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A Survey on Automatic Defect Detection & Classification Technique from Image: A special case using ceramic tiles.

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Abstract—*On the other hand maintaining the rate of production with respect to time is also a major issue in ceramic tile manufacturing. Again, price of ceramic tiles also depends on purity of texture, accuracy of color, shape etc. Quality control in ceramic tile manufacturing is hard, labor intensive and it is performed in a harsh industrial environment with noise, extreme temperature and humidity. It can be divided into color analysis, dimension verification, and surface defect detection, which is the main purpose of our work. Quality control is an important issue in the ceramic tile industry. Considering this criteria, an automated defect detection and classification technique has been proposed in this report that can have ensured the better quality of tiles in manufacturing process as well as production rate. Our proposed method plays an important role in ceramic tiles industries to detect the defects and to control the quality of ceramic tiles. This automated classification method helps us to acquire knowledge about the pattern of defect within a very short period of time and also to decide about the recovery process so that the defected tiles may not be mixed with the fresh tiles.*

Keywords— *Pattern of Defect, Defected Ceramic Tiles; Fresh Tiles, Quality control, Defects detection, Visual control, Image processing, Morphological operation.*

I. INTRODUCTION

The ceramic tiles manufacturing process has now been completely automated with the exception of the final stage of production concerned with visual inspection. Ceramic tiles manufacturing process has now been completely automated with the exception of the final stage of production concerned with visual inspection. This paper is concerned with the problem of automatic inspection of ceramic tiles using computer vision [1]. Image processing is one of the mostly increasing areas in computer science. As technology advances, the analog imaging is switched to the digital system now-a-days. Every day, we capture huge amount of images which are very difficult to maintain manually within a certain period of time [1]. So the concept and application of the digital imaging grows rapidly. Digital image processing is used to extract various features from images [2]. This is done by computers automatically without or with little human intervention [3]. One of the most important operations on digital image is to identify and classify various kinds of defects. Thus to detect the defects from any image some methods are established and placed at three levels. At the lowest level, some techniques are available which deal directly with the raw, possibly noisy pixel values, with de-noising and edge detection being good examples [1].

In the middle there are algorithms which utilize low level results, such as segmentation and edge linking [8]. At the highest level are those methods which attempt to extract semantic meaning from the information provided by the lower level [5]. Ceramic tiles industry sector is now a very important sector for manufacturing the ceramic tiles. All production phases are technically maintained until the final stage of the manufacturing process appeared [6]. Sometimes checking is needed for the ceramic tiles if they are able to serve customer needs, i.e. to find defected tiles. So it is an important task to categorize the ceramic tiles after production based on surface defects [7].

The manual method of defects inspection is labor intensive, slow and subjective. Although automated sorting and packing lines have been in existence for a number of years, the complexity of inspecting tiles for damage and selecting them against the criteria of a manufacturer i.e. automated defected tiles inspection have not been possible [11]. Again human judgment is influenced by expectations and prior knowledge. In many detection tasks for example, edge detection, there is a gradual transition from presence to absence [12]. That ensure the products are free from defects for the classifying process. Classifying process must be effectively, objectively and repeatedly, with sufficient rapidness and low costs. It must have the ability to adapt autonomously to changes in materials [1]. The techniques used range from Long crack, Crack, Blob, Pin-hole and Spot detectors algorithms for plain, and textures tiles. This therefore reduces the number of complaints tiles [12].

The first one defines structural defects as regions of abruptly falling regularity, the second one as perturbations in the dominant orientation [11]. Both methods are general in the senses that each of them is applicable to a variety of patterns and defects. Human judgment is, as usual, influenced by expectations and prior knowledge [22].

However, this problem is not specific to structural defects [15]. In many detection tasks for example, edge detection, there is a gradual transition from presence to absence. On the other hand, in “obvious” cases most naïve observers agree that the defect is there, even when they cannot identify the structure. Such a monitoring task is of course tedious, subjective and expensive but it is based on a long experience and can utilize the huge appreciation and recognition abilities of the human brain [14].

Any machine vision system will never advantageously replace the visual inspection if it is not able to:

1. Analyze the color of the product with reliability.
2. Detect every type of manufacturing defects, with at least the same accuracy as the human eye.
3. Measure with high precision the dimensions of the tiles

The presented inspection procedures have been implemented and tested on a number of tiles using synthetic and real defects [9]. The results suggested that the performance is adequate to provide a basis for a viable commercial visual inspection system which we will see it in the next sections [14]. On the other hand, in “obvious” cases, most naive observers agree that the defect is there, even when they cannot identify the structure. Such a monitoring task is of course tedious, subjective and expensive [16]. For all these reason no one can deny the significance of automated defect detection and classification system. The objective of our research 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 [13].

Exture feature for detecting defect on ceramic, as in [7], [8], and [9]. In this section, defect detection on ceramic tile using extracted shape feature is proposed. 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] study 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. Z. Hozenki *et al*. [12] proposed a ceramic edge defect detection analysis based on contour description.

To prepare the image for analysis, thresholding method was used by the histogram of the foreground image with the background image. For edge detection, canny kernel was used. Afterwards, contour search was performed by tracing five angles (0, 45, -45, 90, -90 degree). The results were clear visible contour based on the shape and geometric structure. In [13], E. Golkar *et al.* proposed an image retrieval system from the top and sides of the tile, so it could detect not only surface defect but also dimensionaldefect. For this purpose, canny edge detection was used. Further, segmentation process for extracting the edge tiles using hough transformation was performed, as well as deep-first algorithm and straight line detection with morphological operations. Classification process was done after calculating the ratio of defects.

II. RELATED WORK

Existing methods for defect detection

We intended to create images that are more suitable the human visual perception object detection and target recognition. hods have been proposed to find out the image defects. But they have some limitations that can be described briefly as follows:

In [1], H. Elbehiery et al. presented some techniques to detect the defects in the ceramic tiles. It must be noted that detection of defect in textured surfaces is an important area of automatic industrial inspection that has been largely overlooked by the recent wave of research in machine vision applications [1]. They divided their method into two parts. In the first part, Existing method consisted with the captured images of tiles as input. As the output, they showed the intensity adjusted or histogram equalized image. After that, they used the output of first part as input for the second part. In the second part of their algorithm.

In [2], C. Boukouvalas et al. concerned about the problem of automatic inspection of ceramic tiles using computer vision. They applied techniques for pinhole and crack detectors for plane tiles based on a set of separable line filters, through textured tile crack detector based on the wigner distribution and a novel conjoint spatial-spatial frequency representation of texture, to a color texture tile defect detection algorithm which looks for abnormalities both in chromatic and structural properties of texture tiles. But, using separate filtering techniques for different types of defects is not a good idea at all, because in such case high computational time is a major issue for applying a large number of operations. Again, their procedure is an automated visual inspection system where they only show the defects making them clear to detect the defects found on image.

In [3], Se Ho Choi et al. presented a real time defect detection method for high speed bar in coil. To enhance the performance of the detection they used edge preserving method for noise reduction, to separate images with different gray levels they used the laplacian filter (2nd differential) and after that they used double thresholding to binarize the image. But the major drawback of their process is that their method will not be able to find the orientation of the edge because of their using of laplacian filter, according to [7] which will be needed for the defect of ceramic tiles. The technique using the laplacian filter malfunctions for corner and curves.

1. Elbehiery et.al. , proposed a method to identify the surface flaw of ceramic tiles. Their proposed method is divided into two distinct portions. First portion of this method consist with the captured image of tiles as input and output of this portion is histogram equalized image with intensity adjustment. After that, they use the output of first portion as input for the second portion [3]. Furthermore, second portion also comprises with different complementary image processing operations so as to identify and to classify a variety of surface and structural defects. Their proposed system is not automated rather it emphasizes on the human visual inspection of defect classification in industrial environment. Moreover, this system is suffered by redundant operation since they apply the second portion on every test image to identify and classify various types of defects. Thus this system is time consuming as well [18].

2. Boukouvalas et al., they applied separable line filters for flat tiles to identify crack and pinhole defects. Again, they applied winger distribution for crack detector and a novel conjoint spatial-spatial frequency representation for textured tiles. In terms of color textured tiles, this type of detection algorithm which looks for abnormalities both in chromatic and structural properties [5]. However, use of separate filtering technique for identifying distinct defect is not a good practice. Consequently, high computational time is taken while we are to handle a large number of operations during production time. It also proceeds with visual defect classification with human intervention [17].

In most cases the last phase is based on human perception capability. Human resources as controllers in this phase are very unreliable [19]. During hard working conditions in plant and human visual perception limitations, a man as a controller chain could be a source of failures and decrease production yield and product quality which increases total production costs. To avoid or minimize human related failure causes as much as possible, this paper presents one of the ways how to introduce automatics as the main worker for this stage in the ceramic tile [11].

Every failure directly reflects on the final ceramic tile. Thus, a failure could be at the beginning of the process being reflected on the ceramic tile structure as irregularity in geometrical composition of the tile (broken tile, broken edges and/or corners, surface scratches, planar concavity and convexity, bumps, pits, etc.) [14]. In the middle and at the end of the process (glazing, texture printing and biscuit baking) a failure could appear as small pin holes, surface cracks, glazing coverage irregularity, texture printing misalignment or misprint and wrong color and texture composition [13].

III. CERAMIC TILE VISUAL INSPECTION SETUP

Ceramic tile visual inspection for the purpose of detecting failures on tiles is performed by the machine vision system and image processing algorithm subsets. In this case a machine vision system fully replaces human resources and in synergy with appropriate algorithms it could be even more powerful than men as a visual inspection resource. In some areas of visual perception, men are still irreplaceable as visual preceptors, especially in areas where texture recognition is important [20]. The main reason for introduction of machine vision instead of man is to increase reliability of a visual inspection system, production quality and yield as well as to reduce production costs [9]. A machine vision system consists of one, two or more digital acquisition cameras and one or more processing computers, depending on process complexity. Today's cameras are developed enough to be able to register even the smallest detail on the tile surface.

Acquisition cameras are often line scan cameras (area scan cameras are used less because of their high cost and other problems related to acquisition processes). These are mono or color cameras with a relatively high resolution of acquisition. Monochromatic cameras are grayscale cameras used for acquisition of a high detailed image of a ceramic tile where image color composition information is not required for analysis [21]. In contrast to them, color cameras are used to acquire images needed for color composition based analysis and they often have resolution lower than mono cameras. Processing computers are ordinary personal computers adapted to the usage in industrial environment with camera interfaces and processing algorithms incorporated. Also, processing computers have interfaces for ceramic tile automated classification machines [9].

Image acquisition and capturing:

We intended to create images that are more suitable the human visual perception object detection and target recognition. We used the principles of Image processing and Morphological operations on the ceramic tiles images. Therefore, we get new images that contain the surface defect only to make easier for the detecting process and classification operation via the judgment of the operator. The ceramic tiles have been captured through the online camera held on the line production at the industry [8].

The image captured will converted to another kinds of images (Binary, and Gray scale) to be suitable for the various defect detection algorithms used for the different types of defects. A bag of tricks is used rather than standard algorithms and formal mathematical properties will be discussed like Edge detection, Morphology operations, Noise reduction, smoothing process, Histogram equalization, and intensity adjustment [5], [6].

The effects of unequal lighting and of the space sensitivity of the TV camera CCD are corrected analyzing a sample tile made of white Plexiglas whose image has been previously divided in 8x8 sectors. This number represents a compromise between spatial resolution distribution and computing time [13].

Edge Finding:

An edge may be regarded as a boundary between two dissimilar regions in an image. These may be different surfaces of the object, or perhaps a boundary between light and shadow falling on a single surface. In principle, an edge is easy to find since differences in pixel values between regions are relatively easy to calculate by considering gradients. Many edge extraction techniques can be broken up into two distinct phases:

- Finding pixels in the image where edges are likely to occur by looking for discontinuities in gradients.
- Linking these edge points in some way to produce

Descriptions of edges in terms of lines curve *etc*. Thresholding produces a segmentation that yields all the pixels that, in principle, belong to the object or objects of interest in an image. An alternative to this is to find those pixels that belong to the borders of the objects [9].

Morphological operations:

Morphological operations are methods for processing binary images also for gray scale images based on shapes. These operations take the binary and gray scale images as input, and return it as output. The value of each pixel in the output image is based on the corresponding input pixel and its neighbors.

By choosing the neighborhood shape appropriately, you can construct a morphological operation that is sensitive to specific shapes in the input image. As binary images frequently result from segmentation processes on gray level images, the morphological processing of the binary result permits the improvement of the segmentation result. Defects are extracted from the background by thresholding the image and classified according to size and shape parameters. Existing machines commonly detect the following defaults [10], [11]:

1. Chips (edges and corners)
2. Cracks
3. Scratches
4. Glaze faults
5. Holes and pitting
6. Lumps

The sensitivity of the imaging system is linked to the local roughness contrast induced by the defect; it has nothing to do with the color contrast. Because they rely on two independent physical properties of the material, color defects and surface defect inspection are complementary [10]. The tiles used in our experiments are of size 200 x 200mm and are either plain or textured. In the testable images, some defects may not be easily visible and we have randomly encircled some of them for saliency [10].

Detection algorithms for fired ceramic tiles:

We will see in this section a number of techniques developed for the detection of multifarious range of ceramic tile defects. Figure 1 shows the first part of the algorithm which takes the captured image for the defective tile then the output is an intensity adjustable histogram equalized image to be the input to the second part of the algorithm [11]. The second part of the main algorithm include many of individual complementary algorithms differs due to the various kinds of defects [12].

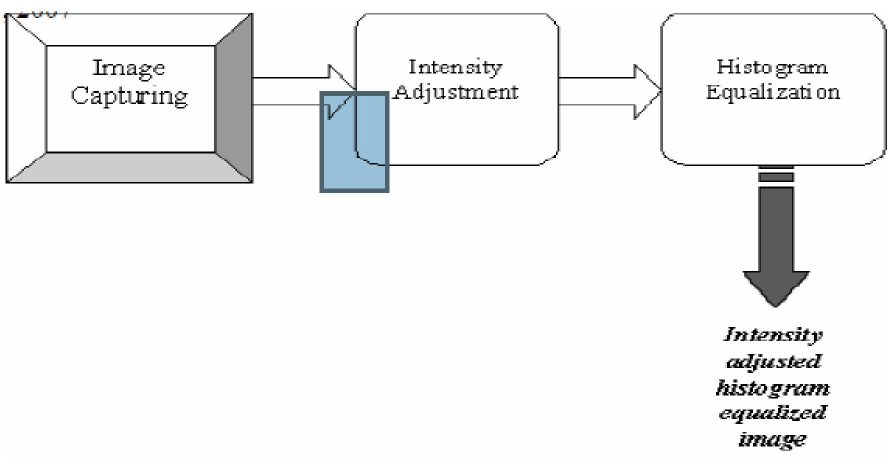

Figure 1: Detection algorithms for fired ceramic tiles

Now we will see the different complementary individual algorithms for the detection of variable defects. These algorithms take the intensity adjusted histogram equalized image as the input image. The input image in these algorithms passes through many stages to get the final image which include only the defect. These stages differ from algorithm to another due to the kinds of defects [14].

Figure 2 shows the Crack and Long Crack defect detection algorithm. The input image converted to a black/white image. An edge detection operation has been done to detect the defect pixels producing approximately areas to the defects so we follow it by a fill gaps operation to discriminate the defect pixels [14].

Some morphology operations have been done to discriminate the defect pixels more accurately followed by Noise reduction and Smoothing object processing to give a clear image containing the defect only. However, this problem is not specific to structural defects. In many detection tasks for example, edge detection, there is a gradual transition from presence to absence. On the other hand, in "obvious" cases most naïve observers agree that the defect is there, even when they cannot identify the structure [14].

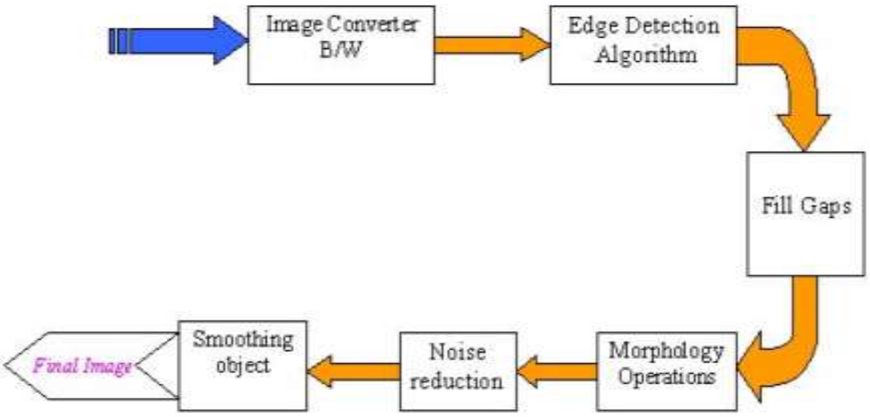

Figure 2: crack defect, and long crack defect detection algorithm

The same operations have been applied to the other kinds of defects detection algorithms but without the same arrange and the number of processing cycles to the images. Figure 3 shows the Spot, Longitudinal Spot, and Depression Spot detection algorithm.

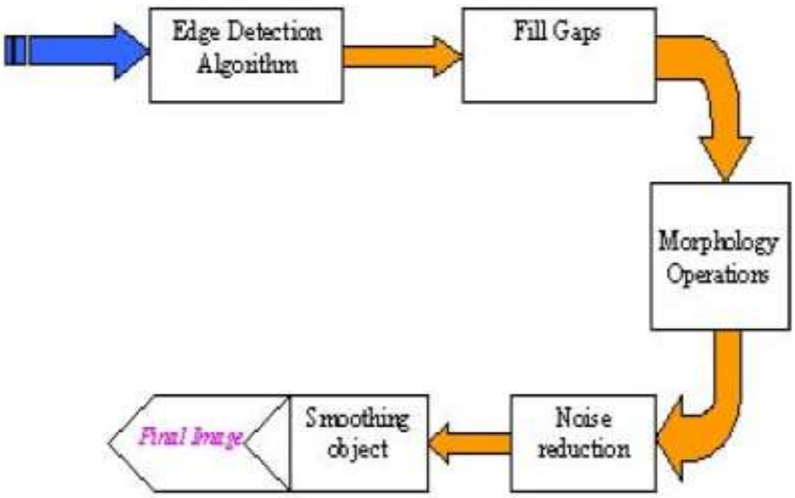

Figure 3: Spot, longitudinal spot, and depression spot Detection Algorithm

It is easier to detect the Pin-hole defects. That by applying some morphological operations directly to the input image followed by SDC morphological operation (morphology operations specialized for grayscale images). Finally in this algorithm the image passes to Noise reduction processing to get a clear image for the defect. Figure 4 shows the Pin-hole defect detection algorithm.

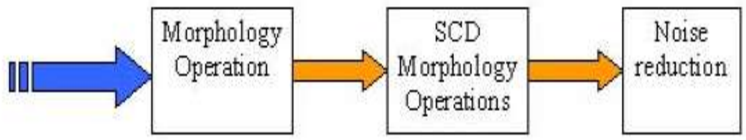

Figure 4: Pin hole defect detection algorithm.

Because the blob defects always have no little pixels so it has a discriminated area needs only to display it. The input image complemented by an inverse operation to display more clearly the blob defect pixels followed by some morphological operations and nose reduction processing to get a final image for the blob defect pixels only. A fill gaps operation may be added to the final image to increase the clearance of the defects pixels than others. Figure 5 shows Blob defect detection algorithm.

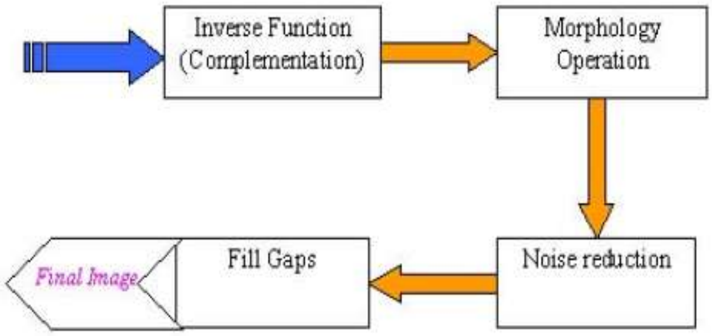

Figure 5 Blob defect detection algorithm

Quality control in ceramic tile manufacturing is hard, labour intensive and it is performed in a harsh industrial environment with noise, extreme temperature and humidity. It can be divided into colour analysis, dimension verification, and surface defect detection, which is the main purpose of our work.

Defects detection is still based on the judgment of human operators while most of the other manufacturing activities are automated so, our work is a quality control enhancement by integrating a visual control stage using image processing and morphological operation techniques before the packing operation to improve the homogeneity of batches received by final users [7]. An automated defect detection and classification technique that can ensured the better quality of tiles in manufacturing process as well as production rate [6].

The problem of detection of the surface defects included on the fired ceramic tiles using the image processing and Morphology operations. By using this technique we can develop the sorting system in the ceramic tiles industries from depending on the human which detects the defects manually upon his experience and skills which varies from one to one to the automated system depending on the computer vision [9]. That affect mainly in the classification or sorting operation which also done by human in the industry. People can work effectively for short periods and many different operators are involved in checking the same batch of tiles [8].

IV. CONCLUSIONS

In this paper can studies the sorting system in the ceramic tiles industries from depending on the human which detects the defects manually upon his experience and skills which varies from one to one to the automated system depending on the computer vision. That affect mainly in the classification or sorting operation which also done by human in the industry. People can work effectively for short\ periods and many different operators are involved in checking the same batch of tiles. Continuity over time is not guaranteed and may result in overall poor quality, which may cause customers to complain or even to reject the batch. Miss-sorting is kept at an extremely low level. Isolating different kinds of defect in ceramic tiles images. Automated sorting systems would bring numerous benefits to the entire sector with major economic advantages, also guarantee product quality, increase plant efficiency and reduce fixed and periodic investments. The continuous measurement of surface defects gives line production operators to optimize temperature profile, speed and other operating parameters.

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