Ceramic Tile Border Defect Detection Algorithms in Automated Visual Inspection System

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Abstract: Automated Visual Inspection Systems (AVIS) are becoming increasingly popular due to low cost maintenance and high accuracy. Ceramic tile factories, for example, are very much interested in these sorts of systems. This paper introduces a different strategy in ceramic tile inspection system to reveal four major problems, namely, edge curvature, thickness, size measuring and edge crack defects. It is believed that this method will cover edge curvature defects and thickness measuring of ceramic tiles in AVIS with recommending an individual algorithm for each defect based on line feature extraction techniques. In addition, it is assumed that our model makes size measuring and edge defects detection easier and more accurate rather than previous approaches. This proposed model will allow ceramic tile companies to perform quality control inspection without costly measuring tools or error-prone inspection by humans. Moreover, factories have to install and apply Flatness Control Machine (FCM) to measure the flatness curvature of ceramic tiles. This machine keeps the ceramic tiles in fixed position to investigate the upper surface only. But our strategy is independent of a specific position through inspection in various angles from top and side views. We hope that our model, which is prominent in low cost implementation, will enable companies to apply this method in different situations in their manufacturing production line systems. Hence, it will assist them to produce not only more accurate reports on defects but also permit improved manufacturing of quality products.
[Ehsan Golkar, Ahmed Patel, Leila Yazdi, Anton Satria Prabuwono. **Ceramic Tile Border Defect Detection Algorithms in Automated Visual Inspection System.** Journal of American Science 2011;7(6):542-550]. (ISSN: 1545-1003). http://www.americanscience.org.

Keywords: Edge curvature; thickness measuring; edge defect; visual inspection; machine vision; ceramic tile

1. Introduction

Automated visual inspection in ceramic tile manufacturing and production systems have been pursued and studied during the last two decades. For example, automated system for surface inspection of tiles by Costas & Ferancesco; colour grading of textured ceramic using colour histogram by Contantinos & Josef Kittler; dynamic photometric stereo of tiles by Farooq & Smith; and automated defect detection and classification of tiles by Rahman & Mobarak (Atiqur Rahaman & Mobarak Hossain, 2009; C Boukouvalas et al., 1998; C. Boukouvalas, Kittler, Marik, & Petrou, 1999; Farooq, Smith, Smith, & Midha, 2005). Elbehiery *et al.* also stated that all parts of a producing line except those of quality control are automated (Elbehiery, Hefnawy, & Elewa, 2005).

The quality control stage which is monitored by human resources (i.e. sorting) is located in the final step. Therefore, the automated system is vital to collect the feedback of their products. With the result obtained from the quality control part, companies can understand which producing part works correctly and which previous part does not work expectedly. Finding accurate inspection in tile manufacturing within acceptable time and cost is of significant concern to businesses, and developers and researches that have to design such systems (Yamaguchi, Nakamura, & Hashimoto, 2008).

Common defects can be divided in four groups; they are those that are related to dimension of products, surface faults, incorrect assembling and operational defects (Malamas, Petrakis, Zervakis, Petit, & Legat, 2003). The main concerns in this paper are about surface defect detection and dimensional techniques in ceramic tiles. This detection can be checked in three stages; steps prior to kilning, colouring and packing. Defected tiles that are being recognized before kilning and colouring will be rejected or will be preceded to the production chain but the continuous production cycle can be marked as a low level sorting function. Pinholes, cracks, scratches, blobs, edge defects, texture faults, spots and glaze are most common surface defects in ceramic tiles (Atiqur Rahaman & Mobarak Hossain, 2009). However, in dimension inspection, part of the goal is finding size defect, parallel edge defect, edge curvature deviation and thickness faults.

Fundamental requirement of Automated Vision Inspection Systems in Ceramic tile (AVISC) which is shown in Fig 1 consists of illumination part, camera vision, and classification part. The camera on top of the conveyer captures the image of the tiles: while the controlling and classifying part is done by a sorting machine.

The important function in AVISC which directly influences decision making is image acquisition. Light resources, camera position, resolution of acquired image and environment properties are considered in this part (Smith & Stamp, 2000). Light resources would be fluorescent, halogen or LEDs *(Z. Hocenski, Dizdar, & Hocenski, 2008; Ž. Hocenski, Sobol, & Mijakovi 2010; Mathiassen, Misimi, & Skavhaug, 2007)* while recent researches have shown that compared to fluorescent and halogen lamps, noise of image captured by LED's lights is reduced to give better images *(Ž. Hocenski, et al., 2010)*. Capturing the images with minimum noise and correct position is the aim of this part.

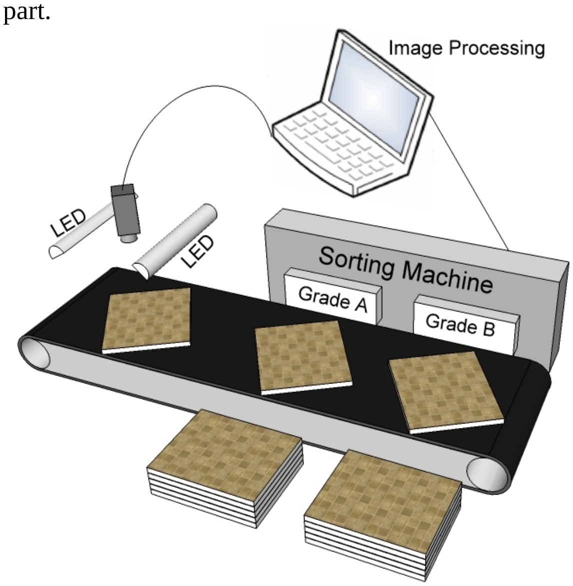

Fig 1. Automated Vision Inspection Systems in Ceramic tile (AVISC)

As shown in Fig1, captured images are sent to the computer for processing. Before analysing captured images, certain techniques such as noise removal, image substruction, histogram equalization and morphological operands will be applied to reduce noise of images. Each of these techniques is applied to enhance a special problem in image analysis to detect defects more accurately. For example, *opening* and *closing* of morphological operands are equivalent or similar to reducing *salt* and *pepper* noises in black and white images while *mean* filter in convolution category applies on colour picture to reduce salt noises.

In the production/processing stage, some methods such as edge detection, binarization, line detection and edge linking are applied to focus on obvious properties of images. Edge detection shows the borders of images and with invariant features, image understanding will be more accurate.

The final stage is post processing. Artificial Intelligent (AI) approaches are applied to simulate manner of system. Neural network, fuzzy logic, and genetic algorithm are common methods that are used in this stage. Decision which is taken is sent to the Sorting machine, where it will sort the ceramic tiles.

He Junji in 2010 introduced a length measuring method of firebricks based on machine vision technology. It is said that edge defect problems such as flatness and thickness defects are relayed by CCD sensors that need a fixed position for detection (He, Shi, Xiao, Cheng, & Zhu, 2010). We go beyond this type of approach by proposing a smarter AVISC strategy and method for ceramic tiles that detects edge defect tiles without the tile to be in a fixed position and with much low cost implementation tools and computer software.

This paper is organized as follows: in section 2, previous related works in ceramic tiles are described. In section 3, our proposed strategy that is related to edge defects detection for ceramic tiles is presented. In section 4, expected results, advantages and disadvantages of this method are mentioned. Concluding remarks are shown in section 5.

2. Related Works

The common approaches in image processing are discussed in this section. The combination of basic image processing techniques leads to creating new algorithms. Some defects are more sensitive than others. Therefore developing new approaches is challenging. We present and discuss smarter methods in two types of defects that are related.

A. Surface defects

As mentioned before, many forms of surface weaknesses exist in ceramic tiles. Some of the methods that are defined for these defects are suitable for specified faults and others are suggested for all defects (Atiqur Rahaman & Mobarak Hossain, 2009). Real time processing and correct classification percentage are proposed for AVISC criterions.

Recently, due to desirable properties of noise reduction, morphological techniques have become popular. Based on morphological operands some image processing algorithms are presented by Elbehiery *et al.* (Elbehiery, et al., 2005). The practical issues that are described in this paper are based on combination of morphological operands and edge detection methods which are specified for only one defect (i.e. crack, spot or pinhole). On the other hand, they introduce an individual algorithm for most of ceramic tile defects but this method's efficiency is less than of individual algorithm.

Another approach is counting number of white pixel after segmentation part (Atiqur Rahaman & obarak Hossain, 2009). If defected tile is detected, morphological operand will be applied when the number of the defected pixel is more than the reference image.

In another work, compound of *morphological* and *Gaussian* detector is attained to take sharp point - focus on the essential features that are pertinent and ignore unnecessary features - of edges of an image in decay of stone surface point (Kapsalas, Maravelaki-Kalaitzaki, Zervakis, Delegou, & Moropoulou, 2007). In addition, in another work via *morphology* operands, small defects of fabric were found better in spatial filtered captured images (Mallik-Goswami & Datta, 2000). In most of above cases, *morphological* operands have been applied to enhance images, to remove noise and also sharpen the edges. This process is repeated in many surface defect detection applications. Some algorithms are suggested for special problems. Hocenski and Keser suggested a simple algorithm which only detects spot defect (Z. Hocenski, Keser, & Baumgartner, 2007). They mentioned that spot defects are not only one pixel but also have its geometry. Based on this property and Local Directional Derivatives (LDD), the new method of moving average with local difference (MALD) is proposed (Z. Hocenski, Keser, et al., 2007). In this method the average of surrounding pixels intensity is compared with a group of pixels to recognize the features which do not follow a similar pattern.

Compared to LDD, which is based on Sobel's edge detection method (Sobel, 1978), MALD is approximately twice faster and has better success detection in false detected. Although this method is fast, the successful rate of detected and undetected defect show weak results.

It is fairly well established that edge detection techniques are one of the fundamental processes in AVISC. Edge detection usually is done after smoothing techniques to minimize noise of the image. But due to similarity between spot and blob defects with *salt* and *pepper* noises in captured image, detecting these defects are generally difficult to recognize precisely. Convolution filters and Gaussian filters such as *median*, *mode* and *low pass* filtering are common methods for removing noise but the *smoothing* task makes the image blurred, thus the problem is not hundred percent resolved.

Hocenski invented the *canny* image processing algorithm to detect ceramic tile defects on their surface and edge detector (Z. Hocenski, Vasilic, & Hocenski, 2007). It is an improvement by firstly using the *mean* filter to smooth the edges of the captured ceramic tile image, then the image is separated from its background by using the *histogram subtraction* technique. Finally, further refinement takes place where a low-level threshold is derived by subtracting minimum and maximum bound of histogram value.

It is said that between 3 and 3.5 times of low level is high level threshold in *canny* edge detection. The successful rate of this method is about 98%. However, the disability to detect the small amounts of texture variations of ceramic tiles is explained as depletion rather than a *defect*, since the amount is so small that it makes little difference to the overall texture of the tile (Z. Hocenski, Vasilic, et al., 2007).

Hocenski proposed a way to detect defect of edges in ceramic tiles (Z. Hocenski & Keser, 2008). The first stage is edge extraction and histogram subtraction. For better edge detection, *canny* method is chosen. Then in five angles (0, 45,- 45, 90 and – 90 degree), the next dot line is traced to cover the entire border of image. Finally, compared to contour descriptor of pattern tile, defected tile is detected. The result of this method is acceptable but it is time consuming to find defected tiles.

Mansoory provides a solution to this problem by presenting a *threshold* technique to detect defected edges of ceramic tiles (Mansoory, Tajik, Mohamadi, & Pashna, 2009). It is based on fuzzy logic. Thresholding is defined as a noisy task and enhancement is required to eliminate it. To reduce the noise, *radon transform* and *morphology* operands technique is applied. No faulty defect ceramic tiles curvature scan has 0, 90, -90 angles. Therefore, if any tile violates these angle conditions, it means that edge defected tile exists. In an experiment run of 300 ceramic tiles, this method achieved 98% accuracy of detection, which is acceptable for most industrial production application or systems.

B. Dimensional faults

As mentioned before, tile manufacturing companies investigate surface defects in ceramic tiles manually. Thus, human errors occur through tediousness, tiredness and carelessness. Totally, the visual inspection is not accurate, thus, it requires more work.

It is time consuming and impossible for humans to measure the length, width, thickness and edge curvature of each ceramic tile all at once. Some ways are suggested such as using sensors or laser beam (Mattone, Campagiorni, & Galati, 2000). Based on the machine vision system for measuring firebreak, He Junji introduced a method in 2010 (He, et al., 2010). In summary, the procedure is carried out in six parts:

- Edge extracting via canny edge detection,
- Edge linking to eliminate noisy edges,
- Edge segmentation to separate lines with different curvature,
- Line fitting
- Finding *homography* matrix to convert perspective edges to direct view,
- Calculate the length of firebrick.

The stable result of this algorithm is the strong point with approximately maximum 2 millimeter error.

3. Material and Methods

In the last two decades, the focus was on visual inspection systems to look at the ceramic tiles from the top side. During this process, the Flatness Control machine (FCM) works on the thickness and edge curvature of tiles. FCM is composed of some sensors to check the flatness of surfaces. In our proposed method we suggest visual inspection model which contains two or four cameras to see the edge of tiles (Fig 2).

Assumptions

Investigation of each border of the tile is needed to have complete tile border inspection. Therefore, one camera is required for each border. It is assumed that this is sufficient, but four cameras together have undesirable effects. When two cameras are in front of each other, they can see each other as well. It is believed that finding a way with minimum noise have better performance. We recommend using two cameras for two sides of the tile (Fig2). To cover the other tile borders one solution is rotate the tile, thereby; the two cameras then inspect the two other borders. This idea seems to solve the problem, but the tile has to stop during visualising.

We suggest dividing this task in two steps (Fig 3):

- Inspect two tile borders with first and second camera
- Investigate other borders with third and fourth camera but in the next stage

Another assumption is the distance between two tiles on the conveyer. The captured image must contain only one border, otherwise size measuring and crack detection on border of tile will be influenced. Processing the border of a tile is not complex. We can use the conveyer with high speed but the distance between the two tiles should be at a relative distance to ensure correct imaging for optimum analysis to take place. The speed of the conveyer belt can be calibrated to derive the optimum pacing. Placing of tiles and tile edges detection rates from control trial runs before the actual production consignment is inspected in normal production operation.

Fig 2. Using two cameras to inspect edges of ceramic tiles and one camera to inspect surface defects

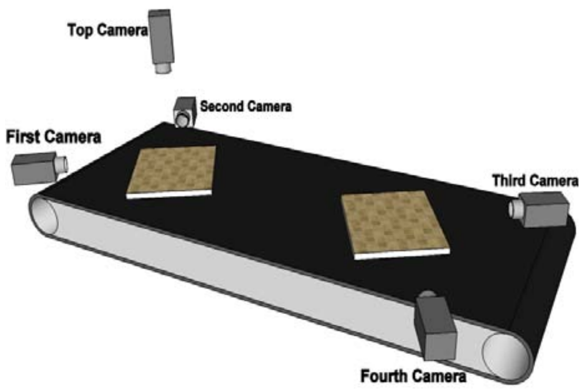

Fig 3.While top camera investigates the surface of tile; first and second cameras inspect two borders of tile. Then, third and fourth cameras investigate other borders.

Two cameras on the sides of the tiles inspect the edge of the tiles while a camera on top investigates the surface. This strategy would control surface and edge inspection in ceramic tiles on a conveyer belt simultaneously.

Fig 4. A sample of edge tile image

As it will be shown, LED light resources and black background for image capturing are recommended. The position of camera should cover the border length of tiles. In addition, it is stated also that 30 cm distance between tile and camera is suitable (Ž. Hocenski, et al., 2010).

An instance of a ceramic tile border is shown in Fig 4. It is believed that other defects such as spots or blobs are not accepted in ceramic tile borders. Therefore, we could use smoothing, filtering and morphological operands to cover all the edges in the defected tile.

In the next stage, we recommend using *histogram subtraction* to separate the tile from background. We suggest applying *canny* edge detector because we want to focus on line gradient and this method is the one suitable for this purpose (Atiqur Rahaman & Mobarak Hossain, 2009). Finding a suitable threshold in canny technique will have a great effect on our work to succeed. In addition, using *morphological* operand (*opening*, *closing*) would help to remove unwanted noises (Ze-Feng, Zhou-Ping, & You-Lun, 2006).

Fig 5. An image of the tile edge after segmentation and enhancement

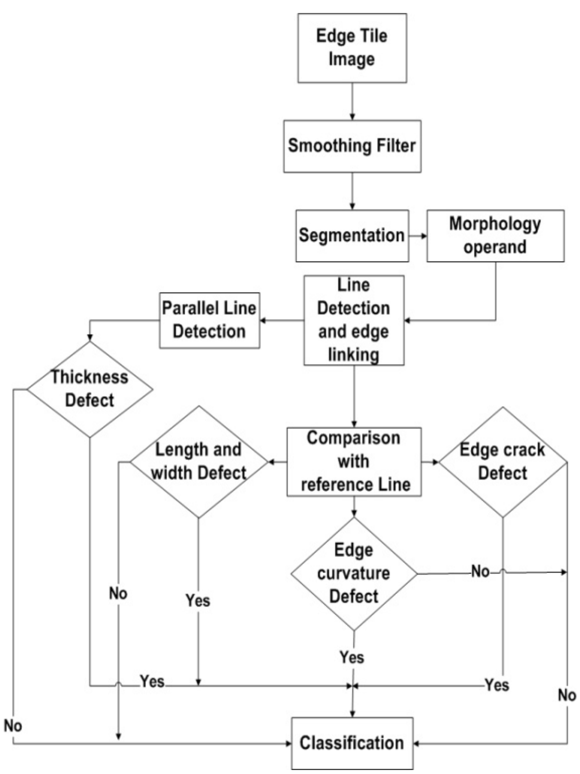

Fig 6. Proposed approach diagram for edges of ceramic tiles

The surface of the *front side* of a ceramic tile is shown in Fig 5 is a good example of how to investigate for *edge* curvature defects. The edge of the tile is derived from the segmentation part and straight edges are needed for assessing no fault tiles. *Hough transform*, *deep-first* algorithm and straight line detection are suitable to extract the edges of tile (Lee, Koo, & Jeong, 2006). Recognizing main correctors related to edges of tile will be interpreted as a line. We recommend using a straight line as a reference line to find defected edges (Pithadiya, Modi, & Chauhan, 2010).

Four major defects are considered in our method. In feature extraction part after line detection, edge linking is needed to join edges. Fig 6 presents a flowchart of edge defect detection in ceramic tile. As mentioned before, after line detection and edge linking part, three faults (edge crack defect detection, thickness measuring and curvature defect detection) still exist. It is assumed that comparing with reference line; this will help to find these defects, while for thickness measuring parallel line detection is chosen. The final stage depends on each ratio of each edge classification part done. Four solutions are proposed for each fault based on line detection.

A. Edge curvature defect detection

According to International Organization for Standardization (ISO) rules, less than five percent deviation is acceptable for edge curvature in ceramic tiles. The area between the edge line and reference line deviation of a tile is shown in Fig 7. By attaching the lowest point of edge line to reference line, the surrounded area is actually calculated by the function in equation (1). *F(x)* is tile border's equation line which is located between 'a' and 'b' points. In practice, equation (1) attains with summation of pixels between reference line and tile border line that is presented in equation (2). In equations (1) and (2) x presents reference line location and x_i shows the edge tile location. The summation of destination between these lines is the curvature of the tile. In addition, the maximum deviation from reference line is interesting because it shows the curvature defect.

$$D = \int_a^b F(x)dx \qquad (1)$$

$$D = \sum_{i=a}^{b} (x_i - x) \qquad (2)$$

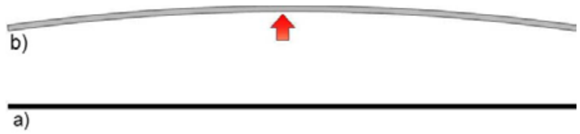

Fig 7. a) Reference line, b) Deviation compared to Reference line

When the maximum deviation is happening edge curvature defect will be seen or while average deviation is more than usual. Fig 8 shows this distance between reference line and edge of tile in practical view. As the line detection and edge linking number of pixels that do not match with reference line is counted in order to verify threshold values. If it is above the threshold value, a fluctuated edge is recognized and the tile is declared faulty. This is specified in algorithm 1.

Fig 8. After segmentation and feature extraction, reference line is matched with the lowest point of tile in same direction to achieve deviation from reference line.

Algorithm 1:

- line extraction method
- Edge linking (L[i,j])
- Match reference(R [i,j]) line and side of tile in same direction and lowest point.

For each i and j
  if distance (R[i,j] *AND* L[i,j]) > Max (deviation)
    defect _counter = defect_ counter +1

if distance (R[i,j] and L[i,j]) > 0
 Total_dis = distance (R[i,j] *AND* L[i,j]) + Total_dis
End For each

If Total_dis > Threshold *OR* defect_counter > Threshold
  Mark tile as a fluctuated surface tile

B. Length and width defect detection

Size measuring has been done in visual inspection systems (Elbehiery, et al., 2005). We predict that focusing on edges of tile will increase the accuracy. In our model other defects such as pinholes, cracks, scratches, blobs and texture of ceramic tiles are not seen. This property will help us to find the edges of tile without having to worry about the other defects.

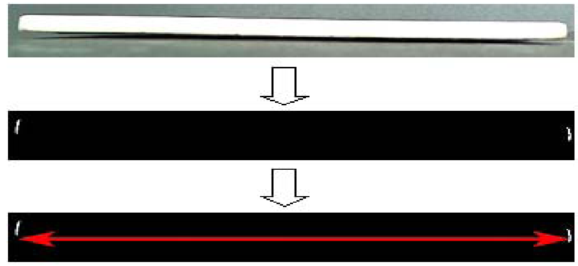

Fig 9. Steps of length measuring: after vertical line extraction method, the summation of pixels from left side to right side is distance between two sides.

Algorithm 2:

- Vertical line extraction method (L[i,j])
- Binarization method

For each i And j From 0 To Width/2
  If Color(L[i,j]) = White
    Left_Position = L[i]
  End If
End For each

For each i And j From Width To Width/2
  If Color(i,j) = White
    Right_Position = L[i]
  End If
End For each

Tile_Length = Right_Position – Left_Position
Reference_Line_Length = Total pixel of Reference line

- Find the ratio between this Tile_Lenght and Reference_Line_ Length

Algorithm 2 expresses the procedure of size measuring. At first, a longest virtual line between two sides of the tile is calculated. Afterward, through comparing the length size against the reference line, the acceptance of length size can be easily determined. Fig 9 shows the way that this process would be performed. Firstly, two vertical lines are fetched from the both borders of captured image so that it would be possible to count the number of pixels between them. Secondly, *binarization* task is performed to make the borders more clear. Thirdly, the total pixels spanning from the left side to right side determine the length of the ceramic tile edge. The same process is necessary for determining the *reference* line. The exact length is obtained by calculating the ratio between this line and *reference* line.

C. Edge crack defect detection

It is assumed that localizing the edges makes edge defect detection more accurate. In addition, we can combine the result of top side camera images – which is suspicious to edge crack - with that of our model to be more reassured about edge crack since defect is a group of pixels that shows unusual manner against the background (Joo, Huh, Hong, & Park, 2010). Therefore, an edge crack on surface of tile appears after straight line detection because crack edge unlike background does not have straight line.

Algorithm 3:

- Use straight line detection with PCA

For each i and j
    If R[i,j] not Match with any L[i,j]
        defect_counter = defect_counter +1
End for

If defect_counter > Threshold _ error
    Mark tile as a defected tile

In above code, each pixel of reference line(R) must have one pixel in edge tile (L) otherwise threshold error value will increase. Threshold error describes amounts of pixel that we want to distinct as a crack. Fig 10 shows an instance of crack edge that is achieved after straight line detection.

Fig 10a) Edge of tile that has crack, Fig 10b) edge crack is detected after applying algorithm

D. Thickness defect detection

Like edge curvature measuring that is not possible to see from top side, thickness measuring should be inspected from sides of ceramic tiles. Thickness is the distance between two sides of ceramic tiles. It should be parallel and it should not be thick or thin. As specified in algorithm 4, after line detecting we need to find two longest parallel lines in our image. Edge linking will help to find thickness measuring process. Then we count all of pixels that are out of thickness distance. If numbers of defected pixels are more than threshold value then thickness defect is observed.

Algorithm 4:

- line extraction method
- Edge linking (L1[i,j]) and (L2[i,j])

For each i and j
    If distance (L1[i,j]) , L1[i,j]) NOT in Thickness_distance
        defect _counter = defect_ counter +1
End for

If defect_counter > Threshold _ error
    Mark tile as a defected tile

Fig 11 presents theory of above algorithm. As we observed, the right side thickness is greater than that of left side which indicate the edges of two sides are not parallel.

Fig 11. Finding two lines that are not parallel and the distance between them is more than normal

3. Discussions and Result

The experiments for the four algorithms are currently undergoing rigorous laboratory tests which will be completely analyzed in a follow up paper. However, our preliminary evaluation of results using algorithm 2 for vertical line extraction method based on Prewitt and Sobel techniques, shows the fluctuation of Prewitt’s method is closer to real size changes ascertained from our laboratory measurement using digital caliber. The maximum relative-error of both techniques shows an approximate deviation of 1.44%.

Since humans make mistakes, visual quality control systems in real time have become favorable recently. Because Ceramic tile companies should qualify their products, analyzing their outcome for efficiency is significant. We believe that this proposed method is suitable before and after kilning and coloring phases. These quality control surveys help to improve the process of production. They are important for preventing faulty tile production through automated feedback adjusting control system. It is also possible to recycle ceramic tiles before kilning to reduce disposal cost or profit margins. Therefore, if we predict defected tile correctly before kilning, the biscuit of each tile will return to the production line again. Even after kilning, it is more economical to reject some tiles that will not classify for “A”, “B” or “C” grade sorting at the end of production. Thus, understanding defected tile during the production is important for factories.

Human eye can detect some defects but the rest that are not recognizable by human eyes or need more accuracy should be investigated in AVIS such as size defects. Border defects of ceramic tiles are also categorized in the second group for example: shadows of ceramic tiles are seen after installation. Because workers are looking at the surface of ceramic tile from the top, so edge curvature is hidden in this kind of inspection.

It is assumed that flatness curvature in ceramic tile manufacturing spreads all over the tile surface. Therefore using two cameras is also acceptable, but for more accuracy, it is possible to expand this model to four cameras or rotate the tile for investigating other sides.

It is expected that many defected tiles that have edge faults will be found in the proposed model. Focusing on the edge of the tiles, size measuring also would be more accurate, particularly within the tolerance or threshold values set. The algorithm 2 can be made more advanced to be self-adjusting to determine more fine-grain values for "A" grade tiles. The opposite can also be true, that is, adjust the values to be more coarse-grain or larger for lower classes of tiles rejected from "A" class batches.

Advantages of this model

Most often it is expensive to use human resources while other times they are not accurate enough for visual controlling. In addition, in many cases, it is impossible to request humans to check all details such as size measuring in ceramic tile companies, because the speed of production line is more than human measuring. All of these limitations encourage companies to use other methods. Accurate method with low cost implementing and less limitation during production is becoming more popular recently.

Factories are using visual inspect systems to inspect surface defects of ceramic tiles and our model is a supplementary method that will be combined with the previous model to detect the border defects of ceramic tiles. In this paper, a method is suggested that is accurate and fast enough with lower cost implementing rather than previous methods while the quality assurance of this model has been considered. In this model we use a maximum of five cheap cameras that are using CMOS (Complimentary Metal-Oxide Semiconductor) technology as opposed to flatness control machines which use laser or CCD sensor. CMOS camera is far more economical. Besides, this model does not need another visual inspection system. Thus, the same AVISC which is used for surface defects can be applied for determining other border tiles. Therefore, with a central computer the visual inspection will be done in different places of the production line. In previous methods, factories needed to buy FCM (Flatness Control Machine) to check other defects of ceramic tiles and usually this checking is done only at the end of production line, because it is expensive and unable to expand in networking.

Another advantage of this strategy in contrast with previous methods which need to fix position during controlling the flatness of tiles is that the ceramic tiles is located on conveyer belt and cameras investigate the tile rapidly without stalling the ceramic tile.

In a follow-up paper we will present our results from many different experiments using different sets of placement and measuring criteria.

4. Conclusion

Installing ceramic tiles with thickness and curvature defects are unpleasant. In this paper, we proposed a supplementary method to cover border defects in ceramic tile by using automated visual inspection system (AVIS). This model is able to cover border defects such as edge curvature, thickness, size measuring and edge cracks. For each defect an algorithm based on line feature extraction methods is suggested. This proposed system would cover edge defect problems more efficiently. In addition, this strategy solves the limitation of last step inspection existing in production lines which involve keeping ceramic tiles in a fixed position. Therefore, boosting the speed of quality control process will inherently increase the speed of production of tiles. Another advantage is that it is economically applicable so as to encourage factories to use this model in various parts of production lines such as before kilning, after kilning, after colouring and final sorting. This model is also flexible enough to be combined with other AVISs methods to investigate surface of ceramic tiles that reduce cost of implementation for factories due to the fact that they have to check ceramic tiles surface as a minimum requirement for quality control purposes. Thus, with the same computer and adding different cameras it will be implemented.

It is assumed, this model has the capability of covering curvature defect problems of tiles in AVIS without any dependency on CCD, flatness measuring laser sensor and fixed position limitation during quality control. By taking each border of tile, size and thickness measuring accuracy, in to account we hope that sorting and packing tiles will be improved. AVIS is a rational solution (Malamas, et al., 2003), therefore, regardless of CCD and laser sensor, this system can be implemented economically. It guarantees factories to apply this method in different stages of production line such as before kilning, or coloring or after kilning.

Acknowledgements:

This work was supported by Islamic Azad University, Tehran, Iran and University Kebangsaan - 43600 Bangi, Selangor, Malaysia. We very sincerely would like to thank Mona Taghavi and Kaveh Bakhtiyari for reviewing this paper with great skills.

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5/20/2011