AUTOMATION SYSTEM DESIGN OF CERAMIC TILE RECTANGULARITY IDENTIFICATION PROCESS USING DIGITAL IMAGE PROCESSING WITH HARRIS CORNER DETECTION METHOD IN *BALAI BESAR KERAMIK* (BBK)

Muhammad Luthfil [1], Rino Andias Anugraha[2], Denny Sukma Eka Atmaja[3]

[1,2,3]Industrial Engineering Study Program, Indsutrial Engineering Faculty, Telkom University

[1]muh.luthfil23@gmail.com, [2]rino.kaprodi@gmail.com, [3]dennysukma@gmail.com

Abstract

Efficiency time in quality inspection process is very important.especially for rectangularity identification process. Manual inspection which is done manually by human operator use amount of time. In existing condition, it consume time until 104 seconds for one ceramic tile sample It will make operator more difficult if the sample size has a big number. This difficulties can be decreased by using digital image processing which is based automation system to do inspection process, especially for rectangularity identification process as an improvement. Digital image procesing will calculate the rectangularity deviation with Harris Corner Detection Method that integrated with PLC and HMI (Human Machine Interface) to make the process more faster. Harris corner detection method will identify the whole corners on ceramic tile sample image and calculate the deviation. The work priciple of improvement start from put the the ceramic tile on a conveyor with a palette,then the sample will trigger sensors and a webcam camera will capture the sample image and process it with MATLAB and the whole process is controlled by PLC (Programmable Logic Controller) and visualize it on HMI (Human Machine Interface). The whole process of improvement system consume about 38 seconds and make an efficiency in time about 62,68%.

Keywords : Keywords : Automation , Harris Corner, Digital Image Processing, Ceramic tile rectangullarity

1.Introduction

Ceramics industry in Indonesia have enough strong role for employment provision, it absorb up to 200.000 workers. Data in 2014 showed that Indonesia was ranked as the sixth largest ceramic manufacturer in the world (ASAKI,2014) [1]. Seeing from this fact, then the rate of production should be increased. The demand for large quantities mustbe accompanied with good quality control. *Balai Besar Keramik* as an offocial agencies, directly under the Ministry of Industry RI has the authority to issue a ceramic tile product certification in accordance with ISO 03-0106 standards. *Balai Besar Keramik* do the inspection process with measurement device called Deformation testing device based on SNI ISO 10545-2-2010.

The Defomation testing device can be seen on Figure 1.

Figure 1. Deformation testing device in *Balai Besar Keramik*

After direct observation in *Balai Besar Keramik*, Generally, overal process in eksisting system in *Balai Besar Keramik* is done by several steps. The steps will be shown on Figure 2.

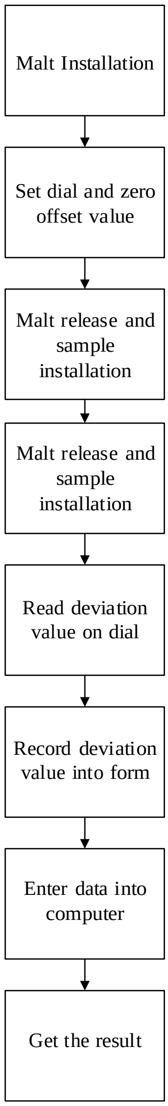

Figure 2. Steps in measure the rectangularity of ceramic tile in *Balai Besar Keramik*

Currently the process of inspection of the quality of ceramic tiles in Indonesia, particularly in the BBK is still done manually by human vision. This is very difficult and requires a relatively long time because of the limitations on human vision and perception differentiation between one individual with other individuals[2]. The measurement process in BBK will be shown on Figure 3.

Figure 3. Measurement process is done manually by operator

Using Image Processing in detecting defects ceramics have been used and proved to be very efficient [3] Digital image processing is used to extract a variety of features in the image. This process runs automatically without human intervention (Rahaman and Hossain, 2009). With the inspection process that runs automatically performed by digital image processing, we expected to replace the inspection process which still done manually by operators who perform measurements right angle of ceramic tiles Test Laboratory BBK. The use of digital processing of these ideals will make the measurement process becomes faster, more accurate and efficient, because it is not needed anymore repeated calibration process, the recording of measurement values manually, and the process of moving the test sample of ceramic tile.

2. Automation System to Optimize process

2.1 Definition of automation

Automation is a technology that create a workable process without human assistance [4]. Automation is applied with using the program and is controlled by the control systems and executed by the control systems with the help of the actuator output. a process can be said automation if there isn't human intervention in it

2.3 Image Processing

Although an image rich in information, but often the image that we have a degraded (degradation), for example, contains a defect or noise (noise), the color is too much contrast, less sharp, blur (blurring), and so forth. Of course, such an image is becoming more difficult to interpret because the information conveyed by the image to be reduced. To make the disrupted image easily interpreted (either by humans or machines), then the image needs to be manipulated into another image quality is better. Field of study in this regard is the image processing (image processing)[5].

2.3.1 Harris Corner Detection

There are many methods used in this Detection Corner, one of the most famous and the first is Moravec been developed by Hans P. Moravec in 1977 [6]. Harris and Stephens improved upon Moravec's corner detector by considering the differential of the corner score with respect to direction directly, instead of using shifted patches. (This corner score is often referred to as autocorrelation, since the term is used in the paper in which this detector is described. However, the mathematics in the paper clearly indicate that the sum of squared differences is used.) Without loss of generality, we will assume a grayscale 2-dimensional image is used. Let this image be given by *I*, Consider taking an image patch over the area (*u*,*v*) and shifting it by (*x*,*y*) . The weighted sum of squared differences (SSD) between these two patches, denoted *S*, is given by:

$$S(x,y) = \sum_u \sum_v w(u,v)\left(I(u+x, v+y) - I(u,v)\right)^2 \qquad (1)$$

Which can be written in matrix form:

$$S(x,y) \approx \begin{pmatrix} x & y \end{pmatrix} A \begin{pmatrix} x \\ y \end{pmatrix} \qquad (2)$$

where *A* is the structure tensor, we get:

$$A = \sum_u \sum_v w(u,v) \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} = \begin{bmatrix} \langle I_x^2 \rangle & \langle I_x I_y \rangle \\ \langle I_x I_y \rangle & \langle I_y^2 \rangle \end{bmatrix} \qquad .(3)$$

Example result picture from Harris corner detection will be shown on Figure 4.

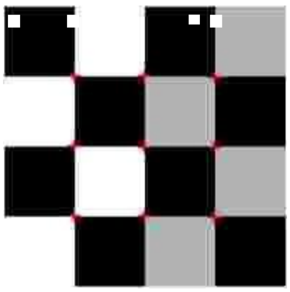

Figure 4. Harris Corner detection result on checkboard image (Mathworks,2010)

2.4 Human Machine Interface

Human Machine Interface (HMI) merupakan penghubung sistem SCADA antara operator dengan teknologi mesin. Hubungan antara manusia dan mesin ini merupakan perubahan bentuk bahasa mesin ke bahasa manusia yang dapat dipahami. Secara sederhana, HMI berfungsi sebagai jembatan bagi operator untuk memahami proses yang terjadi pada mesin [7]

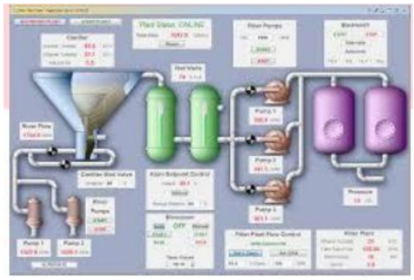

Figure 5. Human machine Interface example

3. Improvement System Design

Improvement system is build to optimize the process measurement in eksisting system of BBK. Here are the conceptual model for improvment system design. The conceptual model will be shown on Figure 6.

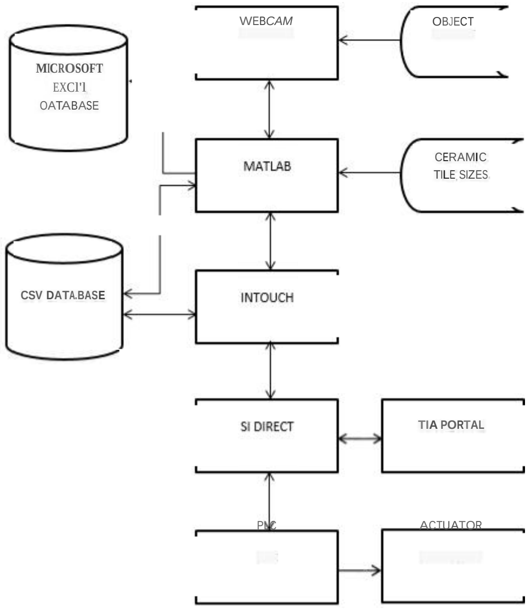

Figure 6. Improvement system design

3.1 Image Processing System Scenario

To get the rectangularity calculation, here are the steps that the Matlab do to realize it. It starts from Input image and end with deviation of each angle results. The process will be shown on Figure 7.

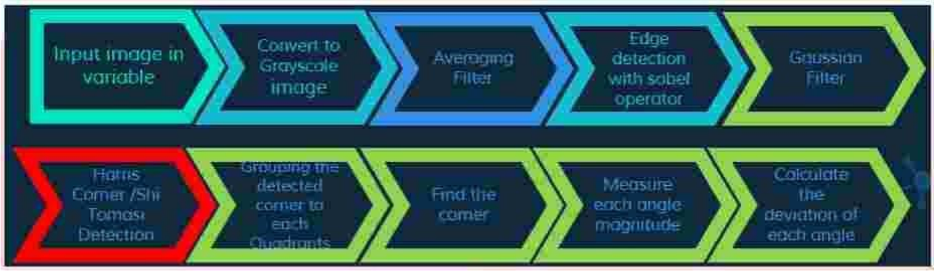

Figure 7. Image Processing System Scenario

3.2 Programmable Logic Controller (PLC) Scenario

PLC as the central of controlling the actuator and output. It controls the whole process based on program that have already created and planted in the PLC before. Scenario process of PLC is shown on Table 1.

No	Inputs	Action	Results	Conclusion
1	Switch Start	Push start button (I0.I)	Indicator start lamp is on (Q0.5) and *conveyor* is moving forward (Q0.1)	Success
2	Switch Stop	Push stop button (I0.7)	Stop indicator lamp is on and system is stopped	Success
3	Switch Sensor 1	Push sensor 1 button (I0.4)	Sensor 1 indicator lamp is on (Q0.3), *conveyor* is stopped and cylinder is risen up at the same time, and *webcam* captured the picture	Success
4	Switch Sensor 2	Press sensor 2 button (I0.3)	Sensor 2 indicator lamp is on (Q0.4) and Conveyor is stopped	Success
5	Emergency	Press emergency button (I0.0)	Emergency lamp indicator is on and conveyor is moving backward (Q0.2)	Success
7	Manual	Press Manual button (I0.6)	Manual indicator lamp is on	Success

Table 1.PLC Scenario

3.3 Human Machine Interface (HMI) Scenario

Human Machine Interface will allow users to control the whole process directly from the Software based. In this system, controlling the whole process is available in 2 ways. Here are the Scenario Process of Human Machine Interface will be shown on Table 2.

No	Indicators	Results	Conclusion
1	Start lamp is on	System started	Success
2	Stop lamp is on	Siystem stopped	Success
3	Emergency lamp	Emergency lamp is blinking and forward lamp is stopped	Success
4	Sensor 1 lamp	Conveyor is stopped and cylinder lamp is on	Success
5	Sensor 2 lamp	Conveyor is stopped	Success
6	Cylinder lamp	Cylinder is risen up	Success
8	Forward lamp	Conveyor is starting to move forward	Success
9	Manual lamp	System is in manual mode	Success
10	Backward lamp	Conveyor move backward	Success

Table 2. HMI (Human Machine Interface) Scenario

3.4 Time Comparison Result

Time comparison is meant to compare existing system time requirement with improvement system time requirement. After field observation, existing system need 104 seconds in total to finish one sample. Existing activity components will be shown on Table 3.

Table 3. Total time summary in existing system

No	Activity Name	Time Process (second)
1	Malt Installation	22
2	Dials Installation	5
3	Dials Calibration	4
4	Malt release	6
5	Ceramic tile installation	17
6	Measure rectangularity (1st Torsion)	8
	2nd Torsion	6
	3rd Torsion	9
	4th Torsion	8
7	Deviation record (1st Torsion)	6
	2nd Torsion	4
	3rd Torsion	4
	4th Torsion	3
8	Take ceramic tile	2
	Total	104

After testing the improvement system and calculate time requirement for test one sample, the result will be shown on Table 4.

Table 4. Improvement time requirement

No	Activities	Time (Seconds)
1	Put ceramic tile to pokayoke	3
2	Put ceramic tile to *conveyor*	4
2	Ceramic is carried	11
3	Capture the image	2
4	Deviation calculation	4
5	Database recording	12
6	Take ceramic tile sample	2
Total		38

And for time coomparison, all of the activity that equvalent for existing and improvement system are compared to calculate time efficiency, and we get efficiency is about 62.68%. The comparison table will be shown on Table 5.

Table 5. Comparison time between existing and improvement

No	Activities	Existing time requirement (seconds)	Improvement system time requirement (detik)	difference (seconds)
1	Peletakan Keramik	17	7	10
2	Perhitungan Simpangan	31	4	27
3	Pencatatan Simpangan	17	12	5
3	Pengambilan Keramik	2	2	0
Total				42

4. Conclusion

After designing and testing the improvement system, it succesfully to identify rectangularity of testing sample. All components successfully integrated to each other, Conveyor successfully bring palette and sample, sensor successfully triggered and stop the conveyor, webcam capture the image sample, MATLAB successfully detect corners then calculate deviation value, and HMI successfully displayed the whole system in realtime. After do time comparison, the system give time efficiency until 62.68% with reduce time up to 42 seconds from existing time requirement.

References

[1] Asosiasi keramik Indonesia (ASAKI) 2014

[2] Atmaja, D.S.E. 2015. *Optimasi Pengukuran Dimensi dan Cacat Permukaan Ubin Keramik Menggunakan Pengolahan Citra Digital dan* Full Factorial Design. Yogyakarta: Universitas Gadjah Mada.

[3] Rahaman, G.M.A dan Hossain, Md., 2009. Automatic Defect Detection and Classification Techniques From Image : A Special Case using Ceramic Tiles, International Journal of Computer science and Information Security, Vol. 1 No.1.

[4] Groover, M.P. 2001. Otomasi, Sistem Produksi dan Computer Integrated Manufacturing. New Jersey:Pearson

[5] Gonzales, R.C dan Wood R.E.2002. Digital Image Processing. New Jersey: University of Tennessee

[6] Marsetio, Sany A. 2012**.** Deteksi Sudut Pada Gambar 2D Berurutan Dengan Menggunakan Metode *Harris/Plessey Corner Detector*. Surabaya: PENS (Politeknik Elektronika Negeri Surabaya).

[7] Wicaksono, H. 2012. Scada Software dengan Wonderware Intouch: Dasar-dasar pemograman. Yogyakarta: Graha Ilmu