textile_manufacturing.
[9] Jind G & Li N, "Claiming Six Sigma", Industrial Engineer Journal, 2004.
[10] De Feo. J , Barnard . W, "Six Sigma breakthrough and beyond", Juran Institute's, New York, Mc Graw Hill.
[11] http://shodhganga.inflibnet.ac.in/bitstream/10603/20616.
[12] Jiju Antony, Ricardo Banuelas, "Key ingredients for the effective implementation of Six Sigma program", Measuring Business Excellence, Vol. 6 Iss: 4, pp.20 – 27.
[13] Breyfogle F. W, "Implementing Six Sigma: smarter solutions using statistical methods", New York: John Wiley, 1999.
[14] Antony J, Banuelas R, "Six Sigma: A business strategy for manufacturing organizations". Manuf. Eng., 80(3): 119-121, 2001.
[15] Hsiang-Chin Hung, Ming-Hsien Sung, "Applying Six Sigma to manufacturing processes in the food industry to reduce quality cost", Scientific Research and Essays Vol. 6(3), pp. 580-591, 4 February, 2011.
[16] Efstratiadis, M.M, Karirt, A.C, Arvanitoyannis I.S, "Implementation of ISO 9000 to the food industry: An overview". Int. J. Food Sci. Nutrients, 51(6): 459-473, 2000.
[17] Starbird D, "Business excellence: Six Sigma as a management system: A DMAIC approach to improving Six Sigma management processes", Annual Quality Congress Proceedings, Milwaukee, pp. 47-55, 2000.
[18] Shweta Loonkar, Dr. Dhirendra Mishra, "A Survey-defect detection and classification for texture defects in textile industry", International Journal of Computer Science and Information Security, Vol. 13, No. 5, May 2015.
[19] Sung H. Park, Jiju Antony, "Robust design for quality engineering and Six Sigma".
[20] https://www.willamette.edu/~gorr/classes/cs449/backprop.html
[21] Martin Riedmiller, Heinrich Braun, "A direct adaptive method for faster backpropagation learning: The RPROP algorithm", IEEE O-7803-0999-5/93/$03.001993.
[22] Xuezhi Yang, Grantham Pang, Nelson Yung, "Discriminative training approaches to fabric defect classification based on wavelet transform", The University of Hong Kong.
[23] Ozgur Kisi, Erdal Ucouglu, "Comparison of three back propagation training algorithms for two case studies", Indian Journal of Engineering and Material Sciences, Vol 12, October 2005.
[24] Christos Stergiou, Dimitrios Siganos, "Neural networks surprise", 1996 Journal volume 4, 180 Queen's Gate, London SW7 2BZ, UK.
[25] Iftikhar Ahmad, M.A Ansari, Sajjad Mohsin, "Performance comparison between back-propagation algorithms applied to intrusion detection in computer network systems", 9th WSEAS International Conference on Neural Networks (NN'08), Sofia, Bulgaria, May 2-4, 2008.
[26] TU. JV, "Advantages and disadvantages of using artificial neural networks versus logistic regression for predicting medical outcomes" 1996 Nov, 49(11), 1225-31.
[27] Ajay Kumar, "Computer vision-based fabric defect detection: A survey", Senior Member IEEE Department of Electrical Engineering Indian Institute of Technology Delhi
[28] Y.H Zhang., WK Wong, "An intelligent model for detecting and classifying color-textured fabric defects using genetic algorithms", The Elman Neural Network, Textile Research Journal, vol. 81, October 2011, ISSN no. 171772-1787..
[29] Henry Y.T. Ngan, Grantham K.H. Pang, Nelson H.C. Yung, "Automated fabric defect detection – a review", vol. 29, issue 7, Science Direct June 2011, Page no. 442 – 458.
[30] https://www.researchgate.net/figure/258998809_fig3_Fig-3-Flowchart-of-backpropagation-neural-network-algorithm.
[31] http://www.cse.unsw.edu.au/~cs9417ml/MLP2/
[32] Manolis I. A. Lourakis. "A brief description of the Levenberg-Marquardt algorithm implemented", Institute of Computer Science Foundation for Research and Technology - Hellas (FORTH), Feb-2011.
[33] http://www.codeproject.com/Articles/55691/Neural-Network-Learning-by-the-Levenberg-Marquardt.aspx.
[34] Peter M. Williams, "A Marquadt algorithm for choosing the step size in back-propagation learning with conjugate gradients", School of Cognitive and Computing Sciences, Feb1991.
[35] https://visualstudiomagazine.com/articles/2015/03/01/resilient-back-propagation.aspx
[36] Parvinder S. Sandhu, Shalini Chhabra, " A comparative analysis of Conjugate Gradient algorithms & PSO based neural network approaches for reusability evaluation of procedure based software systems", Chiang Mai J. Sci. 2011; 38 (Special Issue),123-135 www.science.cmu.ac.th/journal-science/josci.html.
[37] http://smallbusiness.chron.com/advantages-amp-disadvantages-six-sigma-43963.html
[38] http://asq.org/learn-about-quality/six-sigma /overview / dmaic.html
[39] http://www.ehow.com/facts_4760705_advantages-disadvantages-six-sigma.html
[40] Patel Rumana, Darshak A. Desai, "Review paper: quality improvement through Six Sigma DMAIC methodology", International Journal of Engineering Sciences & Research Technology, Katkade, 3(12): December, 2014.
[41] http://kaizenfieldbook.com/marksblog/archives/1490
[42] Jeroen de Mast, Joran Lokkerbol, "An analysis of the Six Sigma DMAIC method from the perspective of problem solving", International Journal of Production Economics 139(2):604–614,October 2012.
[43] http://smallbusiness.chron.com/six-sigma-dmaic-3811.html
[44] Abhishek S. Vootukuru, "DMARC: a framework for the integration of DMAIC and DMADV" A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in the Department of Industrial Engineering and Management Systems in the College of Engineering and Computer Science at the University of Central Florida.
[45] Darshak .A Desai, "Improving productivity and profitability through Six Sigma experience of a small scale jobbing industry", Int. J. Productivity and Quality Management, Vol. 3 No. 3, (2008).
[46] E.V.Gijo, Shreeraga Bhatt, N.A. Jnanesh, "Application of Six Sigma methodology in a small scale foundry industry", International Journal of Lean Six Sigma Vol. 5 No:2, (2014) PP 193-211.
[47] Mohammed T. Haygnesh, Omar Batwineh, Ramial – Tauril, "Applying Six Sigma Methodology based on "DMAIC" tools to reduce production defects in textile manufacturing". Recent Advances in Industrial and Manufacturing Technologies, ISBN: 978-1-68104-186-9.
[48] Jiju Antony, Darshak A Anthony, "Assessing the status of Six Sigma implementation in the Indian industry results from an exploratory empirical Study", Management Research News Vol. 32 No. 5 (2009), PP 413-42.
[49] J Antonyl, M Kumar, M.K Tiwari Pro, "An application of Six Sigma methodology to reduce the engine overheating of Problem in an automotive company", I Mech E Vol. 219 Port Engineering Manufacture (2005).
[50] Craig W Baird, "The Six Sigma manual for small medium business", Yes Dee Publishing Pvt. Ltd.

[51] Brady.J.E. Allen, "Six Sigma literature review and agenda for future research", Quality and Reliability Engineering International 22, 335 – 367, 2006.
[52] Mahajan P.M, Kolhe S.R., Patil P.M, "A review of automatic fabric defect detection techniques", Advances in Computational Research Volume 1, Issue 2, , ISSN: 0975–3273, 2009, pp.18-29.
[53] Ali Javed, Mirza Ahsan Ullah, Aziz-ur-Rehman, "Comparative analysis of different fabric defects detection techniques", An I.J. Image, Graphics and Signal Processing, 2013, pp 40-45 Published Online January 2013 in MECS.
[54] Md. Tarek Habib, Rahat Hossain Faisal, M. Rokonuzzaman, "Feasibility of genetic algorithm for textile defect classification using neural network", Department of Computer Science and Engineering, Prime University, Dhaka, Bangladesh.
[55] Rashmi Mishra, Ms. Dolly Shukla, "A survey on various defect detection", Volume 10, Number 13 International Journal of Engineering Trends and Technology (IJETT) – Apr 2014.
[56] Abdel Salam Malek, "Online fabric inspection by image processing technology". A thesis presented to the University of Haute Alsace in fulfilment of the thesis.
[57] https://www.isixsigma.com/methodology/lean-methodology/integrating-lean-and-six-sigma/

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