Defect Detection of Ceramic Tiles using Median Filtering, Morphological Techniques, Gray Level Co-occurrence Matrix and K-Nearest Neighbor Method

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Abstract - Manufacturing industry companies must be able to maintain the quality of each product produced, including manufacturing companies that produce ceramic tiles. For several years, automatic visual inspection has been applied to determine the quality of ceramic tiles produced. The difficulty of detecting defective ceramic tiles can have an impact on decreasing the quality of production, decreasing the level of consumer confidence, and decreasing profits for the company. The problem discussed in this research is how to defect detection of ceramic tiles so that the model built can improve accuracy to defect detection of ceramic tiles. The solution to this problem is to collect data in the form of ceramic tiles images, then preprocessing images data using Median Filtering to eliminate salt and paper noise and Morphological Techniques to improve images segmentation results. After preprocessing, texture image extraction data is based on texture using the Gray Level Co-occurrence Matrix (GLCM) method which is continued by classifying images data using the K-Nearest Neighbor (KNN) method. The results of this research are models that are built using the Median Filtering, Morphological Techniques, Gray Level Co-occurrence Matrix and K-Nearest Neighbor method can improve accuracy to defect detection of ceramic tiles with an accuracy value of 98.9474% for k=3.

Keywords— Digital Image Processing, Median Filtering, Morphological Techniques, GLCM dan KNN.

I. INTRODUCTION

Nowadays, almost all industrial companies engaged in manufacturing are faced with a problem, namely the increasingly competitive level of competition. Industrial companies are required to produce quality products in order to meet market demand, so that the profits of industrial companies are expected to increase [13].

Manufacturing industry companies must be able to maintain the quality of each product produced, including manufacturing companies that produce ceramic tiles. The control process is one of the important issues in competition between ceramic industry producers and affects prices by looking at the purity of the texture, color accuracy, and shape [19]. During the process of producing ceramic tiles, the use of different raw materials and a long process has resulted in some ceramic tiles experiencing defects on the surface of ceramic tiles [13].

For several years, automatic visual inspection has been applied to determine the quality of ceramic tiles produced. The complexity of detecting defective ceramic tiles is still possible in automatic visual inspection [19]. With increasing consumer demand, from the perspective of quality and quantity, the use of automatic visual inspection is one of the key technologies in the manufacturing industry [18].

Research from [13] applied Artificial Neural Networks and the Backpropagation algorithm applied to Matlab Software with the results of this study showing an accuracy of almost 90%. Whereas [3] conducts research by applying a mechanism based on the process of detecting dimensional defects, specifically rectangular defects with extraction of form features using morphological techniques. After the morphology technique, it was continued by using feature feature extraction and spatial information to get a clear edge position from the side of the ceramic tile and special coordinate points for the defect

measurement process. The results of this study indicate an accuracy value of 67%.

The research conducted [17] proposed an algorithm that divides ceramic images into partitions and identifies defective partitions. Furthermore, the classification algorithm is only applied to defective partitions. Simulation results show an accuracy rate of 72%. According to [5], detection of defects can be detected using the Rotation Invariant Measure of Local Variance (RIMLV) operator from the statistical method. All detected ceramic tiles are labeled and the geometry features that are suitable are extracted, then classified using Support Vector Machine (SVM). The results of this research indicate an accuracy value of 93.4%.

Research conducted [21] proposed an automatic inspection system for the ceramic tile industry based on image processing techniques. This system can detect color variations and defects such as angle damage, edge damage and middle cracks on the tile surface. Tiles are compared with good quality reference tiles using the image processing concept using Matlab software. The results of this research indicate an accuracy value of 96.36%.

Based on the descriptions in the background above, it can be identified that the problem, among others, is the difficulty of detecting defective ceramic tiles which can have an impact on decreasing the quality of production, decreasing the level of consumer confidence, and decreasing profits for the company. So the problem that can be discussed in this reasearch can be formulated as "How to detect defective ceramic tiles". The limitation of the problem in this research is the form of ceramic tiles used as square objects, the level of disability that will be detected in the form of lines and clumps, the ceramic tiles used are Mulia Artic type, the ceramic tiles used are not patterned (plain), and the size of ceramic tiles is 30 cm x 30 cm. The purpose of this research is that the model built can improve the accuracy of disability detection in ceramic tiles using the Median Filtering method, Morphological Technique, Gray Level Co-occurrence Matrix and K-Nearest Neighbor.

II. METHODOLOGY

A. DIGITAL IMAGE PROCESSING

Digital Image Processing is a discipline that studies techniques in image processing. Image is a photo (still image) and video (moving image), while digital is a digital image or image processing using a computer [23]. Images that are presented numerically with discrete values can be processed with a digital computer. Image digitization is repersent from continuous functions to discrete values [11].

B. K-NEAREST NEIGHBOR (KNN)

K-Nearest Neighbor (KNN) algorithm is an algorithm that is used to classify an object based on the data closest to the object. Terms of value that is not greater than the amount of training data, the value must be odd and more than one [4]. K-Nearest Neighbor (KNN) algorithm is an algorithm that is used to classify an object based on learning data that is the closest distance to the object [10].

Euclidean distance is proximity in unit of distance matrix. Euclidean distance can be searched using equation (1) [4].

$$D_{XY} = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2} \quad (1)$$

where D = Proximity distance, x = training data, y = testing data, n = number of individual attributes between 1 through n, f = similitary function of attributes i between case X and case Y.

C. GRAY LEVEL CO-OCCURRENCE MATRIX (GLCM)

Texture is a characteristic or characteristic possessed by a region that is large enough so that naturally these characteristics or characteristics can be repeated in the area. Texture is the regularity of certain patterns formed from the arrangement of pixels in an image [1]. Kookurensi is a joint event, namely the number of occurrences of one level of a pixel value that is adjacent to one level of a pixel value in a certain distance (d) and angle (ϑ). Distance is expressed in pixels and the location is expressed in units of degrees. The orientation is done in four different angular directions with an angle interval 45^o, which is $0^o, 45^o, 90^o$ and 135^o. The distance between pixels is usually set at 1 pixel [20].

The research conducted [6] proposes various types of textural characteristics that can be extracted from the coefficient matrix, namely Energy or Angular Second Moment (ASM) which is expressed by equation (2), Contrast (Con) expressed by equation (3), Correlation (Cor) which is expressed by equation (4), Homogeneity or Inverse Difference Moment (IDM) which is expressed by equation (5).

$$ASM = \sum_i \sum_j \{p(i,j)\}^2 \quad (2)$$

$$Con = \sum_k k^2 \left[\sum_i \sum_j p(i,j) \right], \quad |i-j| - k \quad (3)$$

$$Cor = \frac{\sum_i \sum_j (ij).\, p(i,j) - \mu_x \mu_y}{\sigma_x \sigma_y} \quad (4)$$

$$IDM = \sum_i \sum_j \frac{1}{1 + (i-j)^2} p(i,j) \quad (5)$$

D. MORPHOLOGICAL TECHNIQUES

Morphological techniques represent the image of a two-dimensional object as a mathematical set in Euclidean space which is seen as a set. An image object A can be represented in the form of a set of positions (x, y) which are worth 1 or 0. These values indicate the grayscale level for each position. Value 1 for white gray level and value 0 for black gray level [7].

The basic principle of morphological techniques is the use of structuring elements which are the basic forms of an object that are used to analyze the geometric structure of other larger and more complex objects. The purpose of the morphology technique is to obtain information about the shape of an image by adjusting the size and shape of a structuring element. Structuring elements also have a pivot point (also called a origin / origin / reference point) [7].

E. MEDIAN FILTERING

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Median Filtering is a method that focuses on the middle value of the total value of the overall pixel around it. The median filtering process begins by sorting the values of neighboring pixels first, then selecting the middle value [7].

III. SYSTEM DESIGN AND APPLICATION

The data used in this study are primary data obtained from photographing directly which will be used as a dataset. The dataset will be divided into 2, training data and testing data. In this study there were 190 training data consisting of 86 data for class images of good quality ceramic tiles and 104 data for class images of defective ceramic tiles. While the testing data amounted to 95 data, which consisted of 43 data for class images of good quality ceramic tiles and 52 data for class images of defective ceramic tiles.

The design of the model in solving the problem in this study by utilizing digital image processing in the form of Median Filtering and Morphological Techniques, the classification of KNN has already been carried out with texture-based feature extraction with GLCM. The model design is presented in Figure 1.

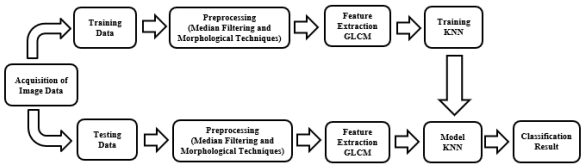

Figure 1: Model Design

Data acquisition in this study is by taking images directly using a mobile camera. Then the data is divided into two types of data, namely training data and testing data. Preprocessing stage aims to process the image so that its characteristics can be taken, eliminate noise and improve the results of image segmentation. At this stage the noise elimination technique is also carried out using the median filtering method and improving the results of image segmentation using Morphological Technique. Then texture-based feature extraction is performed using GLCM and classified using KNN, so that the classification results are obtained whether the image of ceramic tiles including the image of fine ceramic tiles or defects.

IV. EXPERIMENTAL RESULTS

In this study there were 190 training data consisting of 86 data for class images of good quality ceramic tiles and 104 data for class images of defective ceramic tiles. While the testing data amounted to 95 data, which consisted of 43 data for class images of good quality ceramic tiles and 52 data for class images of defective ceramic tiles. Image of ceramic tiles obtained by photographing ceramics obtained from PT. Beautiful Ceramics by using a cellphone camera and stored in .jpg form to be able to train training data and testing data.

Model making in this research was carried out using Matlab R2017a. The screen display in the defect detection model on ceramic tiles can be seen in Figure 2.

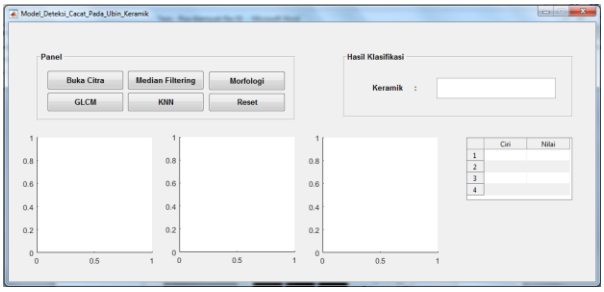

Figure 2: Model of Defect Detection of Ceramic Tiles

In Figure 2 can be seen in the panel there are 6 types of options, namely the option "Open Image", "Median Filtering", "Morphology", "GLCM", "KNN" and "Reset". The image of ceramic tiles that you want to classify can be chosen by selecting the "Open Image" option, then the image of the selected ceramic tile will be displayed in the "Original Image" section. Next select the option "Median Filtering" to remove the noise and select "Morphology" to improve the results of image segmentation.

Then select the "GLCM" option for extracting features based on texture. The value of the extraction of texture features will be displayed in the table section shown in Figure 2. Classification is done by selecting the "KNN" option whose results will be displayed in the "Classification Results" section, image of selected ceramic tiles including good quality ceramic tiles or disabled. If you want to test the image of other ceramic tiles, you can choose the "Reset" option before re-selecting the "Open Image" option. The screen display of the defect detection model on ceramic tiles is shown in Figure 2.

Figure 3 shows the original image, the median filtering result, the results of the morphological technique, the results of feature extraction with GLCM and the classification results of the KNN whose original image is a ceramic tile with good quality.

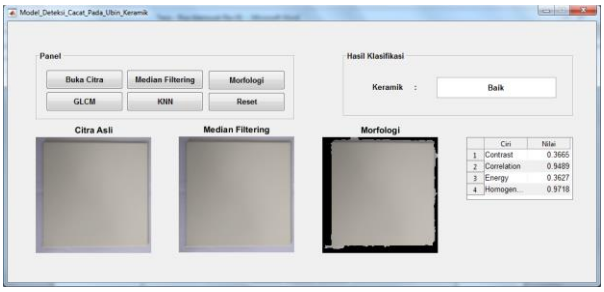

Figure 3: Model of Defect Detection of Good Ceramic Tiles

Figure 4 displays the original image, the median filtering result, the results of the morphological technique, the results of feature extraction with GLCM and the classification results of the KNN whose original image is a ceramic tile with defective quality.

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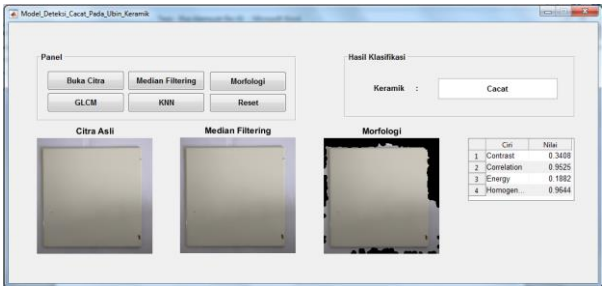

Figure 4: Model of Defect Detection of Defective Ceramic Tiles

In this research, there were 1 prediction error from 95 testing data with 43 test data on the image of good quality ceramic tiles and 52 test data on the image of quality defective ceramic tiles.

The results of testing the defect detection model on ceramic tiles using the Confusion Matrix for all k values tested are presented in Table 1.

Table 1. Value of Accuracy Model of Defect Detection

Value of k	Accuracy Result
k = 3	98.9474%
k = 5	94.7368%
k = 7	94.7368%
k = 9	93.6842%
k = 11	93.6842%
k = 13	93.6842%
k = 15	91.5789%

Based on Table 1, it can be said that the defect detection model in ceramic tiles has the highest accuracy value for k = 3 which is 98.9474%.

V. CONCLUSION

Based on the discussion of the results of the above research, it can be concluded that the model is built using the Median Filtering method, Morphological Technique, Gray Level Co-occurrence Matrix and K-Nearest Neighbor can improve accuracy to detect defects in ceramic tiles with an accuracy value of 98.9474% for k = 3.

Based on the results of the research and conclusions obtained, the suggestion that can be given as a reference for further research is that research can be continued using other different methods to measure accuracy so that the best results are obtained to detect defects in ceramic tiles.

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