# Shape-Based Matching: Defect Inspection of Glue Process in Vision System

**H. M. Haniff[1], M. Sulaiman[2], H. N. M. Shah[3], L. W. Teck[4]**
[1, 2, 3, 4] Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya, 76109, Durian Tunggal,
Melaka,Malaysia

[1]Email: mohamadhaniff87@gmail.com, [2]Email: marizan@utem.edu.my,
[3]Email: hnizam@utem.edu.my, [4]Email: mtg_uncleteck@hotmail.com

*Abstract*— **this research regarding the application of a vision algorithm sensor to monitor the operation of a system in order to control the concerning jobs and work pieces recognition that are to be made during system operation in real time. This paper stresses more on the vision algorithm that mainly focus on shape-based matching application. This algorithm consists of two parts; training phase and recognition phase. Region of interest (ROI) are using to create the special region of the defect model for easier in matching purposes. By minimizing the ROI are able to decrease the processing time taken in order for completing its task. 3 models will be created as a main defect; gap defect, bumper defect and bubble defect are trained through the system to extract the special data created for them and using it to provide data in finding matching defect with tested images after gluing process being done.**

*Keywords-Region of interest; glue defect; matching process; gluing process.*

## I. INTRODUCTION

In this paper, the most important applications used are shape-based matching Using HALCON [1]. This application has the effect that this approach is able to handle changes in illumination, clutter, varying size, position and rotation, or even the relative movement of parts of the template projected, multiple instances can be found and multiple models can be used at the same time.

Shape based matching algorithm has 7 fundamental steps which is image acquisition, image pre-processing, image segmentation, extraction of low-level feature, grouping or mapping to high level feature, image classification and image interpretation [2]. In image processing, the best part are to implement simple algorithm but able to contribute fully according to the task given. The better algorithm implies to the good result with fastest processing time. For example, recognition an object using a region that performs a region algorithm to the image such as shape, colour and texture as the subject to the algorithm [3]. Generalized Hough voting scheme applied to identified object locations, scale and support. Regions have special features that make its important during the recognition because: 1) they encode shape and scale information of objects naturally; 2) they are only mildly affected by background clutter.

There are many techniques that provides a solution in recognizing image or object in image processing such as region [3], edge-based features [4], feature extraction [5], shape context [6], low distortion correspondences [7] and etc.. The other research is based on HALCON Application for Shape-Based Matching [8-9]. This paper is discuss mostly on the process involved in a basic shape based matching algorithm with additional of extended Region of Interest (ROI) available in HALCON that fulfils shape based matching to find object based on a single model image and locate them with sub pixel accuracy. The basic concept of defect matching using shape-based matching algorithm based on extended region of interest is shown in Figure 1.

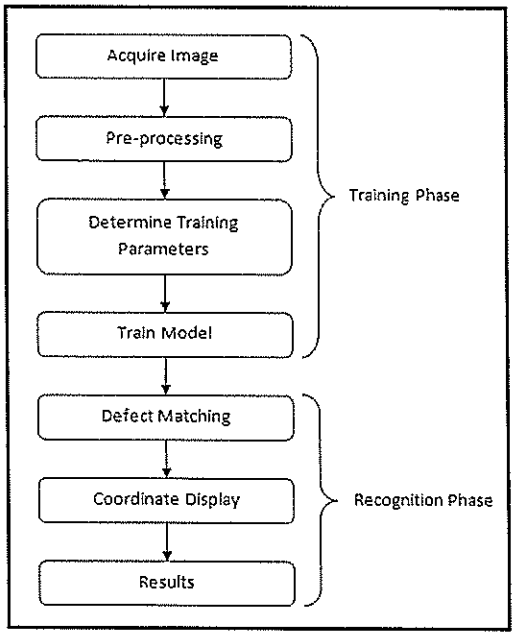


Figure 1: Basic framework for defect matching

The other research is focused on the welding defect by [10] that uses the feature extraction method to simplify image to a simple algorithm which is based on the perceptron model to recognize and classify the defects according to the data

captured from the extraction method. Modeling of the welding defect is important as a main body structure in determining the best recognizing rate for defect detection algorithm.

In all the above research, the machine vision system has two common similarities, first is the three basic framework of the process involved; image acquisition, preprocessing and feature extraction. The second one is the two main phase in shape-based matching algorithm which is training and recognition phase. In the above research, it seems that most model based vision programs are developing for a specific task and the environment explicitly coded into the system.

## II. RESEARCH METHODOLOGY AND DESIGN

### *A. Method*

The main idea of this research is to recognize defects after the robot finish perform glue operation according to the specification given by the vision sensor. In order to develop a system that required intelligent in detecting defects, it's consists with too many techniques can be used but there is a wide range of different algorithm concept that each has its strengths and weaknesses. From all of these algorithms, shape-based matching algorithm was chosen to be used in this research. This is because the requirement of this research is mainly on the inspection of a constant and repetitive type of image. Besides that, because of the wide range of applications that might occurs, shape-based matching which takes only the outline edges of an object into considerations are the best fit for this research since everything has a shape.

This research are based on HALCON software that provides a wide range of library that will helps mostly on image processing algorithm. This is important and very useful that can be manipulate into the system that meet our requirement. The basic of shape based matching application as shown in Figure 1 is based on 2 phases; training phase and recognition phase. In training phase, after all the training parameters are determine by the user, an shape detection library are applied to extract the shape of the glue defect, these shapes are then saved as template that will be used for the recognition phase. At the recognition phase, images are then fed to the system to be matched against the template that was created in the training phase. Based on this framework, the proposed method as shown in Figure 2 is developing according to the needs of the task required in determining the glue defects after the glue application is applied.

The proposed method provides an additional vision sensor system in industrial application. Vision system was known as the analysis of images to extract data for controlling a process or activity. The main function of this proposed method in determining the training parameter that the information obtained will be used as a major factor using feature extraction and created as a template. Feature extraction helps in extracting or minimizing the image size according to the user needs. Region of Interest (ROI) is used in this algorithm because of its special ability that the user manually determines the training parameter just by clicking on the mouse. Hence, it provides the easier way to the user according to system specifications.

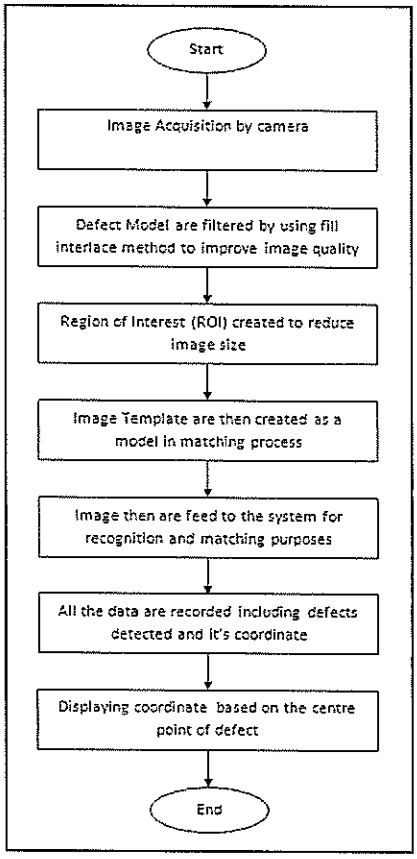


Figure 2: Suggested vision algorithm

### *B. Design*

Vision system is applied to give better services for commanding the system for producing a better product at the end of the system. This research consists of 3 main parts: optic apparatus, working field and main computer. All the arrangement of this apparatus is shown in Figure 3.

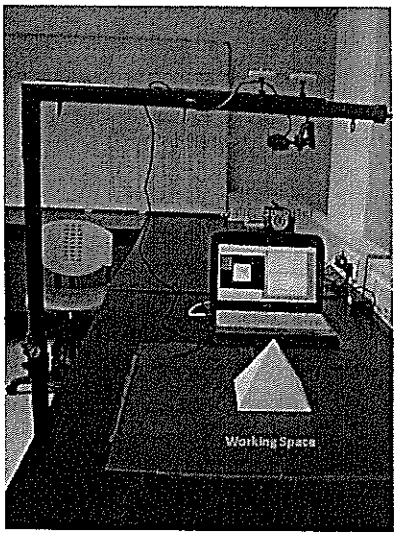


Figure 3: Figure of Experiment Development

Optic apparatus is the most important parts in the vision system because it's provide a vision like human being that able to record what they are seen for the next step of the system. Webcam 12.0 Megapixels is being used as a vision sensor and placed at the top of the object for a better result in getting a complete view of the object for easier to process. The quality of the image is good because of the higher pixel of the camera. The better quality of the images results on the fastest processing time. Reducing the process time increased the performance also benefits to the company.

Working field involves with the object and also the background of the system. Object that being used is a pyramid that manually develops using a white cardboard and the background using a black cardboard. The combinations of colour are used to give a better vision to the system for recognizing the object. With the contrast of the image differs each other, easy for the system differentiate between the object with the background and allows the system run the program smoothly without any problems. 3 models are used as a reference image for matching the image which are gap defect, bumper defect and bubble defect. The model images are shown in Figure 4.

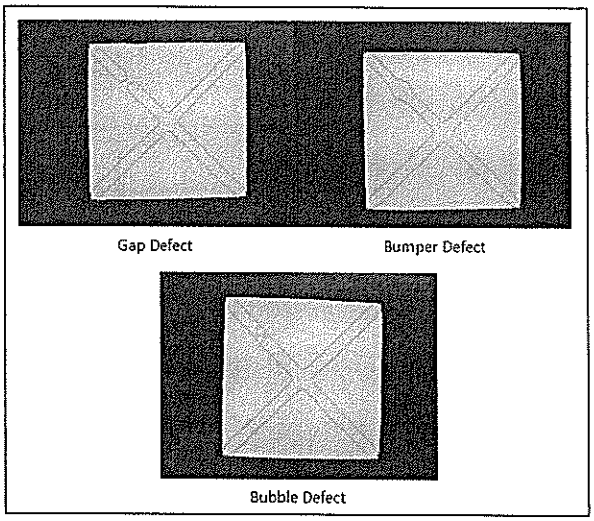


Figure 4: Reference Images

### C. *Template Creation*

Template creation is important in determining the originality of the image characteristic to be submitted into the system for matching purposes. Region of Interest (ROI) play a major role in create a better template of defect model. In the process, the size of image will reduce according to the needs of the system that required only a certain part of the image. This process helps in creating the template without overlap with others that can cause of inaccuracy.

In order to achieve good template matching results, the pixel value difference between the object and the background must be sufficient for the system to work effectively. During the training step, the resultants template must have an obvious shape. The training templates for this experiment are shown as example in Figure 5.

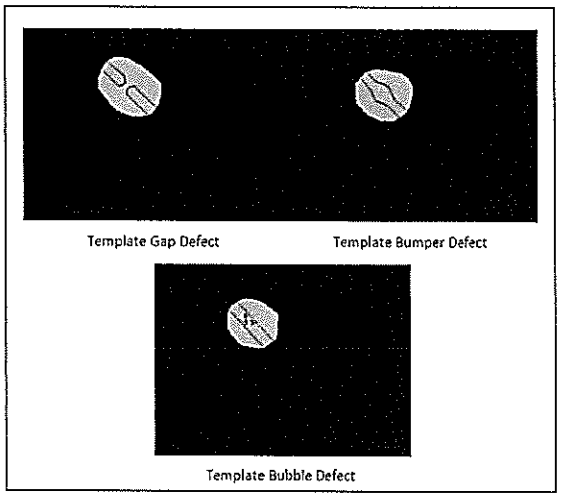


Figure 5: Image Template

## III. DISCUSSION OF RESULT

The potential of the proposed visual algorithm system was the flexibility of the program to accommodate changes. Five tested images are being used to test the flexibility of the system in determining all defects occur in the tested images. The tested images are filled with all the three model defects that are already being trained and fed into the system. Each defect that are match through the system will provide with its own position in the tested images act as row and column coordinate according to the pixel coordinate in the system. This information is important as the task continuing in correcting all the defects after the matching process done its part. Correction phase consists of KUKA arm robot to alter the defects to ensure that glue is in fine shape. Figure 6 to 8 shows the tested images and Table 1 to 3 is shown all the parameter available in the system. All the results are shown using Graphical User Interface (GUI).

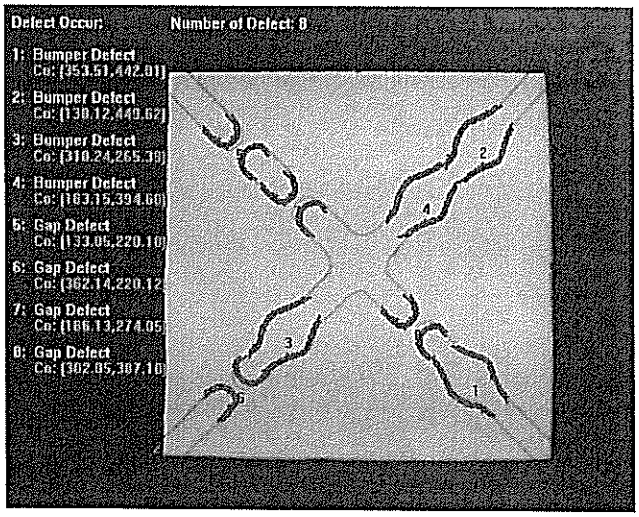


Figure 6: First Tested Image

TABLE 1: PARAMETER FIRST TESTED IMAGE

| No. Defect | Defect Name | Coordinate (pixels) | | Defect Detection |
|---|---|---|---|---|
| | | *Row* | *Column* | |
| 1 | Bumper | 353.51 | 442.01 | √ |
| 2 | Bumper | 130,12 | 449.62 | √ |
| 3 | Bumper | 310.24 | 265.39 | √ |
| 4 | Bumper | 183.15 | 394.60 | √ |
| 5 | Gap | 133.05 | 220.10 | √ |
| 6 | Gap | 362.14 | 220.12 | √ |
| 7 | Gap | 186.13 | 274.05 | √ |
| 8 | Gap | 302.05 | 387.10 | √ |

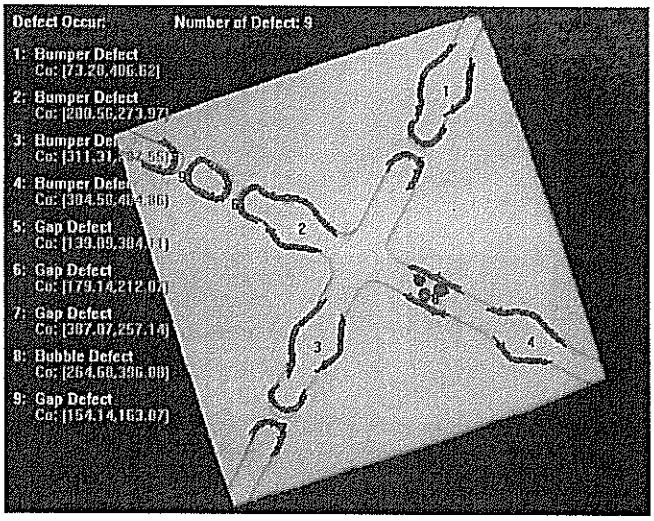


Figure 7: Second Tested Image

TABLE 2: PARAMETER SECOND TESTED IMAGE

| No. Defect | Defect Name | Coordinate (pixels) | | Defect Detection |
|---|---|---|---|---|
| | | *Row* | *Column* | |
| 1 | Bumper | 73.28 | 406.62 | √ |
| 2 | Bumper | 200.56 | 273.97 | √ |
| 3 | Bumper | 311.31 | 287.55 | √ |
| 4 | Bumper | 304.58 | 484.86 | √ |
| 5 | Gap | 139.09 | 384.11 | √ |
| 6 | Gap | 179.14 | 212.07 | √ |
| 7 | Gap | 387.07 | 257.14 | √ |
| 8 | Bubble | 264.68 | 396.88 | √ |
| 9 | Gap | 154.14 | 163.07 | √ |

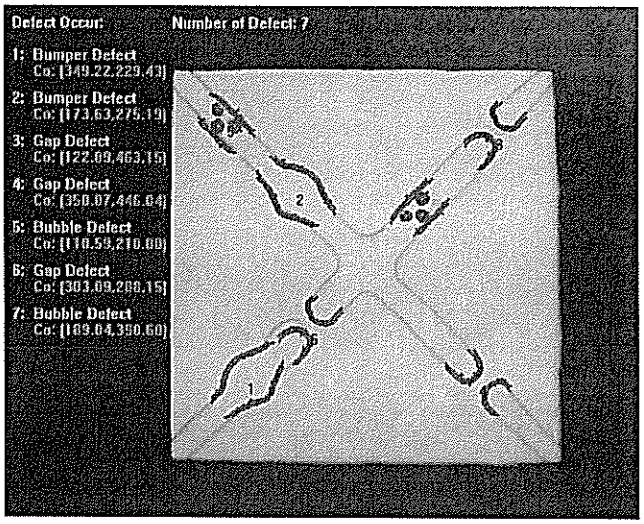


Figure 8: Third Tested Image

TABLE 3: PARAMETER THIRD TESTED IMAGE

| No. Defect | Defect Name | Coordinate (pixels) | | Defect Detection |
|---|---|---|---|---|
| | | *Row* | *Column* | |
| 1 | Bumper | 349.22 | 229.43 | √ |
| 2 | Bumper | 173.63 | 275.19 | √ |
| 3 | Gap | 122.09 | 463.15 | √ |
| 4 | Gap | 350.07 | 446.04 | √ |
| 5 | Bubble | 110.59 | 210.00 | √ |
| 6 | Gap | 303.09 | 288.15 | √ |
| 7 | Bubble | 189.04 | 390.60 | √ |

This automatic defect detection is design according to the matching score for each defect. Parameter *score* in this software is set to 0.9 or 90 percent of similarity with the defect models. Which means the originality of the models is presented each time the defects occur. This is important because with minimal score are set will results to the inaccuracy. The numbering of each defect is referring to which defect that have higher score in the system. The sequential of defects are depends on the defects occur in the system

Table 4 shows the result of defect matching by using 15 tested images. According to the results, the recognition rate of the experiment about 974.55% based on 3 model defects created through the system. This recognition rate shows that the higher accuracy can be achieved through this method. But, with the increasement of the training samples, the recognition rate would be much better. This achievement are depend on how the creation of region of interest being picked all at once gives the almost perfection of the inspection system. Every image character is kept play role in ascertaining process that makes the system capable of working in a short period of time with great accuracy in determining defects occur in the image.

TABLE 4: RECOGNITION RATE OF 15 TESTED IMAGES

| Figure | Total Defect | Defect Detected | Defect Detected (%) |
|---|---|---|---|
| 1 | 8 | 8 | 100 |
| 2 | 9 | 9 | 100 |
| 3 | 7 | 7 | 100 |
| 4 | 7 | 6 | 85.71 |
| 5 | 8 | 8 | 100 |
| 6 | 6 | 6 | 100 |
| 7 | 7 | 7 | 100 |
| 8 | 8 | 7 | 87.5 |
| 9 | 5 | 4 | 80 |
| 10 | 7 | 7 | 100 |
| 11 | 6 | 5 | 83.33 |
| 12 | 9 | 8 | 88.89 |
| 13 | 8 | 8 | 100 |
| 14 | 8 | 8 | 100 |
| 15 | 7 | 6 | 85.71 |
| Total | 110 | 104 | 94.55 |

## IV. CONCLUSION

The main objective in proposing this system is to present the shape based matching application in detecting glue defect in industrial application. The concept of Region of Interest (ROI) is applied to extract the main parameter and characteristic of the image model can be achieved. This vision system concepts help in determining either the defects are minor or major occur in the system after the gluing process being done, so that this algorithm can be used in most situations as seen fit by the user. This innovative approach allows the user to select and adapt the system according to their requirements.

## V. FUTURE PLANNING

This project will be continued further by applying the system with the assisting of KUKA arm robot for gluing process and do the correction when defect occurs during the inspection. The system will consist of a KUKA arm robot and a main pc that control the whole systems including the matching and inspection system. Simple pyramid will be used as a testing objects; the aim of the project is to show ease of implementation of the vision system in recognizing glue defects and to test its reliability and flexibility during and after the gluing process.

## ACKNOWLEDGMENT

The authors appreciate the support granted by Universiti Teknikal Malaysia Melaka (UTeM) in pursuing this research.

## REFERENCES

[1] X. Xu, *et al.*, "HALCON application for shape-based matching," 2008, pp. 2431-2434.

[2] R. Gonzalez, "Richard. E. Woods,"Digital Image Processing"," *2nd International Edition Prentice Hall*, 2002.

[3] C. Gu, *et al.*, "Recognition using regions," 2009.

[4] K. Mikolajczyk, *et al.*, "Shape recognition with edge-based features," 2003, pp. 779–788.

[5] R. A. Salam, *et al.*, "Feature extraction in automatic shape recognition system," pp. 467-468.

[6] S. Belongie, *et al.*, "Shape matching and object recognition using shape contexts," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, pp. 509-522, 2002.

[7] A. C. Berg, *et al.*, "Shape matching and object recognition using low distortion correspondences," 2005.

[8] L. Teck, *et al.*, "Implementation of Shape–Based Matching Vision System in Flexible Manufacturing System," *Journal of Engineering Science and Technology Review*, vol. 3, pp. 128-135, 2010.

[9] L. W. Teck, *et al.*, "Flexible approach for Region of Interest creation for shape-based matching in vision system," pp. 205-208.

[10] J. Peng, "A method for recognition of defects in welding lines," 2009, pp. 366-369.