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The Preliminary Analysis of SSDXCORR Techniques Performance under Multi-Virtual-Condition

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Abstract: Having an automatic vision inspection system has many advantages over manual inspection since it offers research quality at a professional labor level, able to research more consistently for a long duration at a faster rate. However, despite of many advantages this system incurred high cost for initial set up, especially in term of hardware and software set up. Therefore, realizing the cost involved, we suggest the usage of smartphone camera and algorithm that developed by using Matlab 2012a in this study. We also developed and modified readily available algorithms, SSDXCORR by Yu Wu to fit our study needs. Since, our aim are to have fast, robust and affordable system, we test our algorithms, SSDXCORR with virtual modified images as preliminary analysis before in real environment. At the end of the analysis, we found this algorithms limitation and suggest improvement to be done on the algorithm and experimental environment. Having an automatic vision inspection system has many advantages over manual inspection since it offers research quality at a professional labor level, able to research more consistently for a long duration at a faster rate. However, despite of many advantages, this system incurred high cost for initial set up, especially in term of hardware and software set up. Therefore, realizing the cost involved, we suggest the usage of smartphone camera and algorithm that developed by using Matlab 2012a in this study. We also developed and modified readily available algorithms, SSDXCORR by Yu Wu to fit our study needs. Since, our aim are to have fast, robust and affordable system, we test our algorithms, SSDXCORR with virtual modified images as preliminary analysis before in real environment. At the end of the analysis, we found this algorithms limitation and suggest improvement to be done on the algorithm and experimental environment.

Key words: Inspection, defect detection, Sum Square Different Correlation (SSDXCORR), environment, Malaysia

INTRODUCTION

Vision system is generally known as automatic extraction of information from images. This system consists of a lens, lighting, sensors and vision processing and communication unit. They commonly used in various fields, medical, traffic controlling and industry, normally for checking and inspection purpose. In terms of inspection purpose, this system provides imaging-based automatic inspection and analysis for applications such as automatic inspection, process control and robot guidance for industry (Graves and Batchelor, 2003; Steger *et al*., 2008). Interestingly, now a days vision system start to be paired with robot automation to perform various tasks; part identification, inspection, location orientation and range finding (Rehg, 2000).

Vision inspection system has many advantages over manual inspection in term of quality, rate of work and duration of working. As compared to manual labor, automatic vision inspection system offered work quality at a professional labor level, able to research more consistently for a long duration at a faster rate. However, despite of its benefits, this system normally incurred high cost of hardware, software and setup. Realizing this matter, we try to come up with the idea of developing a vision system that fast and affordable. Hardware and software are the most important component that needs to be studied in order to develop an effective vision inspection system. Generally, hardwares refer to image acquisition tools. In industry, various industrial cameras which have high speed image acquisition, high durability and high cost is normally used to fit the industrial

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requirement and environment. In contra for research purpose, researchers normally look for affordable and versatile acquisition tool. Previously, most researchers use webcam, digital camera and smartphone camera as their image acquisition tool (Venkatesan and Ganesh, 2012). However, digital camera usually do not permit real time data process or transfer and the resolution is fix.n. Moreover, webcam provides flexibility to choose resolution like smartphone camera. However, its resolution normally low thus lead to poor photo quality.

Therefore, we believe that selecting smartphone camera as an image acquisition tool is a smart choice since it has great flexibility for relocation wide range of resolution selection, automatic adjustment to light, enable real-time data transfer and most important it is affordable and suit the current technology development (Anuar *et al*., 2000).

In term of image processing techniques, there are many methods that can be used for inspecting including template matching, edge detection and multiple recognition. Template matching can be analogized as a technique of matching a piece of Jigsaw puzzle with the complete puzzle whether it perfectly match or there is differences. Sum Square Difference (SSD), Cross Relation (CR) and Coefficient Correlation (CC) are part of template matching method. SSD count difference in each pixel of two images (Ourselin *et al*., 2002) sum up square product of pixel difference between two figures (Di Stefano and Mattoccia, 2003) and finally finding the minimum value in the image matrices (Hisham *et al*., 2015).

In our study, we want to develop an inspection system for inspecting metal object specifically for counting the number of holes or screws. The main aim of our study is to develop a system that has high inspection accuracy under various condition and fast. Therefore, algorithms that combined SSD and CR is developed, called SSDXCORR.

The algorithm which has been obtained from MATLAB Exchange (Wu, 2011) has been modified and tested virtually in order to achieve the target. Noted that this study only focuses on stationary object inspection, working under close environment where lighting is controlled, focus on inspecting metal product defect due to missing bolt and fasterners.

MATERIALS AND METHODS

Methodology study consists of hardware and software set up, image acquisition, image processing and experimental set up phase (Fig. 1). At software and hardware set up phase, 5 MP of smartphone camera is used as acquisition tool and connected to the Matlab 2012a in the laptop using SmartCam android application via Bluetooth. Noted that we used smartphone camera since it has capability for adjusting resolution, LED lighting and autofocus lens. Moreover, it able to act as portable webcam, therefore it enables real time data transfer to laptop.

After software and hardware been set up, smartphone camera able to act as the acquisition tool. Acquisited images can be be set as template images or input images (Fig. 1a and b).

In this experiment, there will be two sides of the metal surface that need to be inspected as shown in Fig. 1c. Therefore, the templates will consist of screw images for both sides and are stored in the data base. It will be used later as referral data for determining either the inspected surface has defect or not. Meanwhile, input images can directly undergo image processing to get the result or being saved in file for modification purpose.

Noted that the size area of capture images has been determined to be taken at the L = 20 cm and cropped at size 150×180 pixels or 1.27×1.52 cm for side 1, 60×160 pixels or 0.51×1.35 cm side 2, 0.25×0.25 cm for template size. L is the length between camera and metal surface. This size and length has been determined since the detection work optimum at this position. Further, explanation regarding the determination of experimental set up parameters will be explained in details in our next study.

Since, our aim is to develop robust system against various condition while having fast execution time, the performance analysis will be done based on execution time (experiment A), ability to detect parts in various orientations of input (experiment B) and different lighting environment (experiment C) , finally experiment D, to test accurateness of the system while subjecting to random input. In this experiment, instead of manually changing the input images in reality, we modified the readily stored input images in the file by using Microsoft 2010 by assuming the virtual and real modification of images do not affect the result (Fig. 2).

For experiment A, the input will be the images of the two sides surfaces at original lighting and normal orientation which is frontal and upright images. The execution time is recorded for this experiment. Then for experiment B, we adjust the brightness of the input images in order to mimic dark and bright surrounding in real environment (Fig. 3). The brightness is adjusted between 40-50 with 10% brightness increment in each testing. A percentage is used to indicate how much the brightness is increased or decreased as compared to the original image. Next, the minus sign is used to indicate

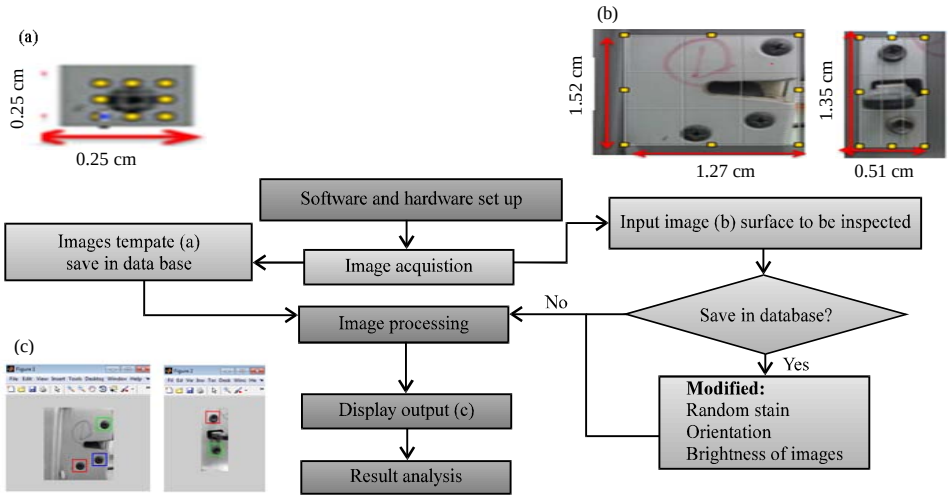

Fig. 1: Methodology flowchart

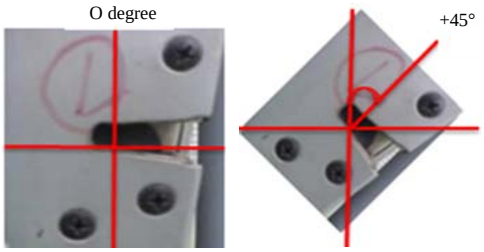

Fig. 2: Oriented input images of side 1

Fig. 3: Brightness lighting adjustment for input images

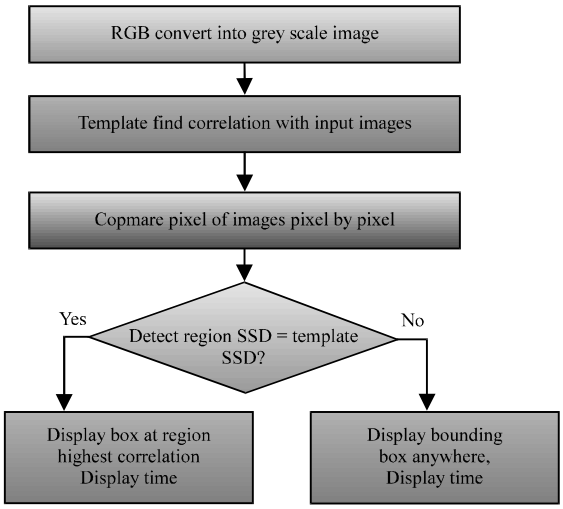

Fig. 4: SSDXCORR working flow chart

darker environment while addition sign indicate brighter environment as compared to normal or original lighting.

Next for experiment C, images of input images in A will be rotated at various orientation of 10, 20, 30, 40, 45, 90, 135, 180°. The aim of this experiment is to test the capability of the algorithm to give correct result even when the input is not place in upright position. The orientation is increased by 10° only since we want to observe the result. However, since the detection does not affected by small changes, we decided to increase the orientation by 45°.

Finally for experiment D, then input images with random modification are made and tested. The purpose of this experiment is to analyze the efficiency of the algorithm to detect parts in case the surface of the object has irregularities such as stain, rust orientation and image brightness (Fig. 3).

As for algorithms, we use readily available SSDXCORR algorithms from MATLAB exchange and modified it to suit our application. The capture images of the metal product will be sent to the laptop and underwent image processing stage before displaying the result. Figure 4 shows the flowchart of SSDXCORR algorithms and Fig. 5 shows the output of the image processing.

The result later will be analyzed in term of point detection percentage. The formula for calculating the percentage is as follows:

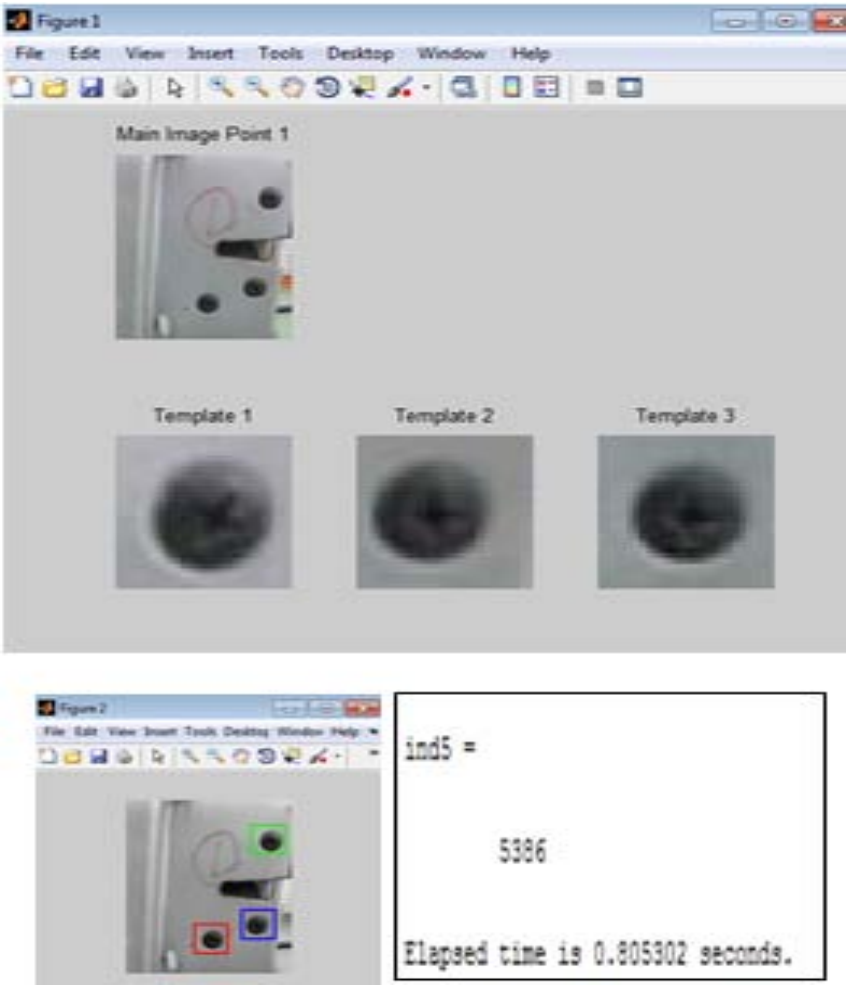

Fig. 5: Input images and its templates (top), detected screws (below left), execution time (below right)

$$\text{Percentage of points detection} = \frac{\text{Total number of detected points}}{\text{Total number of points}} \times 100$$

RESULTS AND DISCUSSION

For experiment A, elapsed time is calculated by having side 1 and side 2 images underwent SSDXCORR image processing for five consecutive times, before taking average execution time. From experiment A, we found the average execution time for SSDXCORR function is <1 sec which is 0.727 sec. This considered fast and satisfy one of the system qualification.

Figure 6 shows the percentage of point detection when input images are rotated to the certain degree. From the result, we found that SSDXCORR work well even with multiple orientation input since it scored 80% detection rate even with input that undergo 180° rotation.

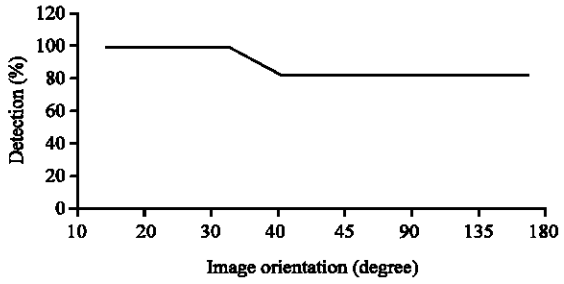

Fig. 6: Graph of experiment B result

As for experiment C, the performance of SSDXCORR against is decreased when the image brightness increase or decrease (Fig. 7). This might happen since SSDXCORR working principle is comparing each pixel of the template with the input image in grey scale conditon.

Therefore, the detection capability will decrease when the brightness change due to change in grey scale

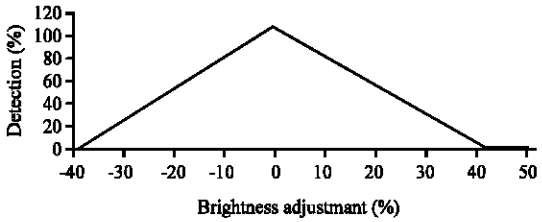

Fig. 7: Graph of experiment C result

intensity of the input images. For experiment D, we modified the ten images of side 1 and 2 with random modification such drawing stain, changing orientation and brightness before testing with the SSDXCORR function. From the experiment, we found that the percentage of detection is only 20% by using SSDXCORR. This happened since grey scale image have difficulty to detect the different in images that has been stained and modified, since they only have three values; 0, 255 and middle of both values to recognised object. It is predicted the detection can be improved if the image do not convert to greyscale.

CONCLUSION

Vision system is well known in the inspection field since it has good accuracy and able to work faster than conventional method. In our study, we would like to develop the algorithms that able to inspect metal object with good accuracy, fast and robust with reasonable cost. Therefore, we suggested the use of smartphone cameras instead of expensive industrial camera for study purpose. Next, we modified readily available algorithms to suit the application. For this study,we used SSDXCORR function as image processing algorithms.

In this analysis, we found that SSDXCORR has fast computational time which is <1 sec. However, in terms of robustness and detection rate, its capability decrease when the input images subject to various changing. This mean, SSDXCORR research well with static and predetermine object position under control lighting environment.

Even though, it has high detection rate when orientation of the images is changed, this may due to the fact that the inspection point is round. Therefore,changes in orientation may not significantly affect the detection rate.

RECOMMENDATIONS

In the future, it is recommended this algorithm is tested on various shape of points in order to study the effect of orientation to the result. Next, it is highly recommended for the experiment to be carried out and testing in real life environment. Then, in order to obtain effective configuration for this system, some modification need to be done on the algorithms. Alternatively, a new algorithm need to be developed, tested and the result should be compared with SSDXCORR.

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