Automatic Defect Detection and Classification Technique from Image Processing

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Abstract: Image processing is one of the most increasing areas in computer science. As technology advances, the analog imaging is switched to the digital system. Every day, we capture huge amount of images which are very difficult to maintain manually within a certain period of time. So the concept and application of the digital imaging grows rapidly. Digital image processing[7] is used to extract various features from images. This is done by computers automatically without or with little human intervention. One of the most important operations on digital image[2] is to identify and classify various kinds of defects. Thus to detect the defects from any image some methods are developed. In this paper a defect detection method for ceramic tiles is proposed. The proposed method is tested for images with resolution 1920×1080 pixels. The method has tested only for defects such as blobs and cracks.

Keywords: *Morphology Operation, Blob Detection, Crack detection, Image preprocessing*.

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I. INTRODUCTION

Ceramic tiles industry sector is now a very important sector for manufacturing the ceramic tiles. In ceramic tile production process many stages lead to different types of faults and defects on the final product. These defects may occur due to chemical impurities in the material or due to some physical faults in the production process. At present the most of the phases of ceramic tile production are automated, but still the last phase of tile inspection is done manually. For inspection of ceramic tiles, the industry requires the human experts. Experts may have different opinions about the presence of defects. The capability of the human depends on training, knowledge and experience. The drawback to the manual inspection is that, human can work for a limited time and easily get tired within a few hours. The judgment of human is affected by fatigue. Such a monitoring task is of course tedious, subjective and expensive. On the other hand the production process runs continuously in the factories, but inspection system doesn't match with the rate of production. For all these reason no one can deny the significance of automated defect detection and classification system. So, the need of automated system comes into the picture. The automated system is free from tiredness and the inspection is done with the same efficiency for all tiles.

The objective of our work is to propose an efficient defect detection and classification technique which will be able to find out image defects at a high rate within a very short time.

II. LITERATURE SURVEY

In the previous years, some proposed defect detection methods have been proposed to find out the image defects. But they have some limitations that can be described briefly as follows:

H. Elbehiery*et al*. [10] proposed techniques for detecting surface defects on ceramic tiles. Their algorithm is divided into two stages. In the first stage, the algorithm for obtaining clear image tiles using histogram equalization was used. In the second stage, the algorithm for detecting different types of surface defects, such as crack, spot, pinhole, and blob using shape feature extraction with morphological operations was performed.

G.M.A. Rahaman*et al*. [11] studied for the preparation of the analyzed image noise removal, which was done using median filter and sobel edge detection. In this study, the proposed algorithm is intended to separate tiles into defect or no defect category. Separation had done by comparing the number of defect pixels on the analyzed image with the reference image. Morphological operations were then applied to the defective tile image during the defect classification process.

ForamSanghadiya*et al*. [2] proposed a simple method to detect defects on ceramic tile surface. Preprocessing step includes contrast stretching which is fulfilled by histogram equalization. Edge defect is detected by a special edge detection algorithm: canny edge detector[9]. Using morphology operation, smoothing, noise reduction, detection of object can be done in less time.

In the paper of Dr.Ankit Mittal *et al.* [5] a defect detection method for ceramic tiles is proposed and the method is compared with existing method. The defect detection rate of the proposed method is better and needs less time as compared to the existing method. The proposed method has tested only for defects such as blobs and cracks

III. MOTIVATION

Currently, the production process at ceramic tiles factory have been done automatically by machine through industrial automation system, except the examination process for ceramic quality classification which is still performed manually by the intervention of human operator. This process has many drawbacks, such as time efficiency, accuracy and endurance, which is very expensive, since it requires workers to work in shifts. The other drawback is subjectivity since it is fully influenced by the experience and knowledge of the workers. These disadvantages can lead to errors in the phase of ceramic quality identification. All these drawbacks motivate for automation of quality control in ceramic tile industry.

We have seen existed methods for defect detection, many of those methods need pattern learning in advance[14][10]. Ideal tile image is given as a reference to algorithm. Image processing techniques are applied to that reference image. Images of tiles to be inspected are captured and various image processing techniques which are applied to the reference image are applied to tile image. This tile image is compared with the reference image and any defects are detected. We tend to design an algorithm which will detect the defects without any reference image. Also, time required for identification of defects should be less than processing time of existed methods.

IV. OBJECTIVE

The objective of work is to propose an efficient defect detection and classification technique which will be able to find out image defects at a high rate within a very short time.

- Acquiring images: tile images should be captured and stored in computer. Defect detection algorithms should be developed on these stored images. If algorithms are properly working on number of images taken, the next stage is to capture an image in real time.
- Segmenting defected region: various image processing operations like, contrast enhancement, filtering, segmentation, etc. need to be performed on tile image to identify defected region in tile.
- Classification of defect: once a defected region in tile image is segmented, it is necessary to classify which type of defect is present. Defects should be classified in various types blob, crack, edge, pinhole.

Thus objective is to develop a system to detect defects in ceramic tiles including real time processing from image acquisition to decision[3][4][12].

V. SURFACE DEFECTS OF CERAMIC TILES

Ceramic and tile products pass various chemical and mechanical stages through the production line. Production of ceramic tiles includes eight main stages: forming, drying, glazing, baking, grading, and sorting as shown in following figure.

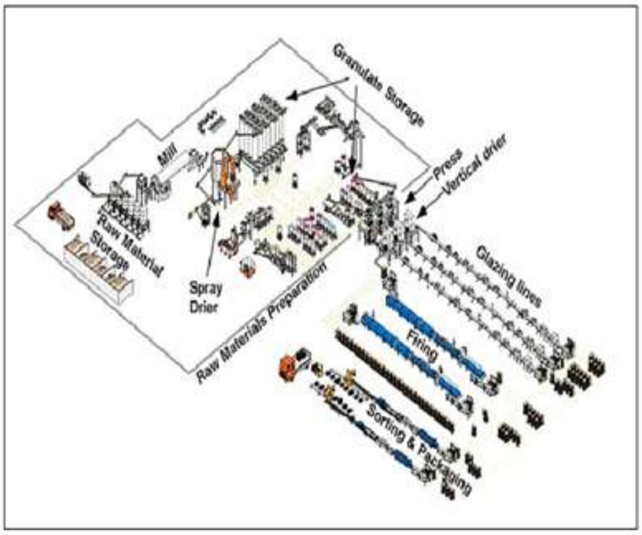

Fig 4.1: General stages of fabrication in ceramic and tile factory [1]

Glazing defects occur in glazing and printing stages. Defects that are associated with breaking and cracks happen in the forming and baking stages. In contrast, edge defects are caused more by the transmission process from glazing lines to kiln. Also, the Pinhole defect occurs typically in kiln. Accordingly, surface defects can be divided into six categories; blob, crack, pinhole, edge, corner and glaze with the following characteristics.

Blob: Some patches like spot drops of water may exist on the tile surface, and are called blob defects. It occurs if humidity is not adjusted or a low sleep time is included before entering into the kiln.

Type of defect	Description
Blob	Convex surfaces dew to water drops on tile surface

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Crack	Break down of tile
Pinhole	Scattered isolated black-white pinpoint spot
Edge	Break down of edge
Corner	Break down of tile corner
Glaze	Blurred surface on tile

Table4.1: Types of ceramic tile defects

Crack: The most common defect is the crack which occurs because of fast baking procedure with rapid increase or decrease in temperature. Cracks at the edges of the tile are mostly caused due to increasing temperature. Cracks due to decreasing temperature are also called air cracks or cold cracks and often occur because of fast baking procedure in the kiln.[12]

Pinhole: Pinhole is a quality fault appearing as small holes on the product surface. Pinhole sizes are typically less than one millimeter. This fault typically occurs during baking.

Edge: Breakdown of edge occurs most commonly in the kiln but they may be generated from other manufacturing stages.

Glaze: This problem originates from accumulation of a part of glaze over a corner or part of the tile. Accumulation of glaze is usually on a few millimeters with significant expansion in the region of defect. This defect appears in the glazing stage by creeping and ringing of the glaze.

Corner: Corner defectsare caused more by the transmission process but they may be generated from other manufacturing stages.

The complete flow chart of defect detection and classification technique is given in the following figure.Here, a common sequence of operations is applied to detect different types of defects in ceramic tiles[6][8][10]. The defect detection and classification approach will be performed using the following steps.

- **<u>Image Acquisition:</u>**

Image acquisition is the process of obtaining a digitized image from a real world source. A ceramic tile image is captured and stored into the computer for further processing.

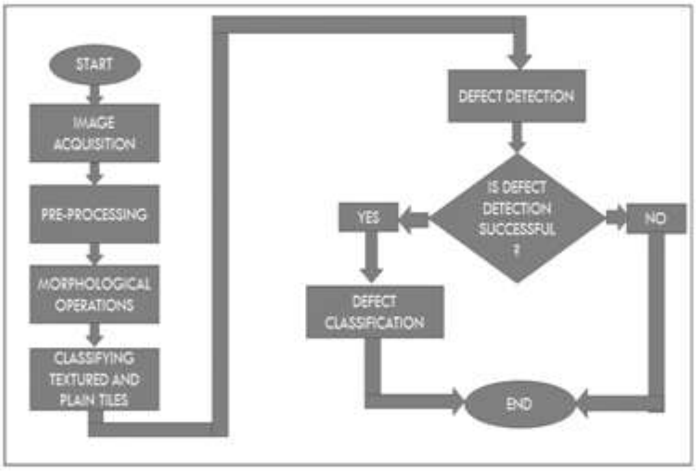

Fig 1: Flowchart of defect detection and classification method

- **<u>Preprocessing :</u>**

It is necessary to employ some image preprocessing operations on the input image before applying the proposed defect detection process. In our method, we apply some preprocessing steps such as image enhancement, noise reduction etc.

1. Convert RGB to Gray

Preprocessing steps includes converting the captured RGB image into gray-scale and then binary for performing any binary operations onto it.

2. Contrast enhancement

Many times the images taken are very dark due to poor illumination, lack of dynamic range of the imaging sensor or due to wrong setting of the lens. Using contrast stretching, the contrast of the pixels of the image is enhanced to obtain an image with an enhanced contrast which represents an appropriate and reliable image for feature extraction. Contrast stretching increase the dynamic range of the intensity level in the processed image. The poor contrast images don't provide good results because it becomes difficult to identify the difference in the intensities of defects and background surface of tile. After contrast enhancement the images of tile become ready for the further processing steps of the processing approach.

3. Noise removal

Noise it the disturbance created in the image, it may be due to low contrast, movement of the camera on the object and wrong setting of camera lens etc. The noise increases the some unwanted pixels in the image. This leads to false detection of region-of-interest in the image. Image filtering operations are performed on the images to suppress the noise in the images.

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4. Edge detection

Edge detection is the most common approach for detection of meaningful discontinuities in intensity values occurring in the image. There are many ways to perform edge detection. However, the most edge detection techniques can be classified into two groups, Laplacian and gradient. The Laplacian technique uses a second order derivative of the image to search zero-crossing in the image for edge detection. On the other hand the gradient method detects the edges by looking the maximum and minimum in the first order derivative in the image[13].

Edge detection techniques have four common steps:

<u>Smoothing</u> : Suppressing the noise to the maximum extent without disturbing the true edges.

<u>Enhancement:</u> Applying a filtering operation to enhance the edge quality in the image.

<u>Detection</u> : Identifying which pixels should be retained as edge pixels and which should be discarded.

<u>Localization</u> : Identifying the exact location of an edge in the image. This step requires edge thinning and linking operations.

5. Segmentation

Thresholding is an intensity-based segmentation technique in which a threshold value is selected and the object of interest is extracted from a background. A threshold value is selected to differentiate the pixels into two groups, one having an intensity level lower than threshold value and another group have pixels those have higher intensity value than the threshold. If a single threshold value is applied to an image, it is known as global thresholding and if a threshold value depends on the neighboring pixels and varies accordingly, it is known as local thresholding. The expression defines a thresholding operation.

$$g(u,v) = \begin{cases} 0, & I(u,v) < t \\ 1, & I(u,v) \geq t \end{cases}$$

- **<u>Morphological operations:</u>**

Morphological operations are very useful to remove the unwanted pixels from the image. Morphological operations take a binary image and a structuring element as input and perform the set operation such as intersection, union, complement and inclusion to produce the output results.

Four basic operations in morphological techniques are: erosion, dilation, opening and closing.

1) Erosion:

Erosion of the input image A with B forming elements defined as:

A ⊖ B= { x : B + x _ A}

The sequence to perform the erosion of A by B is to translate B with x contained in A. The set of all point x corresponding to such a condition is written as

A ⊖ B.

Erosion of an image can also be found at the intersection of all the translation of the input image with the reflection element formation:

A ⊖ B = ∩ {A + b: b _ B}

2) Dilation:

A dilation of the input image with the formation of B elements is defined as:

A _ B = _ {B + a: a _ A}

The sequence to perform dilation of A by B is to translate B to all the points contained in A. The union of all of this translation is written as A_B.

3) Opening:

Opening of the input image A to B forming elements defined as:

A º B = (A ⊖ B) _ B

Definition is equivalent to opening:

A º B =_{B + x : B + x _ A} (5)

The order for the opening of A by B is first to translate B to all the points x contained in A. The union of all translations is written as A º B.

4) Closing:

Closing of the input image A to B forming elements defined as:

A · B = (A _ B) ⊖ B

VI. DEFECTS DETECTION ALGORITHM

There are commonly eight types of defects found on the ceramic tile surface. Out of these types of defects blobs and cracks are commonly found on ceramic tile surface. Detection algorithm of these two defects is explained below.

<u>Blob Defect Detection Algorithm:</u>

Step1: The algorithm of defect detection starts with acquisition of images. A 3 mega-pixel web camera (Logitech C-920) is used for capturing the images of tiles.

Step2: Due to poor illumination the images of the tiles may have low contrast. So, contrast enhancement is performed using Adaptive histogram equalization. Adaptive histogram equalization is a most common technique used for contrast enhancement in many applications based on image processing.

Step3: The image of tiles may have noise. Image filtering is the operation performed for noise removal in the image. In our method we use median filter to reduce the effect of noise in the images. The median filter is an effective technique that can suppress isolated noise without blurring the sharp edges. The median filter replaces a pixel by the median of all pixels in the neighborhood.

$$y(m,n) = median\,\{\,x(i,j), \quad (i,j) \in w\}$$

Where '*w*' represents a neighborhood centered on location (m, n) in the image.

Step4: Segmentation operation is performed to extract the region-of-interest from the background image Global thresholding is used for segmentation. Blobs are segmented using threshold value = 12. [3]

Step5: A class of special type of detector is designed called as "SimpleBlobDetector". Parameters of this class are area, circularity, convexity. When conditions of parameters are true, blob is detected.

<u>Crack Defect Detection Algorithm:</u>

Preprocessing steps i.e step1 to step3 are same as blob detection algorithm.

Step4: To identify the object in the image, the boundaries of the objects are required to be extracted using edge detection operations. There are many edge detection operators are available for edge detection, our algorithm uses canny edge detector, because the further processing of the tiles image gives the best results with the canny edge detection operator.

Step5: Morphological operation closing is applied to the results of the edge detection. Closing tends to smooth the contour of an object. Closing generally fuses narrow breaks, eliminates small holes and fills gaps in contour. The closing of set *A* by structuring element *B* is given as,

$$A ¥ B = (A \oplus B) \ominus B$$

Step6: The result of closing is given to a Houghline transform. As crack is nothing but a line, houghline transform is used as a final step to detect the crack in tile image.

VII.RESULTS

Algorithms explained above successfully detect blobs and cracks on ceramic tiles. This section represents the experimental results of the blobs and crack detection. The method is implemented only for plain ceramic tiles

As per the sequence of operations explained above Following Fig. (a) shows the result of Image acquisition step.

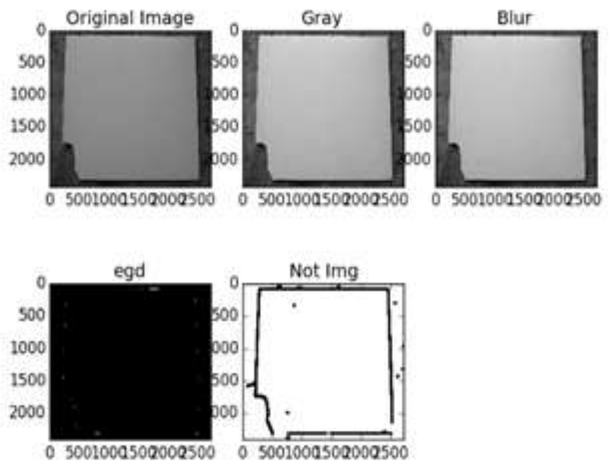
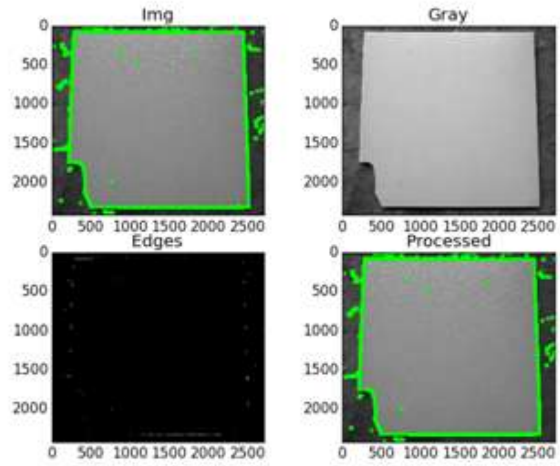


Fig. (a) Image Acquisition

As discussed above Blob Defect Detection is one of the type of finding out defection from ceramic tiles. It will help in removing out unneeded pixels from the image. Below Fig. (b) Shows the result of Edge Detection Algorithm.



Fig(b) Edge Detection Algorithm

The below Figure (c) shows the results of crack detection algorithm. And Figure (d) shows the results how the pinhole detection is done.

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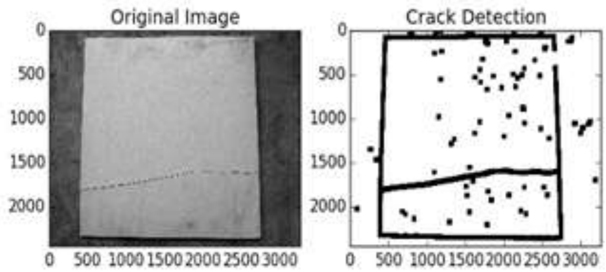

Fig. (c) Crack detection

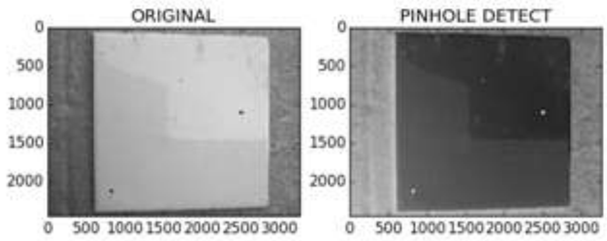

Fig. (d) PINHOLE Detection

CONCLUSION

This paper concerns with the problem of detection of the surface defects included on the ceramic tiles using the image processing and Morphology operations. By using this technique we can develop the sorting system in the ceramic tiles industry by the automated system depending on the computer vision.

In this paper a defect detection method for ceramic tiles is proposed. The proposed method is tested for images with resolution 1920×1080 pixels. The method has tested only for defects such as blobs and cracks. We haven't tested the other types of defects. In this case, future work we try to detect more defects on tiles. In future work we try to detect defects on both plain as well as random textured tiles.

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