PROPOSED DESIGN OF INTELLIGENT INSPECTION SYSTEM FOR QUALITY CONTROL PROCESS

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ABSTRACT

A quality control process mostly relies on a robust inspection process in order to have accurate data to be analyzed for the purpose of quality management. An intelligent inspection system is employed for automatic the inspection process. Choosing this system requires an integrated understanding of quality control process within the production system, instead of the budget consideration. This paper offers the design methodology of intelligent inspection system especially for connecting with the seven tools of quality. First, the required data characteristic of cause and effect diagram, check sheet, control chart, histogram, pareto chart, scatter diagram, flow chart, and run chart should be determined of how the data can be captured. The source of data mostly coming from the process of inspection and added with the previous knowledge of the production system. The inspection process can be designed using an automated process such as the use of sensors and cameras. The digital image processing has been used to simplify the process and using an efficient required tool. The inspection variables for the seven tools are attached to the image captured through a value interpolation mechanism. The additional step is to identify the required component for the designed system such as camera, conveyor, part or product handling and subsequent action to handle the rejected product. Following the proposed methodology that has been used for designing the intelligent inspection system for various type of product will have a robust and suitable system to align with quality control procedures.

Keywords: intelligent inspection system, digital image processing, quality control.

1. INTRODUCTION

In the current competition to increase the competitiveness of companies, product innovation is needed to gain customer interest. Montgomery (2009) suggested that product innovation can only be done when the company has reached the best conditions in achieving the expected quality. Quality control is needed as an absolute procedure to ensure that products produced are by following standards or do not have defects (Besterfield, 2009). Besides quality control is needed as a tool to make improvements to the production process. Improvement is based on data analysis which generally uses seven tools of quality. Okerekehe (2014) shows that the basic data needed in the system is an inspection process.

Inspections can be classified into two types, offline inspection, and online inspection. Online inspection monitors the quality level during the production process, while an offline inspection is performed on finished products. Tzimerman and Herer (2009) show offline weaknesses and anticipate them with dynamic programming methods, while Tirkel and Rabinowitz (2012) show the advantages of doing online inspection to analyze relationships between variables. Inspections also need to be evaluated about financial benefits (Tirkel and Rabinowitz, 2014) because the inspection is not an added value process. Furthermore, Kurniati, Yeh & Lin (2015) suggest that maintenance also needs to be linked to quality inspection to get a robust process.

Even though inspection does not provide value to the product, inspection is considered to be one of the important parts of quality control. Inspection becomes part of decision making to define the conforming lot and non-conforming lot (Bohwmick and Samanta, 2012; Babar, Wook & Sarkar, 2016). Conventional inspection processes have several disadvantages including time-consuming and causing inconsistencies between operators (Khan, Iqbal and Khan, 2005). Besides, there are also risks of fatigue, human error, and slower speed. While using real-time inspection, speed, accuracy, and reliability can be improved (Rahman, Prabuwono, Zamri & Jaya, 2008)

The example of an implementation of intelligent inspection systems is in the form of automated optical inspection. It uses real-time detection of products and improves speed and accuracy. With the induction of deep machine earning techniques based on convolutional neural networks, the defect detection accuracy can be enhanced (Ye, Pan, Chang & Yu, 2018). A research combined image processing which is an Adaptive Network Fuzzy Inference System to differentiate conforming items and non-conforming items, and artificial intelligence. This model is proven to have a very small error rate and a very high accuracy rate (Andri, 2016). Integration of radio frequency identification with a virtual three-dimensional model that is represented by the AutoCAD 360 drawing viewer on a mobile device can also be used as an intelligent inspection system. RFID is proven to be significantly faster to identify types of falsework than a manual process. However, it is found that the system was less efficient in positioning the components (Atherinis, Bakowski, Velcek & Moon, 2017).

This paper presents an intelligent inspection system design for quality control using seven tools of quality. The seven tools for quality control are some methods to make quantitative decisions using numerous data that are obtained from the product, process, and customer. The data is mostly coming from automated inspection that is processed with digital image processing and connected with other useful customer information.

2. METHODOLOGY

First, the Intelligent Inspection System Design begins by identifying expected outputs to formulate design boundaries. The expected output in question is quality characteristics or also called critical quality, which will be inspected for quality control. An alternative that can be done is to map what controls have been needed both variables and attributes. Product specifications are generally used to see the upper and lower limits of the control value.

Second, the identification of expected processes is carried out to determine how the inspection process is carried out. In this research digital image processing techniques are used, captured images are processed to obtain the desired variables or attributes. The intended inspection process is how to place parts/products in the right position, which part of the image is processed and how to set parameters to be processed as data. Image processing is done by greyscaling, matrix application to get a more accurate image, counting the number of pixels in a particular part using a histogram, and comparison with reference images (can be taken from examples of products that are considered perfect).

Third, data retrieval techniques need to be defined by determining the range of data retrieval by synchronizing the speed of the conveyor (material handling device) with the speed of image capture. The specified capture rate will determine the productivity of the system designed with a measure of how many products are inspected in a certain time unit. The designed system also needs to consider how much memory capacity is compared to images taken in one production period (for example 1 production shift).

Fourth, the inspection process is a general design of an integrated system. The system needs to be determined whether the inspection will proceed with grading and also how many branches of the process continue after the inspection process. For example, whether the product will be separated based on the classification of rejects that have been identified and also whether it is separated based on the grade that has been recorded by the system (in the case of design is an inspection of defects as well as grading). Besides, some things that become input data in the seven tools of quality cannot be taken from captured images but derived from data and information obtained from quality control analysis, customer surveys and other references.

Fifth, system design is the stage for determining hardware and software requirements. In this research the software designed is single, involving hardware including cameras, conveyors, jigs and fixtures, and other peripherals that support lighting stability. Lighting stability is very important to get consistent images as raw input from digital image processing.

Finally, prototyping is done by integrating software that has been designed with hardware that has been installed in the system. The integration was tested to obtain some data compared to manual inspection. This stage is important to test the accuracy of the system that will be used as an inspection and grading process. Adjustments and improvements are made to get results that are closer to 100% accuracy.

3. RESULT AND DISCUSSION

This research is an intelligent inspection system design that has been combined to obtain outputs according to the requirements of the seven tools of quality. The information presented in this paper has been carried out as a complete stage of the prototyping process for four types of products namely bottled drinks, ceramic tiles, and shrimp. These three products have their uniqueness but are approached with the same steps so that they can be used as a reference for other products.

At the Expected Output stage, quality characteristics are determined according to the specifications requested or variables/attributes that are considered as important as supporting business value. A small survey was conducted to determine the variables/attributes of each product in the company which is the final seller (interacting directly with buyers). The survey results that are used as guidelines for expected output can be seen in Table 1.

Table 1. Related variable/attribute for each product

Bottled drink	Ceramic tile	Shrimp
Bottle cap	Crack	No head loss
Label	Waviness	No tail loss
Volume	Glazed appearance	Dimension
Crack	Dimension	Color appearance
Content (product) color	Cutting edge	Shape

At the Expected Process stage, each variable or attribute that has been set in the previous stage - the part that needs to be observed and the algorithm needed. The algorithm is designed in such a way as to consider the accuracy and speed of the process, so that one capture is obtained at once the five variables/attributes that are measured/tested. Examples of algorithms for one of the variables in one system can be seen in Figure 1.

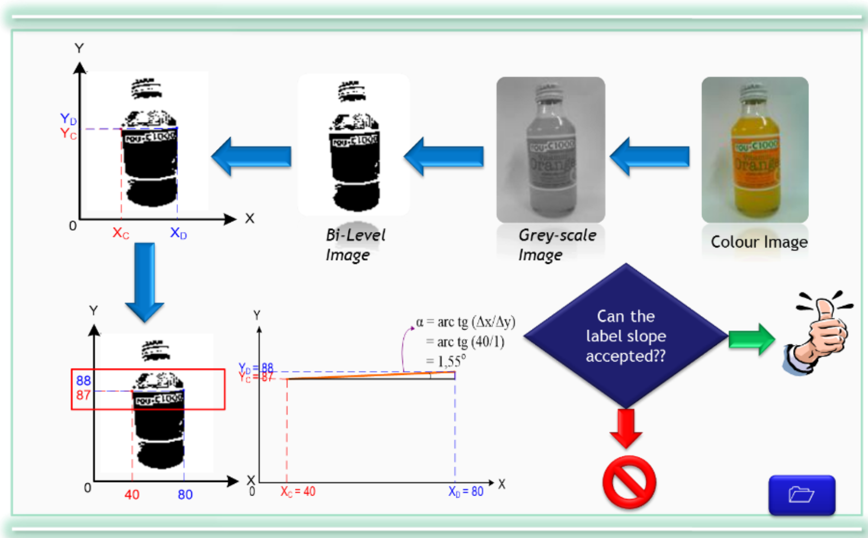

Figure 1. Related algorithm for the expected process within certain variable/attribute

Figure 2. A typical layout for determining conveyor speed – image capturing process

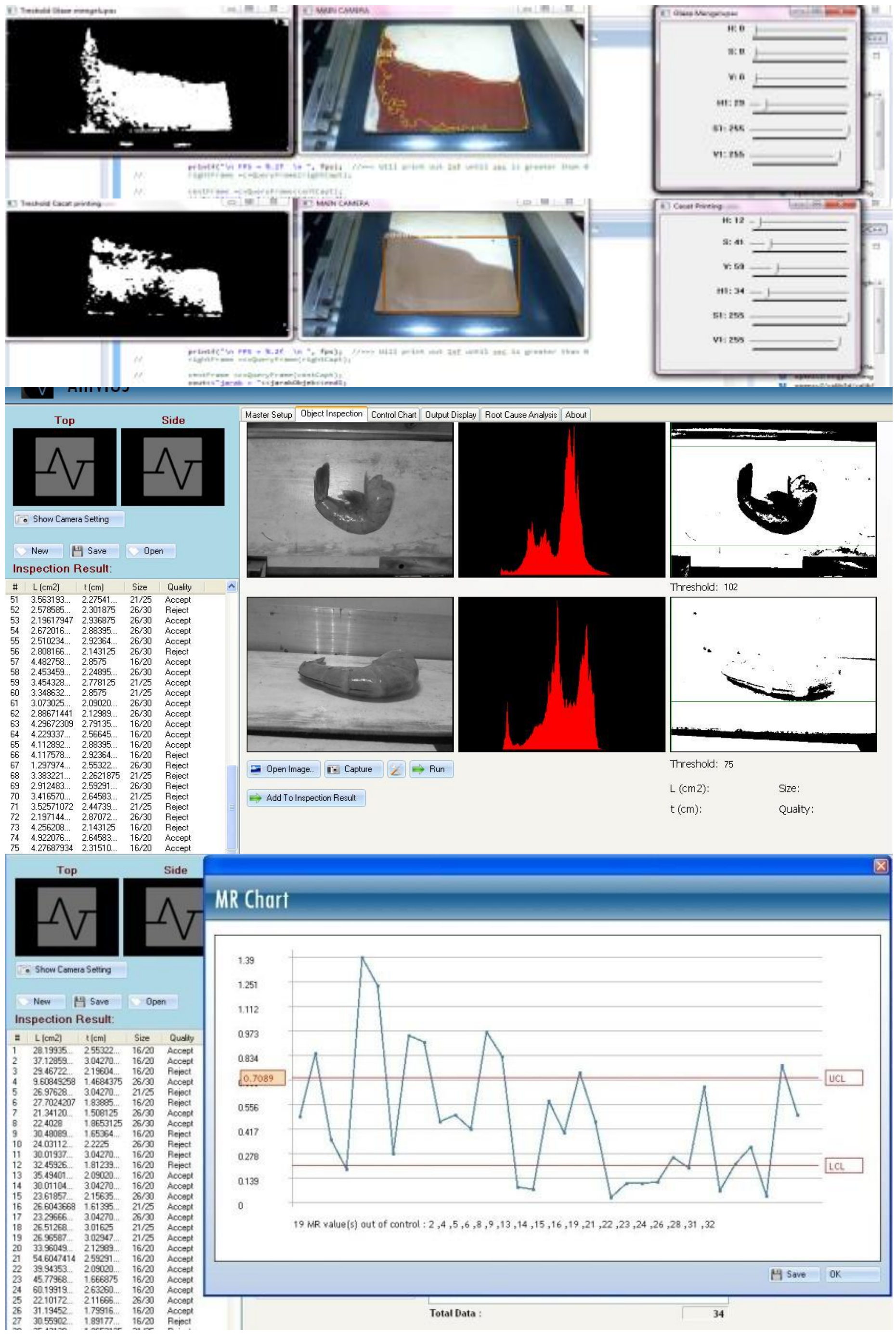

Figure 3. A typical interface of the software

At the data gathering stage, the speed of the conveyor determines how much data can be processed in each unit of time. The area observed in the shooting and the stability of the product's position is considered in the speed of the inspection process. Bottled drinks require 3 seconds for a single process, while ceramic tiles require 5 seconds, and shrimp need 1 second. The time requirement is targeted starting from the start point to the finish point (before and after the image capturing box) as can be seen in Figure 2.

In the inspection process stage, determining the need for the grading process as a complete inspection process is carried out at this stage. Products that cannot be sold in the second quality condition (definite whether it is good or defect) do not need a grading process. The grading process is possible if there is a need to classify products based on certain quality specifications. Bottled drink products are only separated by the defect and finished good, while ceramic tiles use 3 types of grading (Primary quality, Quality 1 and Quality 2) and shrimp using 2 types of grading (Primary quality and Secondary quality).

At the system design stage, the three systems that are designed have the same typical conveyor and image capturing stations. Conveyors are equipped with stopper and branched conveyor ends if desired grading process or separate defect products with good products. The use of jig and fixture is used for bottled drinks to keep the bottle in a stable position, while ceramic tile and shrimp are limited by a special design of the conveyor barrier wall.

In the prototyping and testing stage, a trial and implementation of the design have been carried out. Testing is also used to measure the level of accuracy and robustness of the process to be used in thousands of processes for use at certain time intervals. The trial was carried out within 3 hours of operation for this prototype and checked again the condition of the hardware and software used. The trials are also compared to the speed of inspections carried out manually by operators. A partial display of the software being tested can be seen in Figure 3. The data collected from the inspection will be monitored and managed to support decision makings. The data will be presented in the form of histogram and pareto chart showing the largest to the smallest number of defects occurences. The most significant problems and products have to be analyzed to find the root causes and then improved. The data will also be shown in the form of control chart to keep monitoring the variation of data. By combining the digital image processing and seven tools of quality control, the monitoring and managing process can be done quickly to make sure that every decision will address the right problem, the right product quickly.

The advantage of digital image processing used in all three prototyping examples is that it is easy to prepare equipment and is relatively inexpensive. The disadvantages of using digital image processing are the presence of certain variables that cannot be identified, including odor, weight, and hardness.

4. CONCLUSION

The six basic stages of determining expected output, determining the expected process, designing data gathering, designing inspection processes, hardware and software (system design) as well as prototyping and testing can be used as a reference sequence for the process of intelligent inspection system design that supports the quality control process.

The accuracy of each prototype made has reached more than 96%, with data recording and processing speeds approaching 1 second. This can be improved by using better hardware or by redesigning the fixture jig to match the accelerated conveyor speed. The result will be shown in histogram, pareto chart and control chart to support analysis and decision making processes.

A combination with methods other than digital image processing will be able to complete the ability of the system designed to capture other variables that cannot be estimated through images. Otherwise, new research finding that broadens the interpretation of images is needed to support this highly efficient digital image processing.

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