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Optimizing Woven Fabric Defect Detection Using Image Processing and Fuzzy Logic Method at PT. Buana Intan Gemilang

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***Abstract*—The development of textile industry which 3rd position in the largest export values in Indonesia prove that the quality of textile must be one of factors that should be considered for all of textile companies. Buana Intan Gemilang is one of the companies that produce woven fabric. This company s produce curtain woven fabric. Quality is the most important factor to reach high level customer satisfaction. To get the best quality of product needs to consider their quality control. According to inspection process in Buana Intan Gemilang, manual inspection for woven fabric defect detection need 19.87 second for average inspection time. Therefore, unbalance of production volume with inspection process cause the bottle neck in inspection process. In this research, proposed designing automated fabric inspection using image processing and Fuzzy Logic Model. This processed uses GLCM as feature extraction with three parameters are cluster shade, cluster prominence, and number of object. The proposed fabric inspection using Fuzzy Logic implemented with MATLAB provides better result in identifying fabric defect and optimizing process time. This research using 120 training data, 80 offline test data, and 80 real time test data. Identification automation defect of woven fabric test data can produce accuracy 97, 5% and averaging process time 1.15 second. This result is better than manually inspection process that took 19.87 second for scanning defect of woven fabric.**

Keywords optimizing; defect; detection; image-processing; fuzzy logic method; woven-fabrics

I. INTRODUCTION

The statistical value of the top ten industrial groups with the largest export value in Indonesia., shows that the textile industry is in position with export value of 12.26 billion US $. One of the companies engaged in the textile industry is PT. Buana Intan Gemilang located in Banjaran, West Java. This company produces textile in the form of woven curtains. To produce a product that meets the standards and quality of consumer process quality is required to control the resulting product. This is done by conducting an inspection process on products that have been completed in production in order to meet the standards. At this time, the inspection process on the company is still done manually using the human eye with the help of lighting in the form of lights. Based on observations to the company the manual inspection process takes longer time to process time of 19.7 seconds because of human limitations. Based on the human error factor there will also be defects that are also missed or not visible if the inspection is done without tools. Based on the company's data the company's production volume is not proportional to the inspection volume so as to cause unspoiled fabrication of fabrics on inspection workstations and result in unmet demand on time. The development of image processing technology will help to overcome the problems in the inspection process in order to reduce the time of the inspection process with more accurate results. This study designs a system that focuses on the optimization of the inspection process to detect the types of defects found on the fabric. Thus, appropriate identification techniques are needed to detect defects. The method used in this research is fuzzy logic method that able to handle ambiguity, and variable uncertainty used [1]. This study supports automation systems to identify defects in fabrics using the fuzzy logic method by replacing the function of human vision into digital image processing. The Supervisory Control and Data Acquisition (SCADA) monitoring system is built based on Graphical User Interface (GUI) by using IGSS software. Development of the SCADA application leverages the Wonderware Information Server with Active Factory and Generic Data Grid in order to obtain reporting system a system that can be accessed online. The researcher has been presented these SCADA such as [2-5]. The modelization for the control system is made using Simulink graphical model. In the process, diagram block is used by [6-7]. Mathematical model for a process control plant is important because it provides key information as to the nature and characteristic of the system which is vital for the investigation and prediction of the system operation. Through mathematical equation model, we can study about the dynamics of the process, stability of the system, design controller etc. The mathematical equation model is used to determine a performance of the system [8-16].

II. Basic Theory and Methodology

Quality is a characteristic that a product is expected to have, and is an important factor for customers to choose a product or service [17, 19]. The quality of a product is inversely proportional to the number of defects. The higher the quality of a fabric the less the defects are in the fabric and vice versa. Type of defect in fabric based on Indonesia National Standard (SNI) 08-0277-1989 consisting of 17 types of defects as contained in TABLE I, type of defects based on manual inspection in the company can be seen in TABLE II, and the equation of both can be seen in TABLE III.

TABLE I. Types of Defectts on Fabrics based on SNI 08-0277-1989

No.	Defect Type	Defect Definition
1	Nep	Nep
2	Sub	Thread wrapped, Broken yarn, Dirt, Knot thread
3	Uneven yarn	Big thread, Thread.
4	Yarn broken	Lacking defective defect, Empty feed defect
5	Yarn tense / saggy	Wrinkle shrub fabrics, arch.
6	Fold lines	Cloth folded
7	Warp lines	Different thread structures, Comb line, Double warp, Tight warrant, Rare warp, Different types of fiber, Big thread, thread.
8	The feed line	Double feed, stop mark, Feed tight, Empty feed defect, big thread, thread.
9	Wrong pattern	Defect pattern, Wrong shape stamp, Wrong webbing, The stamp pattern misses, Wrong color weaving style
10	Bare	Different thread structures, Different types of fiber, Empty feed defect
11	Striped	Colorlessness, different Color
12	Torn	Hole, torn
13	The thread is not woven	Yarn jumping
14	Stains	Rust stains, Color stains
15	Defect width	-
16	Feed bias	Feed bias including curved feed
17	Flaw defects	-

TABLE II. The Fabric Defect Type Based on Manual Inspection in PT. Buana Intan Gemilang

No.	Type of Defect
1	Hairy Empty Feed
2	Brodol Empty Feed
3	Lacking Defective
4	Tense Lacking Defective
5	Comb Disability
6	Card Damage
7	Plotting
8	Lusi Double
9	Long Mustache

TABLE III. SIMILARITY OF FABRIC DEFECT TYPE BASED ON SNI AND MANUAL INSPECTION IN PT. BUANA INTAN GEMILANG

No.	Defect Similarity	
	SNI	*Observation Result*
1	Nep	Hairy Empty Feed
2	Slub	Brodol Empty Feed
3	Yarn Disconnected	Lacking defective
4	Yarn Tense	Tense Lacking defective
5	Lusi Line	Comb Disability
6	Wrong Pattern	Card Damage
7	Unfinished Yarn	Plotting

Fuzzy model is a process of input in the form of a value converted by fuzzification into fuzzy value at U value which is then processed by inference with fuzzy rule which then reasserted with defuzzification which will determine is output in the form of firm value (crisp) [1]. The use of fuzzy model in this research, can be seen in Fig. 1.

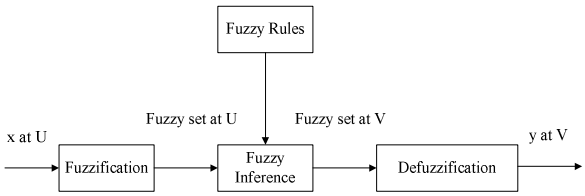

Fig. 1. Fuzzy logic model.

The fuzzy inference maps the fuzzy input set into the fuzzy output set, and defuzzification is a fuzzy mapping [1, 19]. Fuzzification (Fuzzifiers) is a mapping of real values into the fuzzy set on. It can be argued that fuzzification is the process of asserting values (crisp) into fuzzy values using the membership function [17]. Fuzzy rules are at the core of a fuzzy model. The fuzzy rule consists of if-then rules that all components are used to create efficient rules [17]. Fuzzy Inference is the evaluation stage of fuzzy rules. Fuzzy Inference is a reasoning using input and fuzzy rules to get fuzzy output. This research is fuzzy inference using Mamdani method because Mamdani method is very simple but produces optimal output. Fuzzy Inference has three methods namely Mamdani method, Sugeno method, Tsukamoto method [17]. This research uses Mamdani method with MIN implication function and MAX rule composition.

Defuzzification is a mapping of the fuzzy set on to a firm value (crisp) [17]. It can be interpreted that Defuzzification is a transformation process that states the change of form of the fuzzy set resulting from fuzzy inference to its assertion value (crisp) based on a defined membership function. The value of defuzzification is the output of the fuzzy logic process. In GUI design extraction features, there are three push buttons used, including browse picture, process, exit, and reset. There are also two axes that serve to display images that exes greyscale and axes identification. In addition, there are four *edittex*, *edittext* box after browse picture to display the location of the image taken, *edittext* box beside the number of objects that function display the value of the number of objects, edittext cluster shade box that displays the value of the cluster shade, and the edittext cluster prominence Which serves to display the value of cluster prominence. In addition, there are three *statictext* that is writing number of object, cluster prominence, and cluster shade contained in GUI extraction feature. GUI design features extraction can be seen in Fig. 2. Extraction feature results in the value of cluster shade, cluster prominence, and number of objects. Examples of extraction feature results can be seen in Fig. 3.

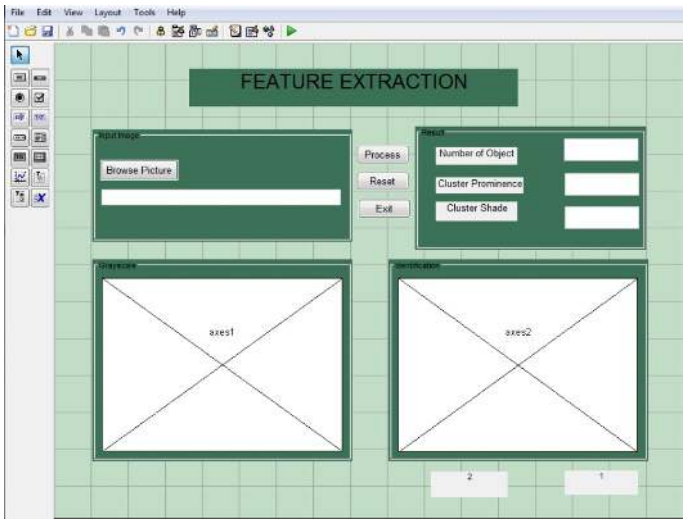

Fig. 2. GUI design of feature extraction.

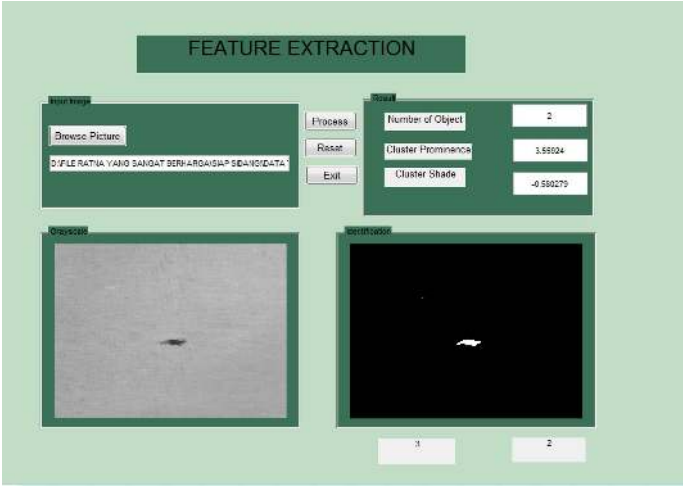

Fig. 3. GUI design result of feature extraction.

In designing GUI extraction feature there are four push buttons used, including browse picture, manual, auto, and identification. There are also two axes that serve to display images of exes preview and axes identification. In addition, there are three edittext, edittext box after browse picture to display the location of the picture taken if the mode used there is manual mode, edittext box beside identification that serves to show the identification result, and edittext box beside time functioning display real time image identification time, In addition there is one statictext that is writing time found on the GUI identification. The design view of GUI identification can be seen in Fig. 4.

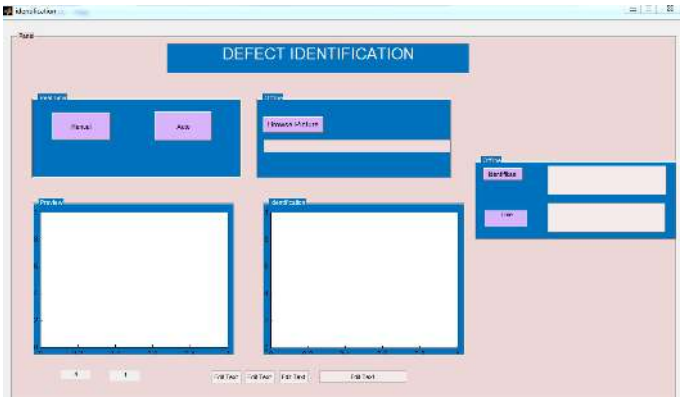

Fig. 4. GUI design result of defect identification.

III. Result and Discussion

The steps undertaken in this research is done with the steps as follows that is, take pictures or imagery via MATLAB using the distance of 16 cm camera, light intensity 1600 lux, and 1.3 megapixel. The next step is to change the image of the capture that is still in the form of RGB (Red, Green, Blue) to grayscale. After the image is converted into greyscale form then the image is converted into binary form. Once the image is in a binary image, the next step is to extract the image using

the GLCM extraction feature to find out the value of cluster shade, cluster prominence, and number of objects. The results of the extraction feature can be seen in TABLE IV.

TABLE IV. RESULT OF THE FEATURE EXTRACTION

Type of defect	Oil defect	Lacking Defective Defect	Empty feed Defect	Normal
Cluster Shade	-9,04638	-1,00373	-0,01449	0,04977
Cluster Prominence	-3,29245	0,18070	0,31701	-0,03391
Number of Object	2	3	7	0
Identification	Defect	Defect	Defect	Normal

Input on fuzzy Mamdani is the values of cluster shade, cluster prominance, and number of objects. With membership functions A1 through A9, B1 to B9, and C1 to C9. Furthermore, the value will be the limit for each parameter used. For fuzzy Mamdani output this is normal and defective. The total of the rules used is 729. Identification is done on the 120-data train so that obtained the results of identification as in TABLE V. Based on the table can determine a accuracy rate used equation in (1) is 95%.

Accuracy rate = (Amount of data is correct)/(Total test data) x 100% (1)

TABLE V. IDENTIFICATION RESULT OF THE TRAINING DATA

No.	Image Data Type	Input Training data	Output Model	
			True	*False*
1	Oil Defect	30	30	0
2	Lacking Defective defect	30	30	0
3	Empty Feed defect	30	30	0
4	Normal	30	24	6

In the offline system the process of detecting defects is done without being integrated with software and hardware other than camera and excel database. The fabrics to be classified are derived from camera captures that have been stored in the database. Matlab software is used to process images taken from the database for identification. TABLE VI shows results of offline identification. Based on the formula, the accuracy of the test data using the fuzzy model with the triangular representation of the fuzzy membership function, fuzzy mamdani inference, and centroid deffuzification, and 729 fuzzy rules is 93.75%.

TABLE VI. OFFLINE IDENTIFICATION RESULT

	Image Data	Input Training	Output Model

No.	Type	data	*True*	*False*
1	Oil Defect	20	20	0
2	Lacking Defective defect	20	20	0
3	Empty Feed defect	20	20	0
4	Normal	20	15	5

In the automatic fabric defect identification system, the process of detecting defects is already integrated with software and other hardware, i.e. PLC, HMI, inverter, motor, webcam, and excel database. Cloth to be classified comes from the results of camera capture in real time. MATLAB software is used to process images taken from the capture process in real time for identification. After the previous fuzzy rules and deffuzification value ranges obtained from the training data, the next step is to test the value against 80 test data. The test results on 80 test data in real time system can be seen in TABLE VII. Based on the formula, the accuracy of test data using fuzzy model with integrated human machine interface system, PLC, database is 97.5%. Trials were conducted to analyze the accuracy and analyze the average processing time. The result of processing time from 80 test data in real time system can be seen in TABLE V.

TABLE VII. ONLINE IDENTIFICATION RESULT

No.	Image Data Type	Input Training data	Output Model	
			True	*False*
1	Oil Defect	20	20	0
2	Lacking Defective defect	20	19	1
3	Empty Feed defect	20	20	0
4	Normal	20	19	1

From the data table process time 80 test data, obtained the average time for the identification of test data with integrated system of 1.150148 seconds. TABLE VIII shows data processing time identification of automatic fabric defects.

TABLE VIII. IDENTIFICATION RESULT OF DATA PROCESSING TIME

Testing Data	Process Time	Testing Data	Process Time
1	4.32	41	1.24404
2	3.04	42	0.73339
3	2.98	43	0.72356
4	2.88	44	0.70753
5	2.86	45	0.66115
…	…	…	…

Testing Data	Process Time	Testing Data	Process Time
20	2.99	60	0.81443
21	1.76464	61	0.69266
22	1.73764	62	0.70171
23	1.47355	63	0.67786
24	1.61301	64	0.67526
25	1.74046	65	0.68613
…	…	…	…
40	1.74136	80	0.69093

In the existing process, there is an average time to do a recap of data manually by filling form defects. In this study, the form of defects replaced with a database of excel. Automatic data recap time can be seen in TABLE IX. From the data table recap time 80 test data, obtained the average time for the process of recording test data with an integrated system of 3.54 seconds. Based on the research that has been done, the comparison of processing time from the existing system that is still manual with the system of ideas that have been automated can be seen in TABLE X. Based on TABLE X, process time required to perform scanning process defects in the existing process by manual in the company is equal to 19.87 seconds, while using the automatic defect detection tool that has been integrated to be reduced by the process time of 1.16 seconds. For a manual defect recap in the company takes 13.5 seconds, while using an automated tool is reduced to 3.54 seconds. For the total overall activity, the existing process takes an average time of 33.37 seconds and for the proposed system takes 4.67 seconds. Thus, the decline in processing time for the all system amounted to 28.69 seconds.

TABLE IX. RECAP TIME ONLINE IDENTIFICATION RESULT

Testing Data	Process Time	Testing Data	Process Time
1	4.32	41	3.91
2	3.04	42	3.77
3	2.98	43	3.83
4	2.88	44	3.92
5	2.86	45	3.75
…	…	…	…
20	2.99	60	3.91
21	2.93	61	3.92
22	2.99	62	3.81
23	3.26	63	3.93
24	3.03	64	3.74
25	3.09	65	3.87
…	…	…	…
40	3.69	80	3.79

TABLE X. COMPARISON OF EXISTING AND PROPOSED SYSTEMS

No.	Activity	Existing (Seconds)	Proposed (Seconds)
1	Defect Scanning	19.87	1.16
2	Defect Recap	13.50	3.54
	Process Time	33.37	4.68

IV. CONCLUSION

Image processing is required to improve accuracy and to reduce inspection time. The use of fuzzy logic method in image processing with GLCM extraction feature and cluster shade parameter, cluster prominence, and number of object is a step proposed in this research. Thus, fuzzy logic applied by using MATLAB software can give better result in detecting defects in fabric. The process time required to perform the scanning process of defects in the existing process by manual in the company is 19.87 seconds, while using the automatic defect detection tool that has been integrated to be reduced with a process time of 1.16 seconds. For a manual defect recap in the company takes 13.5 seconds, while using the automated tool is reduced to 3.54 seconds for the total activity, the existing process takes an average time of 34.08 seconds and for the proposed system takes 4.67 seconds. Thus, the decrease of process time for the all system is 28.69 seconds. Accuracy rate obtained in the training data of 95%, on the offline test data of 93.75% and on the real-time test data of 97.5%

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