



Blobs and Cracks Detection on Plain Ceramic Tile Surface

Yadraj Meena , Dr. Ajay Mittal

Department of Computer Science and Engineering
PEC University of Technology, Chandigarh, India

Abstract: Defects detection on ceramic tiles is a major issue in the ceramic tile industry to maintain the Quality of tiles. On the other hand maintaining the production rate with respect to time is also a major in the ceramic tile industry. Considering these criteria an efficient surface defects detection technique has proposed in this paper that can ensure better quality of tiles in the production process as well as production rate is also improved. Our proposed method plays an important role to maintain the quality standards in the ceramic tile industry. This proposed method detects the surface defects such as blobs and cracks on ceramic tiles in a very short period of time with high accuracy.

Keywords: Thresholding, Morphological operations, Image filtering, Adaptive histogram equalization, Ceramic tile.

I. INTRODUCTION

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. On the other hand the production process runs continuously in the factories, but inspection system doesn't match with the rate of production. 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 blobs and cracks are common defects that we easily found on the ceramic tile surface. Considering all the problems related to tile inspection, an efficient method is developed for ceramic tile inspection, which can detect blobs and cracks very efficiently on the surface of ceramic tiles. The proposed method is based on image processing and morphological operations. The objective of the research paper is to propose an efficient defect detection technique which can find out surface defects on images of tiles with high accuracy and within a very short time. The proposed paper is organized as, section 2 represents literature review. In section 3 gives a brief overview of techniques used in proposed method. Section 4 provides the explanation of the proposed approach. In section 5 and section 6 experimental results and conclusion is mentioned.

II. Related Work

Throughout the last decade many kinds of defect detection systems have been developed. These systems have developed to identify the various kinds of defects on ceramic tiles and applied to industrial process.

D.O. Aborisade [3] has suggested a method for automatic surface inspection of plain ceramic wall tile, which is based on computer vision. The algorithm starts with an application of edge enhancement operation to input image in order to highlight the edges of the objects in the images of tiles. Image edge enhancement and detection algorithms are applied using a spatial convolution process. A 3X3 mask is used to measure the gradient and the direction of the gradient in the image. The gradient at a specific location is threshold to obtain the edge map of the defect. After segmentation of cracks from the image some discriminant functions were developed. To identify the tiles into either a defect class or a reject class based on the feature extracted at the real time. In H. Elbehiery, A. Hefnawy, and M. Elbehiery have proposed an algorithm for surface defect detection on ceramic tiles which is based on Image processing and morphological techniques [4]. First part of the algorithm starts with image acquisition, and then histogram equalization is performed on the images. The intensity adjustable histogram equalized images are the input to the second part of the algorithm. The second part of the main algorithm includes many of the individual complementary algorithms differ due to the various kinds of defects. For cracks and long crack detection the input images are converted to black/white images. An edge detection operation is performed to detect the defect pixels. Some morphological operations have been done to discriminate the defect pixels more accurately followed by noise reduction and smoothing object processing to get clear image containing the only defect. Pinholes are detected using grayscale morphological operations followed by noise reduction processing to get a clear image for the defects. Similar approach is used for blob detection. Their algorithm requires much computational time because for each type of defect the

algorithm differs in the second part. If the single tile has different types of defects on the surface, then it has to repeatedly pass through different inspection algorithms for identifying the types of defects.

Suzana Vasilic and Zeljko Hocenski [5] have proposed an edge detection method for ceramic tiles defect detection. The method used Canny edge detector for edge detection and Gaussian filter is used for noise removal. The gradient of 2D function is calculated to the direction in which the function is changing most rapidly. To determine if a given point in the gradient magnitude image is maximum. Authors checked the surrounding points in the direction of the gradient. The connected set of edge points is found and formed into the lists. On these edges thresholding hysteresis is performed to eliminate insignificant edges. Two threshold values are used to define the edge and edge points. The higher threshold is usually 3 times the lower threshold. Any pixel in an edge list that has a gradient greater than the higher threshold value is classified as a valid edge point. Any pixel connected to these valid edge points that have gradient above the lower threshold value are also classified as edge points.

III. IMAGE PROCESSING TECHNIQUES

A. Image Acquisition

The images of tiles are acquired using a digital camera. A distance of 1.5 meters is maintained between the tile surface and the camera lens to ignore the texture of the tiles in the images captured by camera. For experimental purposes, a 12 mega-pixel digital camera is used to capture the images of tiles.

B. 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 proposed method used Adaptive histogram equalization technique for contrast enhancement of the images. Adaptive histogram equalization divides the image into multiple local regions, and then histogram equalization is performed in each local region. It is the most common technique for contrast enhancement in the images. 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

C. Noise Removal

Noise is 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.

In our proposed method we use median filter and wiener 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. Edge Detection Specifically, the median filter replaces a pixel by the median of all pixels in the neighbourhood:

$$y[m, n] = \text{median}\{x[i, j], (i, j) \in w\} \quad (1)$$

Where w represents a neighbourhood centred around location (m, n) in the image.

D. 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.

Edge detection techniques have four common steps

1. Smoothing: suppressing the noise to the maximum extent without disturbing the true edges.
2. Enhancement: applying a filtering operation to enhance the edge quality in the image.
3. Detection: identifying which pixels should be retained as edge pixels and which should be discarded.
4. Localization: Identifying the exact location of an edge in the image. This step requires edge thinning and linking operations.

In the proposed method Sobel edge detector is used for edge detection. The Sobel edge detector is a gradient based method and it uses a pair of 3x3 convolution mask. One of which is a horizontal convolution mask and the other is a vertical convolution mask. The vertical convolution mask eliminates the gradient in y-direction and horizontal convolution mask eliminates the gradient in the x-direction.

-1	0	1
-2	0	2
-1	0	1

Horizontal

-1	-2	-1
0	0	0
-1	-2	-1

Vertical

Fig 1: Horizontal and vertical masks of Sobel operator

E. 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.

$$g[u v] = \begin{cases} 0, & I[u v] < t \\ 1, & I[u v] \geq t \end{cases} \quad \forall (u v) \in I \quad (2)$$

F. Morphological operations

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.

IV. DEFECTS DETECTION ALGORITHMS

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. The proposed method is limited to identifying these two common types of defects on the ceramic tile surface.

Proposed defect detection process

Step1: The proposed method starts with image acquisition. A 12 mega-pixel digital camera is used for capturing the images of tiles. The camera is kept at a distance of 1 meter from the tile surface to ignore the texture details of the tile surface.

Step 2: 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.

Step 3: The image of tiles may have noise. Noise may occur due to movement of the camera or tile, due to use of poor quality camera or due to unfavorable light conditions. The noisy images don't give the intended results. So, the images require some noise removal operations. Image filtering is the operation performed for noise removal in the image. In the proposed approach Median filtering and Wiener filtering is used to perform the noise removal step.

Step 4: 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, but for the proposed approach the Sobel operator is selected, because the further processing of the tiles image gives the best results with the Sobel edge detection operator.

Step 5: Segmentation operation is performed to extract the region-of-interest from the background image Global thresholding is used for segmentation. Different threshold values are used for segmentation of blobs and cracks from the images of the tiles. Cracks are segmented using threshold value = 55 and blobs are segmented with threshold value=12.

Step 6: The results of the segmentation operation give some unwanted detected cluster of pixels in the results of the segmentation operations. So, morphological operation opening is applied to the results of the segmentation. Using erosion the unwanted objects are removed from the image using an appropriate structuring element. The objects of interest would also lose their structure that usually regains by applying dilation on eroded image. To extract the defects from the image, first the small spots and structure look like noise are removed from the image then dilation is applied to the image to thicken eroded boundaries of the defects and to obtain the clearest view of defects in the image of the ceramic tile surface.

Step 7: The results of opening are reconstructed to gain the original shape of defects. The image reconstruction is followed by object filling operation to enhance the visibility of the defects.

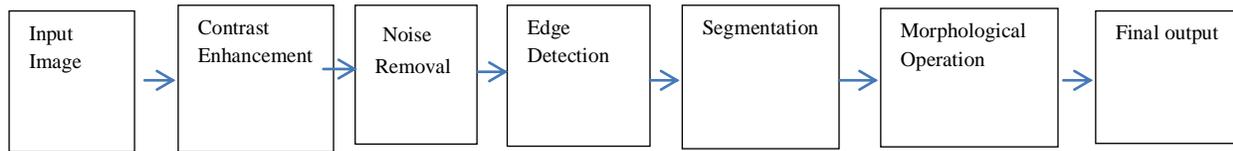


Fig. 2: Block Diagram of proposed method

V. EXPERIMENTAL RESULTS

The proposed method successfully detects blobs and cracks on ceramic tiles. This section represents the experimental results of the proposed method for blobs and crack detection. The proposed method is implemented only for plain ceramic tiles. To get a particular realization of the proposed defect detection method, the proposed method is applied to a number of flat ceramic tile images. After that, it is checked whether there is any kind of defect exists in the original image or not by applying the proposed processing operation on the test image.

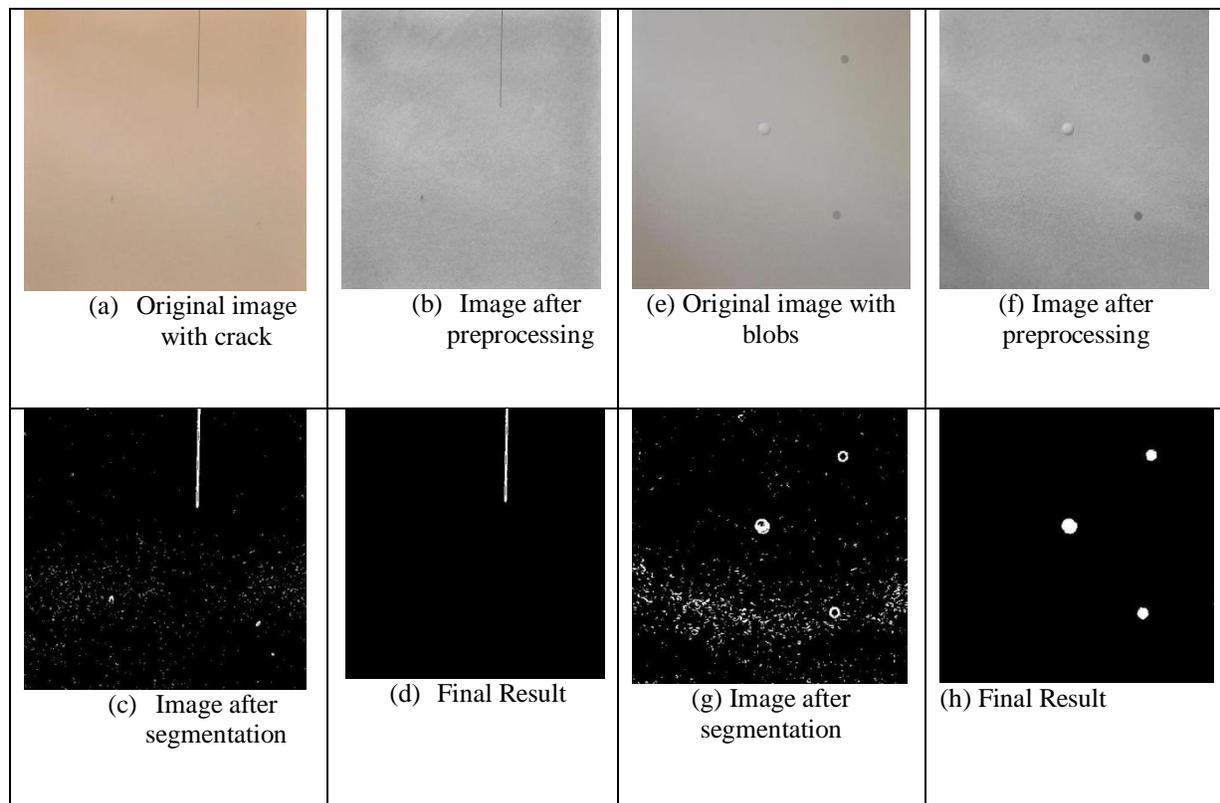


Fig. 3: (a) Original image with crack, (b) Image after contrast enhancement and noise reduction, (c) Image after segmentation operation, (d) Final result shows the crack on the tile, (e) Original image with blobs on tile surface, (f) image after preprocessing, (g) image after segmentation operation, (h) Final result shows the blobs detected on the tile.

The results of the proposed approach are good and satisfactory for above blobs and cracks present on ceramic tiles. The graph in Figure 4 shows the Efficiency comparison of existing methods for defect detection on ceramic tiles [2] and the proposed method. It can be clearly seen that the proposed method is much more efficient than an existing one. The average efficiency of the proposed approach for defect detection is nearly 96%. The evaluation is done on a different set of tiles.

In Figure 4, the horizontal axis in the graph represents the number of tiles taken at a time and vertical axis represents the defect detection rate.

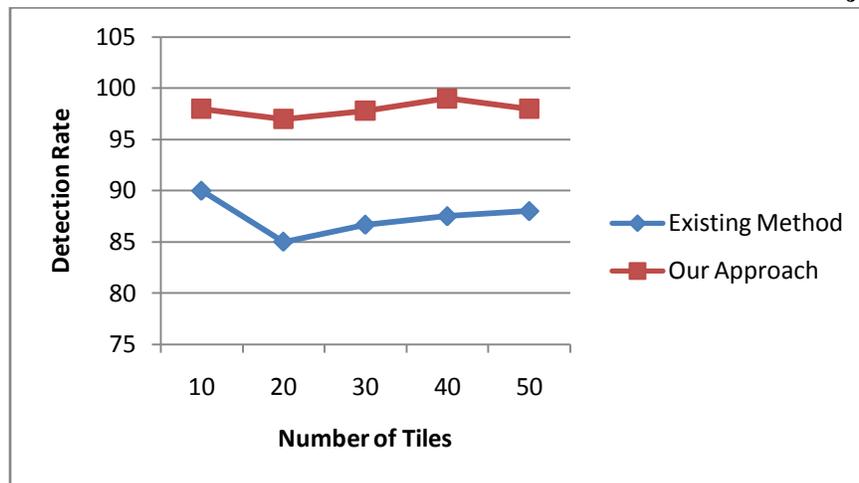


Fig. 4: Defect detection rate comparison of existing and proposed method

Figure 4 shows the comparison of the time efficiency. Small batches of tiles are taken and a loop is generated to calculate the time required of the proposed approach and the existing one [2]. Then a comparison is done on the basis of results which are shown in the graph. The graph shows that the proposed method is more time efficient as compared to existing methods. The proposed approach takes less time for defect detection as compare to the existing method. It takes less than half second to process a tile image for defect detection. Before applying the proposed approach the size of the images of tiles is reduced to a range of 600x600 to 800x800. This reduces the processing time requirement of the system. Then the comparison is done between the existing method and the proposed method

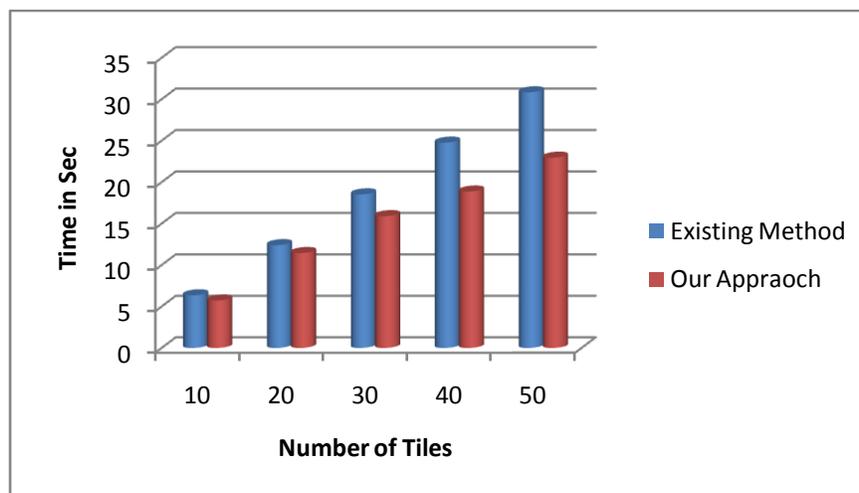


Fig. 5: Time efficiency comparison of existing and proposed method.

The proposed algorithm is tested on 200 images of plain tiles, which include both defective and fresh tiles. On the basis of the results of the test the sensitivity and specificity of the proposed method are calculated. These parameters show that the proposed method is highly efficient in detecting the defects on the ceramic tile surface.

Sensitivity

Sensitivity (SE) is defined as the true positive rate. True positive are the findings the tiles defects which are actually defects. True positive rate is the ratio of actual defects findings of the total defects on ceramic tiles.

$$SE = TP_{rate} = \frac{TP}{TP + FN} \quad (3)$$

Total 200 tiles were tested to calculate the sensitivity. The sensitivity measured for proposed method is nearly 0.96.

Specificity

Specificity (SP) is defined as true negative rate, expresses the probability of classifying the tiles having no defects as fresh tiles.

$$SP = TN_{rate} = \frac{TN}{TN + FP} \quad (4)$$

Total 50 fresh tiles were tested to calculate the specificity. The specificity measured for proposed method is 0.08.

VI. CONCLUSION AND FUTURE WORK

In this paper a defect detection method for ceramic tiles is proposed and the method is compared with existing method [2]. The defect detection rate of the proposed method is better and needs less time as compared to the existing method [2]. The comparison of the proposed method with existing method for detection of defects such as blobs and cracks is shown in figure 4 and figure 5. The proposed method takes less than half second for processing the image and detecting the defects on ceramic tiles. The proposed method is tested for images with resolution 600x600 to 800x800 pixels. The proposed method has tested only for defects such as blobs and cracks. We haven't proposed the categorization of defects. In this case, future work we try to detect more defects on tiles and try to categorize them. In future work we try to detect defects on both plain as well as random textured tiles.

References

- [1]. R.C. Gonzalez, R. E. Woods, "Digital Image Processing", Pearson Education (Singapore), Pte. Ltd., Indian Branch, 482 F.I.E, Partapgang, 2005 2006
- [2]. Md. Maidul Islam, Md. Rowshan Sahrir, Md. Belal Hossian, "An enhanced automatic surface structural flow inspection and categorization using image processing both for flat and textured ceramic tiles" Internation Journal of computer Application(0975-888), Vloume 48-No.3,June 2012
- [3]. D.O. Aborisade "Computer vision system for automatic surface inspection of plain ceramic wall tile" Journal of Engineering and applied sciences 3(11) : 865-871, 2008
- [4]. H. Elbehery, A. Hefnawy, and M. Elewa, " Surface defects detection for ceramic tiles using image processing and morphological techniques" Proceeding of World Academy of Science, Engineering and Technology, vol 5, pp 158-160, April 2055, ISSN 1307-6884
- [5]. Suzana Vasilic, Zeljko Hocenski "The edge detection method in ceramic tiles defects detection", IEEE !SIE 2006, Montreal, Quebec, Canada, , July 9-12, 2006