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Research Article

CERAMIC TILE'S SURFACE QUALITY ESTIMATION USING IMAGE PROCESSING TECHNIQUES

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ABSTRACT

Surface defects classification and identification is very common task in all surface finish based product industries. Surface finish products industries includes primarily tiles, ceramic, plywood, metal products, pottery industries etc. In the proposed work, the surface inspection task has been focused on tile’s surface quality. Tile’s surface normally suffers from cracks, holes, spots and corner defects. In order to bring the defects at identifiable level, the surface image is processed to some threshold level so that the image could be binarized in order to get the surface defects visible for image processing techniques based measurements. One of the important tasks in tile’s surface defects identification is to segment the real defects from the tile’s design pattern.

Keywords: *Eqalization, Thresholding, Cracks, Spots, Holes*

INTRODUCTION

The use of machine vision system in tile’s surface industries is limited till date at least in Indian scenario. This may be accounted for high cost of initial cost and skilled operator for use of the machine vision system. The manual system of tile’s inspection system has inherent problem of repeatability and reproducibility of results due to human involvement at different stages of inspection. Repeatability is affected due to human fatigueless after a prolonged time of operation; however, reproducibility suffers due to different human operator on duty for the same task.

For, low load inspection task in terms of time and quantity, the human inspection system can be the best. But in longer run an auto system is required for continuous operation and uniform quality of production.

However, in the proposed system, an automated machine vision system is proposed. It consists of a conveyor belt over which the tiles come across the CCD camera (fixed at one position), the image is acquired once the tile is at the desired position (Shire 2011).

The acquired image is then brought under some image processing operations like thresholding, enhancement, noise removal and defects identification algorithm. The result is displayed on computer screen in minimum possible time. A microcontroller based system may be incorporated that can be controlled to segregate the pass and rejected tiles in different bins.

Related Works

From the observed literature, it has been found that most of the surface quality related estimation is performed using the color profile of the surface images. By analyzing the color profile in terms of dark or light gray shades, the presence of foreign particle or extra material is analyzed (Song 1995).

Some work has been done in frequency domain using wavelet approach. However, the wavelet approach decomposes the images into four frequency sub-bands and then analyzes one of the most informative sub-band. Normally the low frequency sub-band has the maximum information or entropy and color frequency patterns can be analyzed for surface defects (Coe, 2000; Coulthard, 2001; Liu, 2001).

It is also observed from the study that the defects does not occur in a particular orientation but may occur at different angle. Therefore, the same defect will appear differently if rotated at some angle. Hence the surface images are required to be rotation invariant so that any defect or object lying on the surface at any angle should be treated same as that of the original axis (Lehr, 1996; Wen, 1997).

MATERIALS AND METHODS

Tile's Surface Defects

Cracks, spots, holes and corner defects are commonly found defects on any kind of surface. However, hair line cracks, corner defects and spots are the important defects when adjudging the tile's surface quality. A crack may be identified by its high value of figure aspect ratio i.e. length to width ratio. The ration may be very high in case of hair line cracks.

Holes are in the form of circular identities and can be identified by low degree of standard deviation or evenness of radii around the centre of mass.

Spots are in the form of asymmetric shape around the centre of mass and can be identified by high degree of standard deviation of radii taken from the centre of mass (Singh 2012).

Surface Defects Identification

The proposed scheme of operation is divided into following steps:

- Tile's Surface Image Acquisition
- Image Enhancement and Thresholding
- Noise Removal
- Centre of Mass Extraction
- Radii Computation
- Area and Perimeter Computation
- Normalization of Radii, Area and Perimeter
- Standard Deviation of Radii Computation
- Defects Identification Criterion

Tile's images are acquired using the CCD camera interfaced with the PC in MATLAB environment. The images acquired are in jpeg format i.e. 24 bit color format. They are converted to gray scale format (8-bit color format), where 0 being the black and 255 is the white color and in between 0 to 255 are the shades of black and white combinations. Followings are the examples of the tile's surfaces with crack and spot type defects.

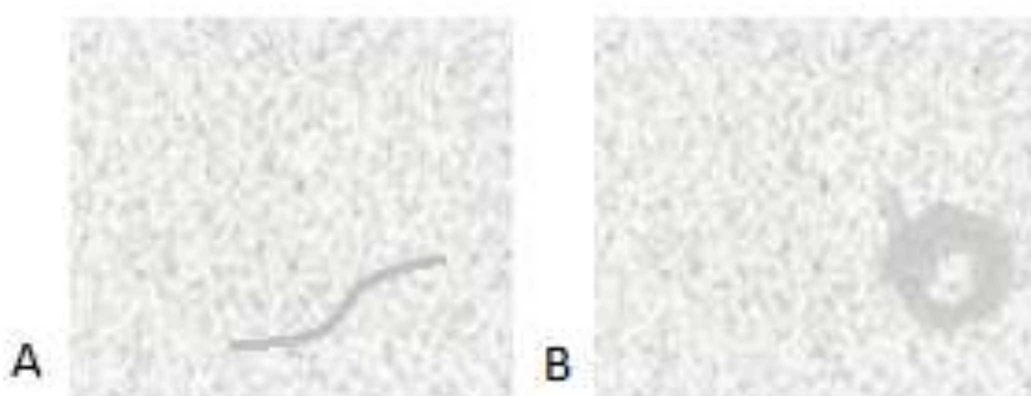

Figure 1: Tile's Surface Images. A-Crack Type Defect, B- Spot/Hole Type Defect

Image enhancement techniques are applied to enhance the gray image. Histogram equalization technique works well in case of tile's surface image enhancement.

Otsu algorithm (Karimi 2013) is applied on enhanced image for thresholding purpose. A threshold 'T' is selected based on minimum within class variance. The gray pixel below threshold T are made black and above 'T' are made white or vice versa. This results in a binary image with some noise in the form of salt and pepper type.

Salt and pepper type noise can be removed using the 3x3 kernel and inspecting the neighborhood pixels. A 3x3 kernel is shown below:

P8	P1	P2
P7	P0	P3
P6	P5	P4

Figure 2: 3 x 3 Kernel

If Pixel P_0 is black and all pixel from $P_1 \rightarrow P_9$ are white, then Pixel $P_0 \rightarrow$ Black
If Pixel P_0 is White and all pixel from $P_1 \rightarrow P_9$ are Black, then Pixel $P_0 \rightarrow$ White

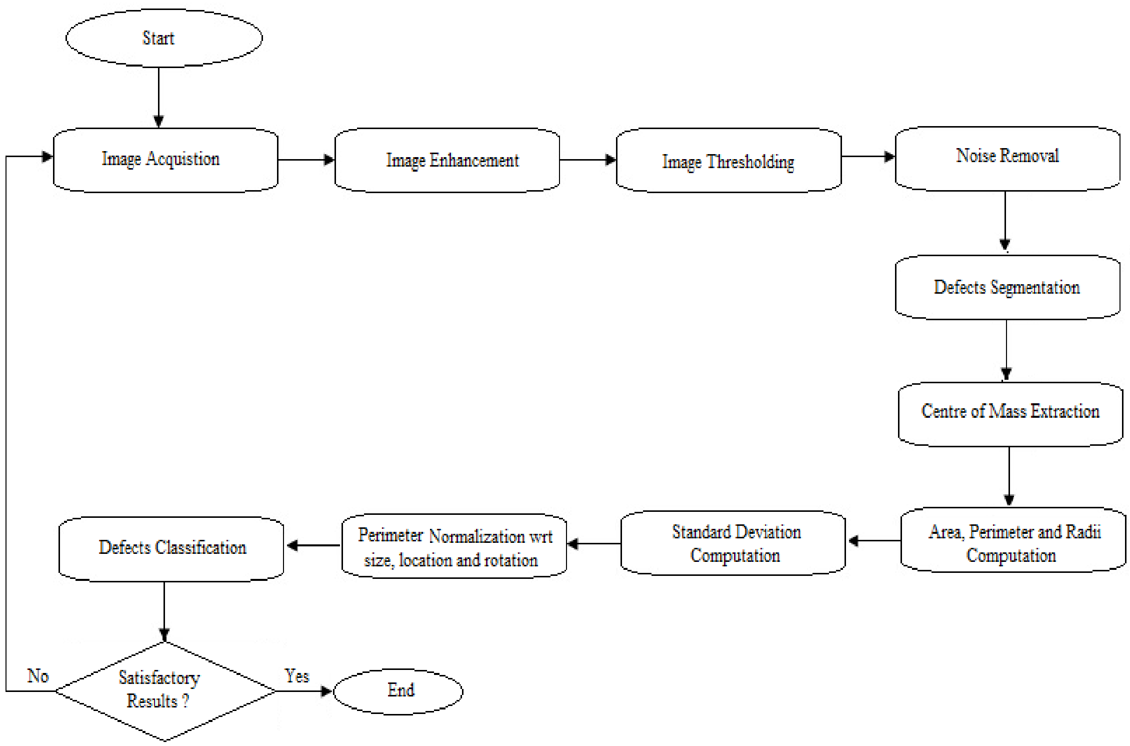

Figure 3: Flow Chart of Proposed System

Feature Extraction

All features are centre of mass oriented. Therefore, very firstly, the centre of mass is computed by using the first order moments as follows:

$G_x = (1/N) \sum X_i$

$G_y = (1/N) \sum Y_i$

where (X_i, Y_i) are the coordinates of the pixels on object (defect in the proposed case) in image and 'N' is the total no. pixels on the object (Singh 2012).

The contour of the object in the image frame is extracted using the bw boundaries command in MATLAB. This gives the boundary pixel coordinates of the object. The no. of boundary pixels gives the perimeter of the object.
The radii are computed by using the following formula:

$$R = \sqrt{\{ (X_c - G_x)^2 + Yc - G_y)^2\}}$$

where (X_c, Y_c) and (G_x, G_y) are the contour and centre of mass coordinates respectively.
After computation of all radii, maximum and minimum radii are sorted from the radii array as computed above in all four quadrants. This exercise gives the estimate of the defect shape i.e. crack, hole or spot. When the intercepts of axes i.e. +X, -X, +Y and –Y are computed, this gives the idea about the presence of crack by calculating the figure aspect given by:
Figure Aspect = $(X_1 + X_2)/(Y_1 + Y_2)$,
where X_1, X_2, Y1and Y_2 are the intercepts on +ve and –ve X and Y axes respectively.

RESULTS AND DISCUSSION

The results are obtained for regular shapes till date and the work is on for real time surface defects. Following test image was used in getting the value of parameters for various segmented parts of it. These parameters include maximum & minimum radii of segment in each quadrant with origin at centre of gravity, perimeter and area of each segment.

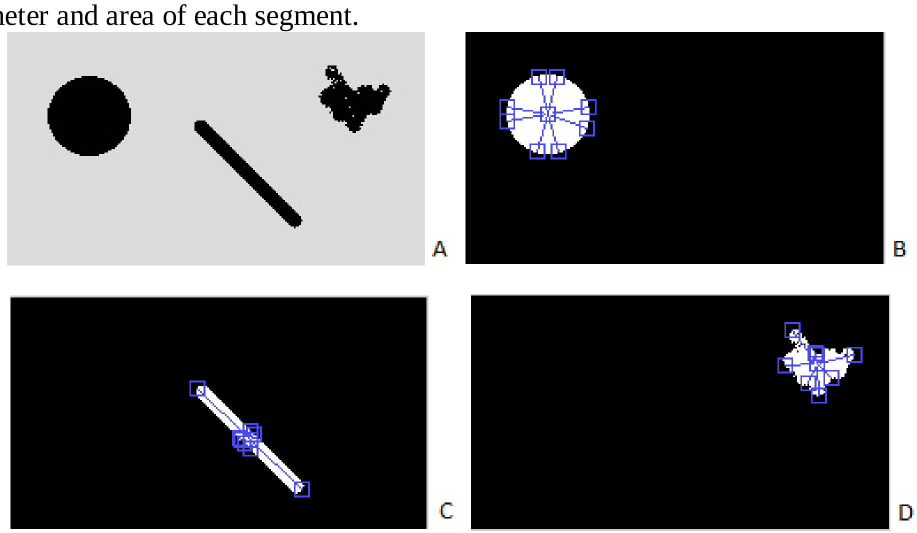

Figure 4: A) Test Image B-C-D) Segmented Images representing pinhole, crack, spot/bump respectively

Following table shows the features for holes, crack and spot type defects.

Table 1: Feature Parameters

Sr. No.	Feature	Holes	Spot	Crack
1	Max. R1	1	2	0
2	Max. R2	1	2	2
3	Max. R3	1	1	0
4	Max. R4	1	1	2
5	Min R1	1	0	0
6	Min R2	1	0	0
7	Min R3	1	1	0
8	Min R4	1	1	0
9	Area	5	4	4
10	Perimeter	8	13	10

Conclusion

It can be observed from the result section that the defects like crack, spot and holes can be very accurately identified by using the proposed algorithm. The accuracy of the results primarily depends upon the image acquisition device and illumination conditions. Further, there may be ambiguity while extracting the crack. A crack may be an open loop or closed loop entity. In the proposed case, only open loop crack is worked out. However, a closed loop crack may resemble with a hole as the parameters will be of the nature of hole like. Therefore, the concept of Euler number may be utilized to differentiate between closed loop crack and a hole. Corner defects are very well identified by the morphology study of the object in the image frame.

REFERENCES

Coe S (2000). Automatic tile inspection, Surface Inspection Limited, International Ceramics, Bristol, U.K., Issue **1**.

Coulthard M (2001). Measuring and Classifying Tile Shades, Chairman, Surface Inspection Ltd, Great Britain.

Elbehiery H, Hefnawy A and Elewa M (2005). Surface Defects Detection for Ceramic Tiles Using Image Processing and Morphological Techniques, World Academy of Science, Engineering and Technology **5**, 158-162

Karimi MH and Asemani D (2013). A Novel Histogram Thresholding Method for Surface Defect Detection. *8th Iranian Conference on Machine Vision and Image Processing (MVIP) IEEE* 95-99.

Lehr ME and Li KS (1996). Template basis techniques to Pattern recognition, University of California Riverside, Department of Statistics Riverside, California, USA, Vol. **2825**.

Liu Y and Rodrigues M (2001). A novel machine vision algorithm for a fast response quality control system, Department of Computer Science, the University of Hull, Hull, HU6 7RX, UK.

Shire AN, Khanapurkar MM and Mundewadikar RS (2011). Plain Ceramic tiles surface defect detection using Image Processing, *Fourth International Conference on Emerging Trends in Engineering & Technology- IEEE,* 215-220.

Singh S and Kaur M (2012). Machine Vision System for Automated Visual Inspection of Tile's Surface Quality. *IOSR Journal of Engineering* **2**(3) 429-432.

Song KY, Petrou M, and Kittler (1995). Texture crack detection Machine Vision Applications

Wen W and Xia A (1997). Verifying Edges for visual Inspection Purposes, School of Mechanical and Manufacturing Engineering, School of Mathematics, The University of New South Wales, NSW **2052**, Australia.