DESIGN OF AUTOMATION SYSTEM FOR CERAMIC SURFACE QUALITY CONTROL USING FUZZY LOGIC METHOD AT BALAI BESAR KERAMIK (BBK)

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Abstract

Indonesia is the world's top 10 ceramic users. To obtain best quality need to consider process of quality control, in SNI ISO 13006: 2010 there are six variables characteristic requirements related to quality of ceramic tiles. Currently the process of ceramic quality inspection in Indonesia, particularly in the Balai Besar Keramik is still done manually by human vision. Therefore, it is necessary to design a visual inspection system for digital image processing of ceramic automation using Fuzzy Logic method. Fuzzy model is one method that can be used to determine ceramic surface quality control. This study aims to apply fuzzy model in design of automation system for ceramic surface quality control and describes its accuracy rate and automatic database. To perform feature extraction using GLCM extraction method to obtain autocorrelation, sum of square (variance), and number of object. The information is used as input for data processing using fuzzy model in the identification of quality of ceramic surface defect. This research uses 13 real time test data which can produce the accuracy of automatic ceramic quality identification 92.31%.

Keywords : Automated Ceramic Surface Quality Control, Ceramic Defect Detection, Image Processing, Fuzzy Logic Model

1. Introduction

1.1 Research Background

Ceramic is the most popular type of media used in Indonesia because there are various advantages possessed, and also available for high usage and can be applied to almost all parts of the house. In addition to strong, ceramic house also does not require polishing and easy to maintain. Based on Table I.1 can be seen from the export side, the export volume growth has fluctuated. The export volume of ceramics in 2013 to 2014 has increased by 4.3%, and in 2014. On the import side, the growth of ceramic import volume always increases every year. The rate of import increase of 8.6%, and in 2014 to increase by 1%. Factors that cause import volumes to be higher than export volumes are that ASAKI coach is the government's very easy to include imported products without any more in-depth examination of standards, and in terms of price the difference is also cheaper than the price of ceramics in Indonesia [4].

Table 1 Volume Ekspor dan Impor Keramik [2]

Tahun	2013	2014	2015
Volume Ekspor (Ton)	295,780	337,000	336,520
Volume Impor (Ton)	733,510	966,000	991,910

To fulfill the demand for export and import on ceramic products required quality products that can compete with other companies. Quality is the overall nature of a product or service that has an effect on its ability to satisfy the stated or implied needs [5]. To obtain the best quality of a product needs to consider their quality control process. In SNI ISO 13006: 2010 there are six variable characteristic requirements related to the quality of ceramic tiles, namely: length and width, thickness, starightness of side, rectangularity, surface flatness and surface quality [1].

Currently the process of ceramic quality inspection in Indonesia, particularly in the Balai Besar Keramik is still done manually by human vision. Process of ceramic quality inspection manually will cause fatigue and saturation because process performed repeatedly. There are five groups causes of fatigue, namely monotonous work, load and duration work both physically and mentally, work environment, psychological, and disease [8].

Based on research Atmaja error rate of measurement of tile surface area obtained at light intensity 300 lx with a distance of 50 cm by 0.0675%. Influencing factors for the percentage of ceramic tile measure wide error rate ie camera distance, light intensity, and interaction of both factors (camera distance and light intensity) [1].

1.2 Problem Definition

Problem definition from this research are:

1. How to design of automation system for ceramic surface quality control using Fuzzy Logic method?
2. How to measure the accuracy rate in process quality control of ceramic surface?

1.3 Research Objectives

The objectives of this research are:

1. To design of automation system for ceramic surface control quality using Fuzzy Logic method.
2. To measure the accuracy rate in process quality control of ceramic surface.

2. Literature Review

2.1 Automation System

The automated system consists of three basic elements (1) power to achieve the process and operate the system, (2) the instruction program to direct the process, and (3) the control system to drive the instruction. The relationship between these elements is illustrated in Figure 1. All qualified systems as automated include the three basic elements in one form or another [3].

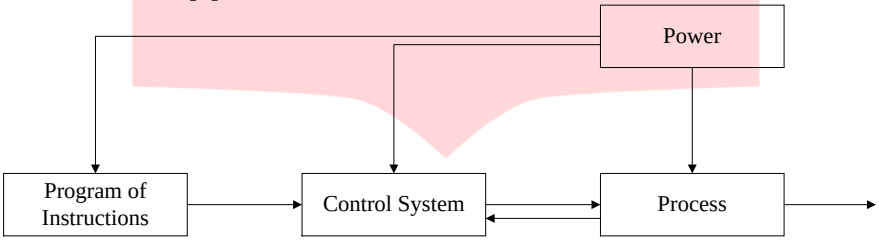


Figure 1 The basic elements of automation systems [3]

The basic element of automation systems consist of

1. Power
   Power is basic element which is required and used to operate some process and drive all of the component in the automation system.
2. Program of Instruction
   Program of instruction is element required to operate control of the process from list of program and used to direct the operational of automated system.
3. Control System
   Control system is an element to execute program of instruction and to accomplish the process from each automation elements.

2.2 Gray-Level Co-occurence Matrix (GLCM)

Gray Level Co-occurrence Matrix (GLCM) is a technique for obtaining image textures using second order calculations. First-order texture measurements using statistical calculations are based on pure image values only, such as variance, and do not pay attention to the neighboring pixels [6].

2.3 Fuzzy Logic

Fuzzy logic is a methodology of problem-solving control systems, suitable for implementation on systems, from simple systems, small systems, embedded systems, PC networks, multichannel or workstations based data acquisition and control systems [10].

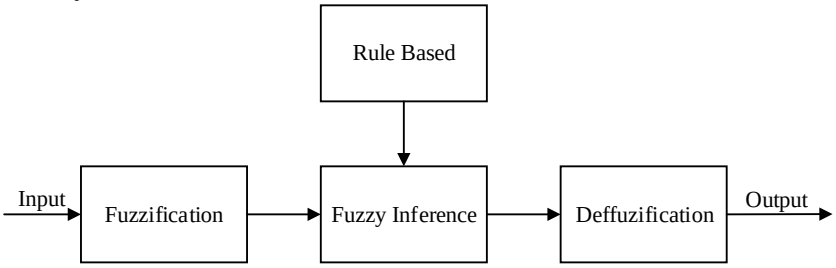


Figure 2 Fuzzy Logic Chart Block [9]

There are several operational stages which include, among others:

1. Fuzzification
   Fuzzification is defined as a mapping of real values point $x^* \in U \subset R^n$ to fuzzy set A' in U. It can be said that fuzzification is the process crisp value into fuzzy value by using membership function [7].

2. Fuzzy Inference
   Fuzzy inference is the process of implication in the reasoning of the input value in order to determine the output value as a form of decision-making. One of the most commonly used reasoning models is max-min reasoning. In this reasoning, first process is to perform the min signal operation of the fuzzified output output, which is continued by max operation to find the output value which will be furtherefefined as output [7].

3. Rule Based
   The rule based on fuzzy logic control is a form of "If-Then" or if-then relation rule as follows:
   If x is A then y is B
   Where A and B are linguistic values defined in the range of variables X and Y. The statement "x is A" is called antecedent or premise. The statement "y is B" is called consequent or conclusion [9].

4. Defuzzification
   Defuzzification is defined as a mapping from fuzzy set B' in $V \subset R$ to crisp point $y^* \in V$. It can be interpreted defuzzification is a transformation process that states the change of form of the fuzzy set resulting from fuzzy inference to its crisp value based on a defined membership function. The value of defuzzification is the output of the fuzzy logic process [9].

3. Discussion

3.1 Fuzzy Logic Model

Data analysis is performed to identify ceramic defect using Fuzzy Model. fuzzy model is described in the diagram shown in Figure 3. The steps are as follows.

1. Capture a ceramic image
2. Undertake feature extraction, therefore it will be obtained the value that will be used to Fuzzy Model, these are: autocorrelation, cluster shade, and number of object. Feature extraction process is conduct with Matlab software.
3. Determine the universal set in input variable
4. Determine the universal set in output variable
5. Define fuzzy set in input and output
6. Create fuzzy rule
7. Fuzzy inference
8. Defuzzification
9. Testing of Fuzzy Model.

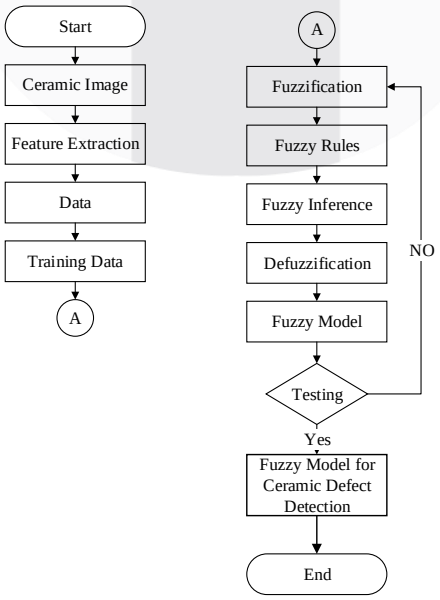
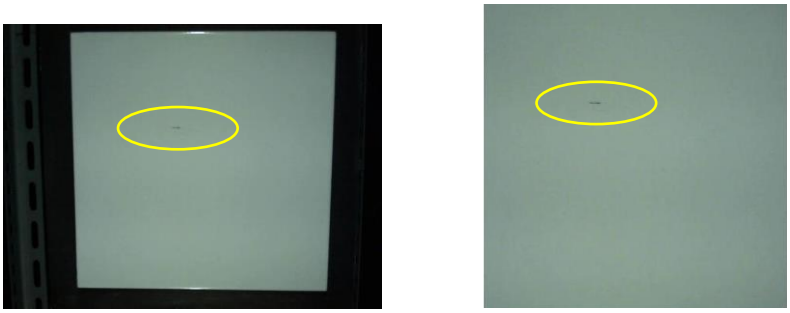


Figure 3 Step of Create Fuzzy Model

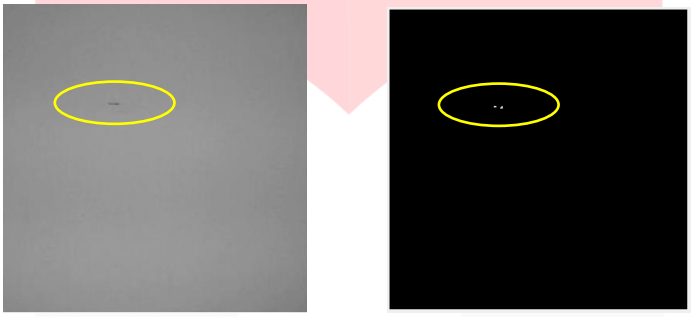
In this research, first step the ceramic defect identification capture digital ceramic images by image acquisition (light intensity 300 lx, 1.3 megapixels, and 50 cm camerea distances). Crop image so only ceramic image are detected, as shown in Figure 4.



(a) (b)

Figure 4 Original defect ceramic (a) and crop ceramic (b)

Convert RGB (Red Green Blue) to grayscale image and convert grayscale into binary image, where white is defect, as shown in Figure 5.



(a) (b)

Figure 5 Grayscale Image (a) and Binary Image (b)

Second step, then calculates autocorrelation, sum of square (variance) and number of objcet using interface, as shown in Figure 6.

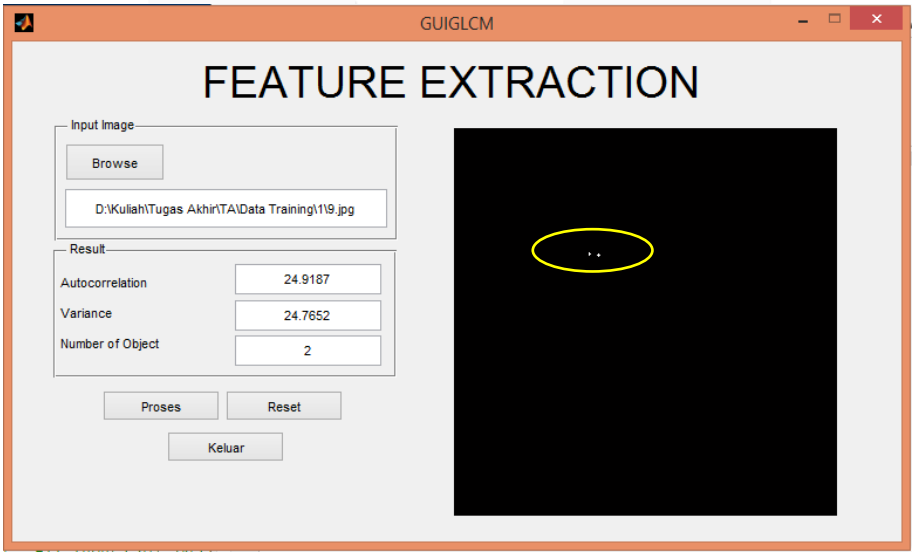


Figure 6 Result extraction features

Third step, after all sample data were processed by feature extraction, then the next step is the classification of fuzzy logic as the basic fuzzy model, which consists of various step.

The universal set is value that allowed to be operated in a fuzzy variable. In other words, universal set is a range of minimum to a maximum value of all sample data. Based on data obtained from the feature extraction then the universal sets of each image as follows:

1. Autocorrelation
   The universal set for autocorrelation from the training data of feature extraction is minimum 24.1814 and maximum 34.2239. Then the universal set for number of object is UA = [24.1814 34.2239].
2. Sum of Square (Variance)
   The universal set for sum of square (variance) from the training data of feature extraction is minimum 24,0395 and maximum 34,0558. Then the universal set for number of object is UB = [24.0395 34.0558].
3. Number of Object
   The universal set for number of object from the training data of feature extraction is minimum 0 and maximum 4. Then the universal set for number of object is UC = [0 4].

This result as an input set of the fuzzy logic. In this research, applied fuzzy uses Mamdani model. Using membership function to definition group fuzzy set shown in Tabel 2

Table 2 Result from extraction feature

Data	Result of Extraction	Membership Function	Fuzzy Set
Autocorrelation	24,9187	0,5873	A_2
Sum of Square (Variance)	24,7652	0,5796	B_2
Number of Object	2	1	C_5
Kondisi Keramik	Defect	Defect	V_{Defect}

Based on Tabel 2 then the rules are from the extraction is:

“IF autocorrelation is A2 AND variance is B2 AND number of object is C5 THEN Kondisi Keramik is VDefect”

Input variable as antecedent and output variable as consequent. If there is a same antecedent but the consequent is different, then optimization rules is needed. The determination of optimization rules is by choosing multiply of the largest value of membership degree. This research use 729 rules.

3.2 Defect Detection

For validating the result for the fuzzy model, image used as an input in this system is test data using 13 samples of ceramic imagess consisting of 8 normal ceramic images and 5 defects ceramic images. Testing the model shown in Table 3.

Table 3 Result of System in Real Time Process

Data	Real Ouput	Output Model	Deffuzifikasi	Information
Data Test 1	NORMAL	NORMAL	1.63277	TRUE
Data Test 2	NORMAL	NORMAL	1.62542	TRUE
Data Test 3	NORMAL	NORMAL	1.6361	TRUE
Data Test 4	NORMAL	NORMAL	1.63807	TRUE
Data Test 5	NORMAL	NORMAL	1.63451	TRUE
Data Test 6	NORMAL	NORMAL	1.63918	TRUE
Data Test 7	NORMAL	NORMAL	1.63201	TRUE
Data Test 8	NORMAL	NORMAL	1.63903	TRUE
Data Test 9	DEFECT	DEFECT	1.36873	TRUE
Data Test 10	DEFECT	DEFECT	1.3673	TRUE
Data Test 11	DEFECT	DEFECT	1.36595	TRUE
Data Test 12	DEFECT	DEFECT	1.36672	TRUE
Data Test 13	DEFECT	NORMAL	1.62537	FALSE

As shown in Figure 7.

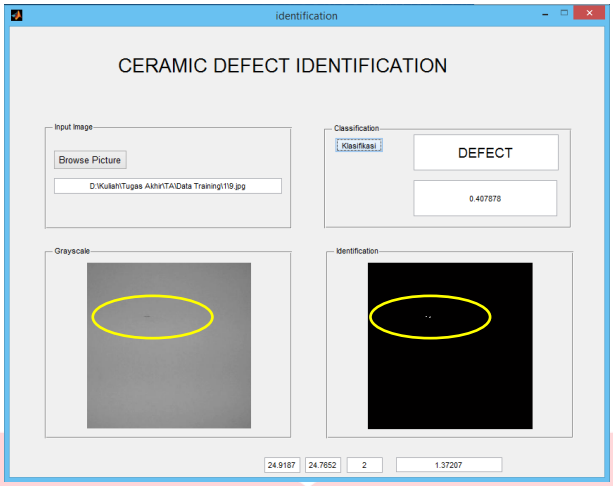


Figure 7 Result ceramic defect detection

This result is determined from deffuzification values for normal ≥ 1.5 and deffuzification values for defects < 1.5. To determine the accuracy of this training data, use the following formula:

$$\text{Accuracy Rate} = \frac{\text{Number of True}}{\text{Total Data Training}} \text{x}100\%$$

$$\text{Accuracy Rate} = \frac{12}{13} \text{x}100\%$$

$$\text{Accuracy Rate} = 92.31\%$$

Therefore, the accuracy rate used Fuzzy Model with triangle representation of membership function, Mamdani of Fuzzy Inference, centroid of defuzzification, and 729 rules the obtained accuracy rate 92.31%.

4. Conclusion

Automatic ceramic surface inspection using fuzzy logic with GLCM extraction to get autocorrelation, sum of square (variance), and number of object is proposed. Thus the proposed ceramic inspection using fuzzy logic implemented with MATLAB provides better result in identifying ceramic defect. The above proposed system obtained an overall accuracy rate 92.31% of by considering three variable feature extraction.

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