

## **Intelligent Surface Quality Assessment of Ceramic Tiles with Irregular Textures**

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**Abstract:** In ceramic tiles manufacturing industry, tiles are manufactured at large scale which makes it more challenging to ensure the quality of each tile according to the set standards. Mostly, Statistical Process Control (SPC) is used by tile manufacturers at each step to monitor various processing parameters. SPC procedures are implemented manually that requires sufficient number of experienced human resource to identify defected tiles from a batch of tiles. To solve the problem of false defect detection owing to the interference of the texture attribute of ceramic tiles, a method for detecting surface defects in complex-textured ceramic tiles is proposed. Based on the visual detection principle of ceramic tile surfaces, an image acquisition system is established to obtain the ceramic tile image. After image segmentation and correction, the surface defects are preliminarily detected using a saliency detection method. Then, the image sub-block containing the defect area is cut out for secondary detection. The false defects are eliminated, and the final detection of the ceramic tile surface defects is completed using the defect determination method. The feasibility and effectiveness of the defect detection method are studied via comparative experiments. Experimental results show that the maximum accuracy rate of the proposed defect detection method which satisfies the actual detection requirements and confirms the practical significance of the proposed method.

**Keywords:** Tiles, Ceramics, Surface morphology, Image segmentation, Image edge detection, Image colour analysis, Surface treatment.

### **1. Introduction**

Previously, in ceramic tiles manufacturing industry, Statical Process Control (SPC) was a widely used method to monitor the build quality of tiles. The SPC is a manual procedure, and its successful implementation depends on the knowledge

and training of the person deployed for quality control. The manual procedure for quality check is somewhat slow and results could be different regarding same object because of experience, level of concentration, and tiredness of the person. For last couple of

decades, the field of digital image processing and computer vision has turned into exceedingly onerous unit of information Technology in automating industrial processes [16]. Digital images are processed by means of digital computer to extract important information, also called features, from images using simple to complex mathematical procedure. Defect identification of tiles through digital images is widely used application of digital image processing to enforce computerized quality control process in manufacturing industry. For defect identification in tiles images, researchers have proposed many different algorithms depending on the types, sizes, and textures of tiles. A gradient-based algorithm for ceramic tile defect detection involves scaling down the image, converting it to grayscale, and applying edge detection with a fixed threshold of 0.13. Morphological operations are then performed on both the test and reference images [17]. Defects are identified by comparing the white pixel counts of both images. However, this method suffers from high processing time due to pixel-by-pixel comparison, making it inefficient for large-scale or real-time applications [19].

## **2. Literature Survey**

Mohammad et al. Studied on the pattern recognition and image processing algorithms which have been used to detect surface defects. Each method appears to be limited for detecting some subgroup of defects. The detection techniques may be divided into three main groups: statistical pattern recognition, feature vector extraction and texture/image classification. A thorough survey is made in this paper on the existing algorithms in each subgroup. Also, the evaluation parameters are discussed including supervised and unsupervised parameters [18]. Using various performance parameters, different defect detection algorithms are compared and evaluated.

## **3. Existing System**

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 [20]. To reduce the fatigue of human operator at ceramic tile inspection point an alternative and fully Automatic Tile defect detection and elimination method has been proposed. 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.

### Drawbacks

- 1) If the ceramic tiles have a similar color or texture to the background, it can be challenging to detect them
- 2) Noise in the image or outliers in the histogram can adversely affect the accuracy of tile detection.

### 4. Proposed System

A new surface defect detection and classification method has been proposed by this section. Our proposed method consists of two major portions. One includes some pre-processing image operations to contrast features. And another portion includes some prominent feature extraction operations to identify defects and to classify those defects as well.

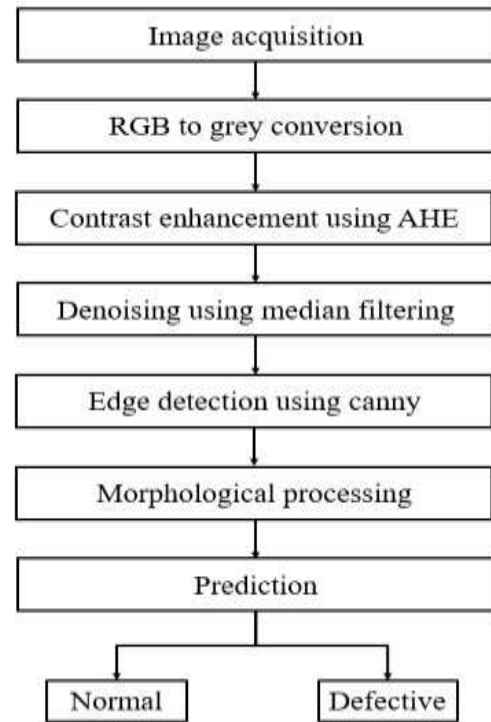


Fig.1: Block diagram of proposed system.

Our proposed model also introduces several algorithms by which we can boost up the system performance at a higher rate than existing one during production time. Thus it also can reduce the computational time all together Figure shows the proposed block diagram. Initially, image is read using Image acquisition. Then, the colour image is converted in grayscale for easier operations. Then, contrast of the images is enhanced using histogram equalization (HE), which also preserves the brightness values. The median filtering is introduced for removal of basic

noises by replacing the noisy pixels with median values. Then, canny edge detection is applied to extract the edges of ceramic tile crack with boundary analysis. Apply Canny Edge Detection: Use the Convolve image  $f(r, c)$  with a Gaussian function to get smooth image  $f^{\wedge}(r, c)$ .

$$f^{\wedge}(r, c) = f(r, c) * G(r, c, \sigma)$$

- Apply first difference gradient operator to compute edge strength then edge magnitude and direction are obtained as before.
- Apply non-maximal or critical suppression to the gradient magnitude.
- Apply threshold to the non-maximal suppression image.

**Gradient Calculation:** Compute the gradient of the smoothed image to find the strength and direction of edges. **NonMaximum Suppression:** Suppress nonmaximum pixels, which helps to thin the edges by keeping only the local maxima in the gradient magnitude. **Edge Tracking by Hysteresis:** Apply edge tracking by using two thresholds, a high threshold and a low threshold. Pixels with gradient magnitudes above the high threshold are considered strong edges, and those between the high and low thresholds are considered potential edges. Edge pixels are connected if they form a continuous path above the high threshold. a second order derivative defined as

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

It has two effects, it will smooth the image and it computes the Laplacian, which yields a double edge image.

Locating edges then consists of finding the zero crossings between the double edges. The digital implementation of the Laplacian function is usually made through the mask below,

0	-1	0
-1	4	-1
0	-1	0

$$G_x$$

-1	-1	-1
-1	8	-1
-1	-1	-1

$$G_y$$

The Laplacian is generally used to found whether a pixel is on the dark or light side of an edge.

Apply high and low thresholds to determine strong and weak edges: If  $G(x, y) > \text{High\_Threshold}$ , it's a strong edge pixel.

If  $\text{Low\_Threshold} < G(x, y) < \text{High\_Threshold}$ , it's a weak edge pixel.

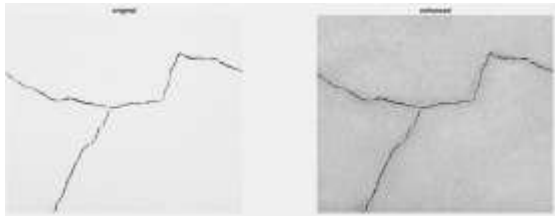
If  $G(x, y) < \text{Low\_Threshold}$ , it's not considered an edge pixel.

Finally, morphological processing is applied to extract the region-based extractions, which enhances the perfect crack regions. Finally, prediction operation is performed by

comparing the test values with existed values.

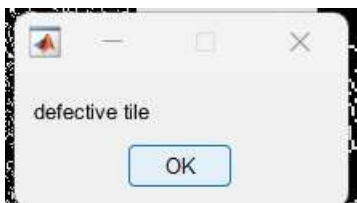
## 5. Results and Discussions

In this work, in order to detect and identify the defects such as Crack, different types ceramic tile images were considered. Figure1 represents the input tile image and to improve image quality by used edge detection.

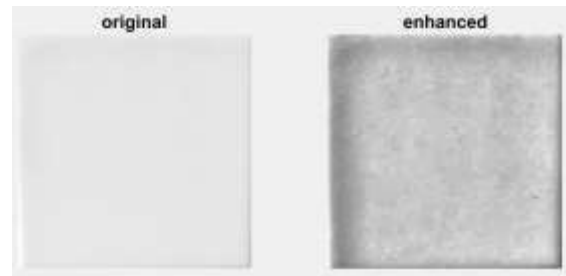


**Fig.2:** Ceramic tile input

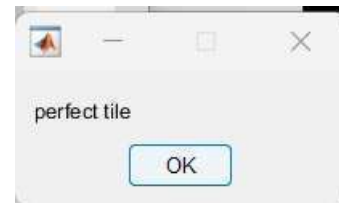
After that we check whether there is any kind of defect exists in this test image or not by applying our proposed preprocessing operations on this sample RGB image (i.e. image enhancement, noise reduction and edge detection). This is shown in the following Figure 3ss is defective tile based on defect area



**Fig.3:** Defective tile.



**Fig.4:** Perfect tile input. After that we check whether there is any kind of defect exists in this test image or not by applying our proposed preprocessing operations on this sample RGB image (i.e. image enhancement, noise reduction and edge detection). This is shown in the following Figure 5 is perfect tile based on defect area



**Fig.5:** Predicted as perfect tile.

## 6. Conclusion & Future Scope

Picture acquisition is used to read the image at first. The colour picture is then turned to gray scale for simpler manipulation. The contrast of the photos is then increased using adaptive histogram equalization (AHE), but the brightness values are preserved. The median filtering technique is used to remove fundamental noises by replacing noisy pixels with

median values. Then, using boundary analysis, canny edge detection is used to recover the boundaries of the ceramic tile fracture. Finally, morphological processing is used to extract region-based extractions, improving the optimal crack areas. Finally, the prediction process is carried out by comparing the test results to previously known values.

**Future Scope:** Future research can focus on integrating patch-based methods with deep learning models to improve accuracy and automate the detection process. Additionally, optimizing patch selection and feature extraction can reduce computational load, making real-time, high-resolution inspection feasible for industrial applications.

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