An Automated Ceramic Tiles Inspection System using Image Processing Technique with Cloud Management System

Riffat Fatima Siddiquie, Faizan Abid, Komal Tahir, Muhammad Wasim, Lubaid Ahmed, Syed Faisal Ali

Abstract— **Globally, the Ceramic tiles technical industrial sector is a comparatively new but very huge industry that has taken significant gain of the robust development of automation in the past few years. This industry these days hold significant ratio of consumer need. For industries, the measurement and perfection of tiles analysis is a challenging task. Ceramic tiles process through different stages of production with technologies except the final process of inspecting the defective tiles, which, done manually by human vision in many manufacturing industries. Detecting the defects manually takes a lot of human effort in enormous industries, which costs highly and is time-consuming. With human error factor involved in inspection process, there are evident cases where defected pieces gone unnoticed into the market and it creates a negative impact of any industry. The system proposed will detect visual defects such as cracks, pinholes, spots on the surface of the tiles with acute accuracy. It will also detect irregularities in patterns printed on the tiles. The proposed system provides a state of the art solution to measurement and defect analysis in the tiles using image-processing techniques. The outcome of this project is to detect defects and pattern mismatch in the tiles, then indicating any defect signaling red or green light using raspberry pie and mentioning that defect ratio with an inspection report as decision parameters. The work described here comprises of two modules an automated Ceramic measurement and defect analysis system (AMTDS) using image processing techniques and cloud management. The AMTDS is an effective and low cost technique, which minimizes the issue of accurate measurement and defect analysis of Ceramic tiles with the accuracy (87.5%) and precision .((80.3%**

Keywords— **Tiles inspection, Cloud Computing, Image .Processing, Tiles Defect Detection**

INTRODUCTION

For the last few years Ceramic tiles industry is one of the most demanding and consuming industry not only in Pakistan but in other countries as well [1]. Unfortunately, most of the system for tiles inspection and fault detection are manual by extensive labor work, which is time-consuming and costly. Efficiency of measurement and inspection is also increases by human error and negligence [2]. Therefore, there is a need of a state of the art automated tiles measurement and inspection system, which should be effective and accurate to measure, detect the faults of tiles. The proposed system not only measure the standard size of tiles but also detect visual defects such as cracks, pinholes, spots on the surface of the tiles with acute accuracy [3-4]. It will also detect irregularities in patterns printed on the tiles. Image processing techniques [5-10] are utilized for the automated measurements and defect detection in tiles.

The outcome of this project is to detect defects and pattern mismatch in tiles. For this purpose a hardware setup is done in Image Processing Research Lab (IPRL) as shown in figure 1.

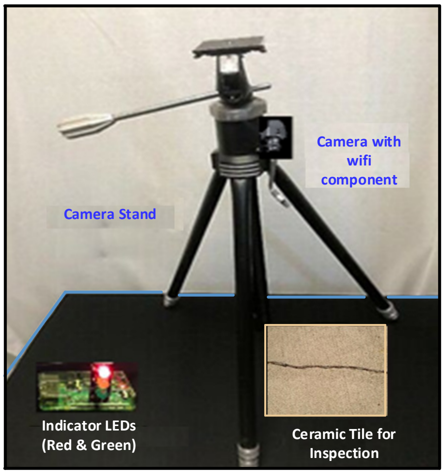

Fig. 1 AMTDS setup in IPRL

The AMTDS application, developed in IPRL [11], comprises of a black color wooden base. A rectangle-shaped space is formed on the wooden base to lock the position of the Ceramic tiles. A digital camera with wifi connection is connected with to a tripod at the top of the tile to capture the tile surface images. This Ceramic tiles captured images are then measured and analyzed through the developed software. The developed software then produces the reports on the tile size and center position of tile adjustments with the measurements of all patterns and tile sizes which are properly adjusted according to standard values. A green LED will illuminate to indicate that the tested tile is "good". If not, it is "bad" and the red LED will light up. The raspberry Pi processor is programmed and used to display these good and bad tiles status. The complete hardware structure is shown in Figure 1.
Top of Form
Bottom of Form

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CLOUD SYSTEM MANAGEMENT FOR AMTDS

The second part of the developed system is related to the cloud management and monitoring system [12-16]. These days cloud computing from various features, such as descriptions, distinct structures, and empowering technologies is the best choice for distributed database [17]. All measurements made by the technician are stored directly in the cloud database [18-19]. The technician simply places the Ceramic tile in the designated location in the hardware setup, observes live streaming on the camera, and captures an image of the surface of tile. This camera is connected with a WiFi network. The application program reads the image, measures the measurement according to the standard values of the tiles, and verifies the measurements and texture or patterns of the tile. Good and bad measurement decisions are shown using red and green LEDs controlled by the Arduino component. The administrator displays and reports all the details of the stored measurements, along with the technician ID, technician shift time (data can be filtered on daily basis), and the good or bad status of the tile measurements. The complete system architecture is shown in Figure 2.

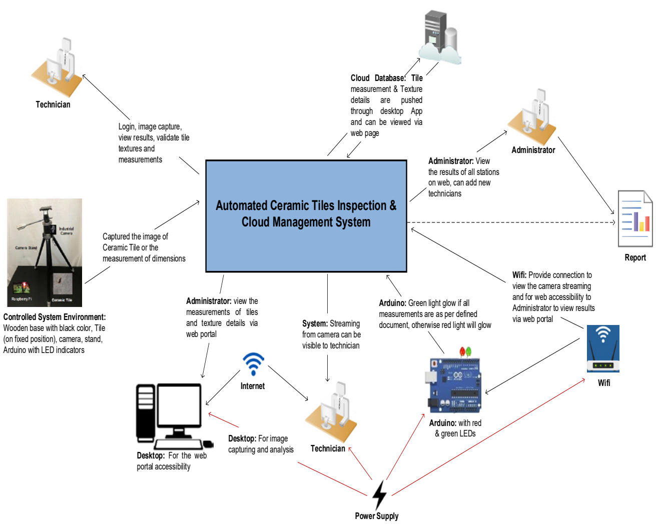


Fig. 2 Automated Ceramic tiles inspection & cloud management system

LITERATURE REVIEW

Elbehiery et al., [20] and other authors mentioned the issues of manual system for tiles inspection and highlighted the need of automated tiles inspection system. Authors discussed the different techniques and methods to automated inspection of tiles. Some very common approaches are machine learning based, image processing based and sensor based techniques [21-24].

METHODOLOGY

An Image Processing (IP) wireless camera is used to take input images for tiles that require uniform light for clear vision. The image captured for preprocessing where scaling, translation, and rotation are performed. Once preprocessing is done, contrast balancing operations are performed. Image filtering techniques are applied to the input image. Gaussian Filter helps to reduce the noise and gives the more contrasted image for further processing. Media filters will reduce the noise while keeping the contrasted edges sharp without having them blur. By subtracting the image with standard image inspection of defect will be done for any crack, hole, or unusual pattern. If there is any defect detected the system transmitted a message for bad tiles and a red light is ON, otherwise green light will be ON, this was controlled using raspberry pie built-in the system. The complete status about the tiles along with measurements and findings are stored in cloud database along with the profile of technician and time of observation. It will help the tile inspection organization to find the details online. The detailed system process model is described in figure 3.

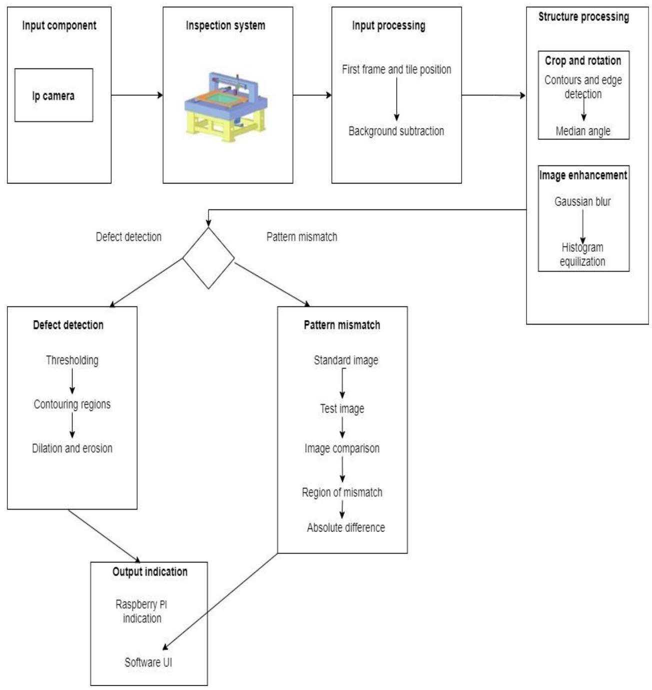


Fig. 3 System Process Model

Image Processing Part

The image processing part applied on each captured image is described in figure 4

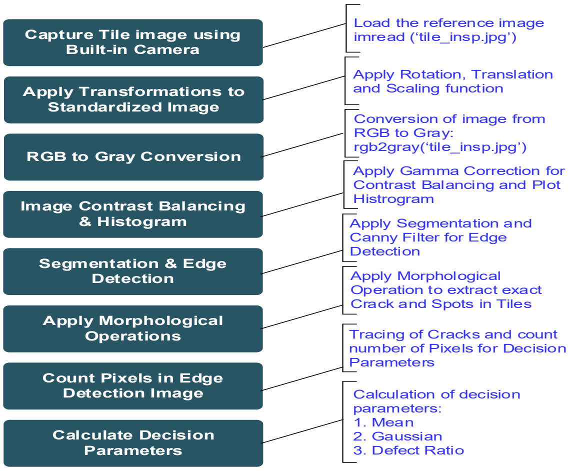


Fig. 4 Image Processing Module

Level of Defected Tiles

After the observation and analysis of multiple tiles it was noted that the maximum defect ratio detected in the tile exceeds to 50% will be considered severely defected, if the tiles exceed the defect ratio of 10% then they are slightly defected, and rest are not defected.

Defect Ratio

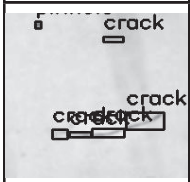
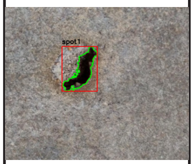
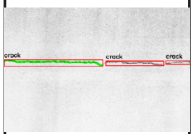
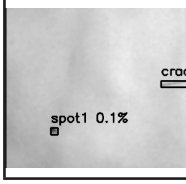
The defect ratio of the image is the decision parameter from which the tile is categorized as severely defected, defected, and non-defected.

The defect ratio is calculated by

$$Defect\ Ratio = \frac{Area\ of\ Defected\ Region}{Total\ Area\ of\ Sample} * 100$$

It was observed that the maximum defect ratio found in a tile which has multiple defects and tiles are graded based on defect ratios, number of cracks and pinholes. The analysis is shown in Table 1.

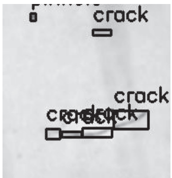
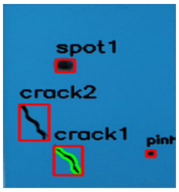
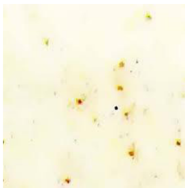
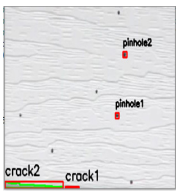
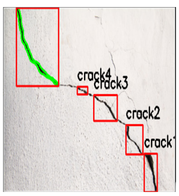
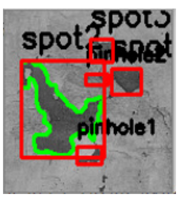
Table 1. Analysis and Observations

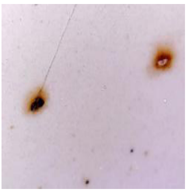
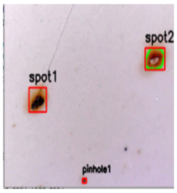
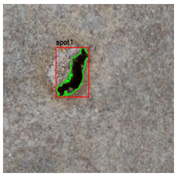
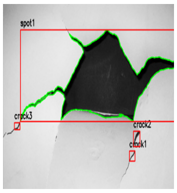
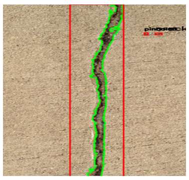
Tile	Cracks and Defect Ratio	Spots and Defect Ratio	Pinholes and Defect Ratio	Mean of Defect	Max Defect Ratio
	Crack1: 0.198 Crack2: 0.25 Crack3:0.012 Crack4:0.12	-	:Pinhole1 0.017	0.145	0.25
		Spot1 1.592		1.592	1.592
	Crack1:3.58 Crack2: 1.958 Crack3: 1.003			2.180	3.58
	Crack1: 0.24	Spot1: 0.1		0.17	0.24

Results

The results of tested tiles are shown in table below. The red color box indicates severe defect detected by the system based on number of cracks and defect ration as shown in Table 2.

Table 2. Observation Table with Defect Ratios

ID	Tile Sample	Resulted Tile	Cracks and Defect Ratio	Spots and Defect Ratio	Pinholes and Defect Ratio	Correct Defect Result	Actual Result
1			Crack1: 0.198 :Crack2 0.25 :Crack3 0.012 :Crack4 0.12	-	:Pinhole1 0.017	Crack1 Crack2 Crack3 Crack4 Pinhole1	Crack1 Crack2 Crack3 Crack4 Pinhole1
2			Crack1: 0.69 Crack2: 0.694	Spot1: 0.612	Pinhole1: 0.13	,Crack1 ,Crack2 ,Spot1 Pinhole1	,Crack1 ,Crack2 ,Spot1 Pinhole1
3			-	-	Pinhole1: 0.416 Pinhole2: 0.299 Pinhole3: 0.43 Pinhole4: 0.26	:Pinhole1 :Pinhole2 :Pinhole3 :Pinhole4	:Pinhole1 :Pinhole2 :Pinhole3 :Pinhole4
4			Crack1: 0.0612 Crack2: 0.6910	-	Pinhole1: 0.049 Pinhole2: 0.05	,Crack1 ,Crack2 Pinhole1 ,Pinhole2 ,Pinhole3 Pinhole4	,Crack1 ,Crack2 Pinhole1 Pinhole2
5			Crack1: 0.478 Crack2: 0.2303 Crack3: 0.253 Crack4: 0.08 Crack5: 0.858	-	-	Crack1 Crack2 Crack3 Crack4 Crack5	Crack1 Crack2 Crack3 Crack4 Crack5
6			-	Spot1: 1.95 Spot2: 13.7001 Spot3:1.042	Pinhole1: 0.657 Pinhole2: 0.402	Spot1 Spot2 Spot3 Pinhole1 Pinhole2	Spot1 Spot2 Spot3 Pinhole1 Pinhole2

7			-	Spot1:0.87 Spot2: 1.050	Pinhole1: 0.047	Spot1 :Spot2 Pinhole1	Spot1 :Spot2 Pinhole1
8			-	Spot1 1.592	-	Spot1	Spot1
9			Crack1: 0.0209 Crack2: 0.066 Crack3: 0.023	Spot1: 16.68	-	Crack1 Crack2 Crack3 Spot1	Crack1 Crack2 Crack3 Spot1
10			Crack1 : 32.85	-	Pinhole1: 0.25	Crack1 Pinhole1	Crack1 Pinhole1

Confusion Matrix

Below table 3 is the confusion matrix for the detection of tiles defects.

Table 3. Confusion Matrix

Parameters	Cracks	Spots	Pinholes	Parameters	Cracks	Spots (%)	Pinholes (%)
Number of true positive (TP)	43	16	41	$Accuracy = \frac{TP+TN}{TP+FP+FN+TN}$	87.5	91.6	87.5
Number of true negative (TN)	62	94	64	$Precision = \frac{TP}{TP+FP}$	86	84.2	80.3
Number of false positive (FP)	7	3	10	$Sensitive = \frac{TP}{TP+FN}$	84.3	69.5	89.1
Number of false negative (FN)	8	7	5	$Specificty = \frac{TN}{FP+TN}$	89.8	96.9	86.4
-	-	-	-	$Poitive\ predictive\ value = \frac{TP}{FP+TP}$	86	84.2	80.3
-	-	-	-	$Negative\ predictive\ value = \frac{TN}{FN+TN}$	88.5	93	92.7

CONCLUSION

We addressed the problem of examining and testing the tiles of defects and pattern mismatch which many Ceramic tiles industry face. Preprocessing operations, enhancement and noise reduction algorithms were used to remove unwanted results from the image and for better output. SVM was used for the classification of defects. The main features are Image acquisition, image enhancement, defect detection and pattern mismatch, defect severity and LED indications using Raspberry Pi. The project successfully detected the different kinds of defects like pinholes, cracks, or spots. It also successfully matched the tiles which had pattern.

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