# Shape-Based Matching: Application of Edge Detection Using Harris Point

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*Abstract* — This paper presents a sequence of object recognition algorithm using shape-based matching that mainly focused on image recognition, image segmentation, and flexible Region of Interest. The image of pyramid is used as a medium to locate each corner of the object and specified the location in details. First, the image reference is used as a training image and the template is created. Then, the process image will be compared with the reference image by using template matching to calculate the score of the successful matching. Each correspond image will be rotated around 60 degree to see whether the system able to recognize the object. All score for matching are recorded. After that, Harris point generates the specific corner of the pyramid and the location of each point is located and clarified with number starting from one. Distance between one point to another is calculated using mathematics' equation to generate a new point between those points. The location of all generate points are displayed using Graphical User Interface (GUI). This method is proposed to develop an additional new system of the glue process in automation industry that provides input data from vision sensor to reduce possibilities of failure.

## INTRODUCTION

In this paper, the most important applications used are shape-based matching Using HALCON by [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. 3 important steps involved in this system: Firstly to specify and create the model; Secondly, the model is used to find and localize an object; thirdly, to identify and locate the critical point of an object.

Shape based matching algorithm has 7 fundamental steps which is image acquisition, image pre-processing, image segmentation and etc [2]. The crucial part is on image segmentation which is involved of de-noising technique. The segmentation procedure brings the process a long way toward successful solution of imaging problems that require objects to be identified individually. On the other hand, weak or erratic segmentation algorithms almost always guarantee eventual failure. Image segmentation involves a various type of command that will lead to smoothen of the image as a result for easier execution in recognition system. 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, color 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.

The other research is based on HALCON Application for Shape-Based Matching is done by [4]. 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 fulfills shape based matching to find object based on a single model image and locate them with sub pixel accuracy. The basic concept of image matching with addition of Harris Point in the model image is shown in Fig. 1.

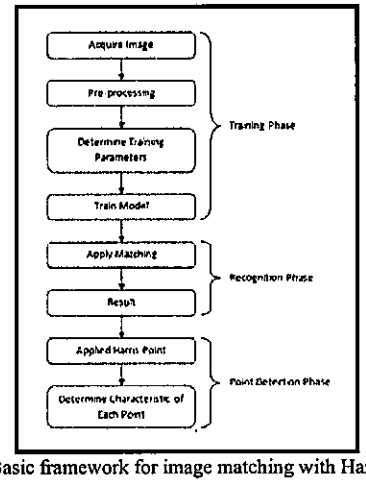


Fig. 1: Basic framework for image matching with Harris Point

On the other hand, Harris corner detector is one of the important applied features in this paper. As being shown by [5] on their paper states that the Harris point detector is used to calculate the bias mean square error matrix of Harris detector calculated corner. The other paper produced by [6], Harris has a good performance on its stability and robustness because of the practice of Gaussian smoothing link which is based on intensity. Both papers discuss more on improving the performance and processing time of the Harris corner detector which is limited.

Equation of straight line [7] is applied in this research according to the object specimen used that has a shape of rectangle. The calculation between one points to another retrieve all the information needed to be used in pointing another point between the previous two points. Firstly, identified the two points needed to be calculated and labelled as $(x_0, y_0)$ and $(x_1, y_1)$. Then, the points are applied it into the equation to define the slope of the line in pixels coordinate.

$$m=(y_2-y_1)/(x_2-x_1) \quad (1)$$

After that, value of the slope and point is used in the slope-intercept equation to define the intersection of the line.

$$y=mx+c \quad (2)$$

Then, the distance in x-axis and y-axis between two points is calculated and defines it as *k* and *l*. The point will then be integrated into equation (2) to find new location of the point based on the information obtained. Lastly, new point being declared and classified as one of the point needed in the system.

## RESEARCH METHODOLOGY AND DESIGN

### *Method*

The main idea of this research is to recognize objects before run the robot to perform glue operation according to the specification given by the vision sensor. In order to develop a system that required intelligent in detecting objects, 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 using edge detection 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.

The vision system in this research used based on HALCON software, which is provides a broad vision library which is very useful that can be manipulate into the system that meet our requirement. The proposed system is based on 3 phase; training phase, recognition phase and point detection phase. In training phase, it provides the application for users to determine all the training parameter of the model images. Then the edge detection library is applied to extract the edge of the image and saved it as a template for matching purposes. At the recognition phase, the image then is being fed into the system for matching the image with the template that is already being created in the training phase. Then, in point detection phase, Harris Corner Detector is applied to get point at the edge of the image with all the information needed for next process. The suggested vision algorithm is shown in Fig. 2.

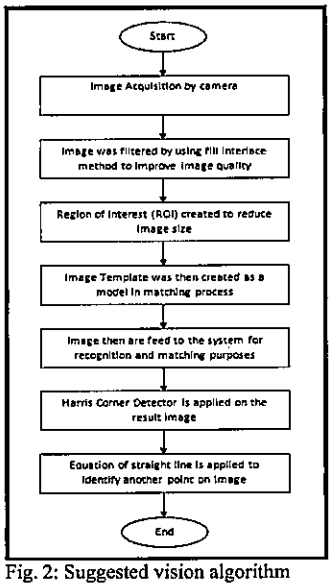


Fig. 2: Suggested vision algorithm

This method is proposed to provide an additional system using vision sensor in industrial application. Vision system was known as the analysis of images to extract data for controlling a process or activity. Therefore the most important part in this algorithm is determining the training parameter (User defines as

feature extraction). Feature extraction one of the special tools for extracting image size according to the needs of the system in order to ensure that the processing time of the system will reduce. 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.

This algorithm is improved with addition of Harris point detector that provides the point at the edges of the image with the location of each point. It is important because with the specific location of certain object it will help in developing the system more accurate while doing their job. Most specifically help to monitor system to weld or glue an object from one point to one point. By improvised the system with the addition of equation of straight line for calculating the important value of one point to another, the system will able to provide other services in pointing another two points in conjunction of the previous point.

*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 Fig. 3.

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. A1Pro 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.

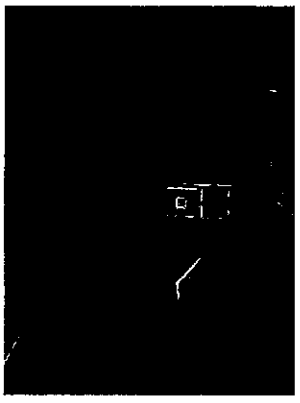

Fig. 3: Figure of Experiment Development

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 model is used as a reference image for matching the image which are model image with no lighting (webcam) image model with half lighting (webcam) and the model image with full lighting (webcam).

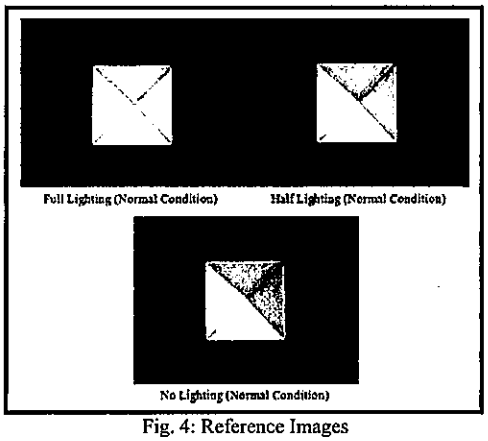


Fig. 4: Reference Images

Main computer is used as an agent to operate the entire process to ensure everything runs smoothly. Graphical User Interface (GUI) used to interact with the program in getting a clearer picture of the results obtained. All the results of experiments are carried out is displayed on the main computer screen with the help of GUI.

## EXPERIMENTAL RESULT

*Matching Result*

Firstly, this system develops to apply matching application in the system that required a lot of process before it will consider being match with the training model. 3 factors that play a major role in determining the success of the best available is the object scale, rotation of objects and lights from environment. These three factors are tested for their efficacy to carry out three experiments respectively using the three most important factors in determining the level of matching object model used. The first experiments carried out at a height of 60cm from the webcam to the base where it is regarded as a position scale. The second and third experiments were conducted at the height of 40cm and 60cm respectively.

Experiment is conducted in the dim light lab to prevent the emission of light is so bright that could affect the results. The processed images will undergo 6 matching process from 0 degrees to 360 degrees (0 /

360 degrees, 60 degrees, 120 degrees, 180 degrees, 240 degrees and 300 degrees) as shown in Fig. 5. All images are gone through the matching process to determine if the system is able to get good results even if the image is rotated from the original position. In addition, each image will also be tested with the light-controlled webcam with no lighting, half lighting and full lighting. All the data are recorded in Table 1, Table 2 and Table 3, as shown.

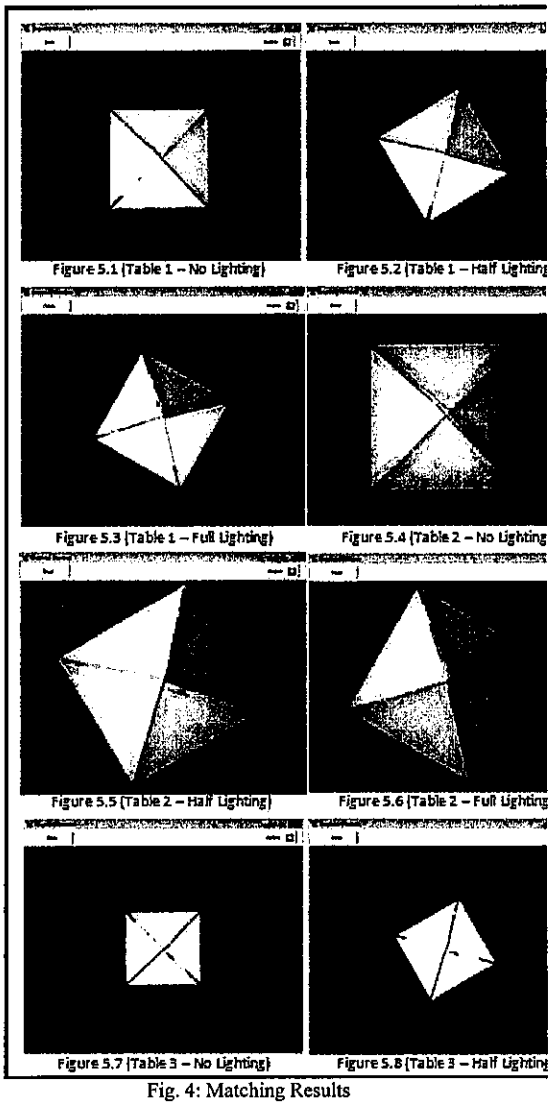


Fig. 4: Matching Results

Table 1: Condition→Webcam Position=60cm (from base)

| Figure | No Lighting (Webcam) | Half Lighting (Webcam) | Full Lighting (Webcam) |
|---|---|---|---|
| 0°/36 0° | Score=0.976 Scale=0.999 | Score=0.980 Scale=1.003 | Score=0.983 Scale=0.999 |
| 60° | Score=0.911 Scale=1.005 | Score=0.915 Scale=1.008 | Score=0.891 Scale=1.009 |
| 120° | Score=0.865 Scale=1.010 | Score=0.869 Scale=1.013 | Score=0.892 Scale=1.020 |
| 180° | Score=0.919 Scale=1.002 | Score=0.929 Scale=1.005 | Score=0.958 Scale=1.006 |
| 240° | Score=0.915 | Score=0.891 | Score=0.911 |
| | Scale=1.003 | Scale=1.002 | Scale=1.006 |
| 300° | Score=0.878 Scale=0.997 | Score=0.869 Scale=0.999 | Score=0.902 Scale=1.002 |
| Total | Score=91.09 % Scale=1.003 | Score=90.88 % Scale=1.005 | Score=92.28 % Scale=1.007 |

Table 2: Condition→Webcam Position=40cm (from base)

| Figure | No Lighting (Webcam) | Half Lighting (Webcam) | Full Lighting (Webcam) |
|---|---|---|---|
| 0°/36 0° | Score=0.897 Scale=1.483 | Score=0.884 Scale=1.486 | Score=0.874 Scale=1.486 |
| 60° | Score=0.828 Scale=1.479 | Score=0.871 Scale=1.486 | Score=0.875 Scale=1.489 |
| 120° | Score=0.807 Scale=1.465 | Score=0.845 Scale=1.488 | Score=0.836 Scale=1.491 |
| 180° | Score=0.921 Scale=1.481 | Score=0.938 Scale=1.482 | Score=0.874 Scale=1.486 |
| 240° | Score=0.887 Scale=1.482 | Score=0.857 Scale=1.471 | Score=0.833 Scale=1.480 |
| 300° | Score=0.825 Scale=1.465 | Score=0.864 Scale=1.466 | Score=0.849 Scale=1.476 |
| Total | Score=86.09 % Scale=1.476 | Score=87.64 % Scale=1.480 | Score=85.67 % Scale=1.485 |

Table 3: Condition→Webcam Position=80cm(from base)

| Figure | No Lighting (Webcam) | Half Lighting (Webcam) | Full Lighting (Webcam) |
|---|---|---|---|
| 0°/36 0° | Score=0.811 Scale=0.740 | Score=0.810 Scale=0.763 | Score=0.874 Scale=0.759 |
| 60° | Score=0.802 Scale=0.757 | Score=0.772 Scale=0.775 | Score=0.848 Scale=0.758 |
| 120° | Score=0.851 Scale=0.758 | Score=0.793 Scale=0.758 | Score=0.865 Scale=0.758 |
| 180° | Score=0.853 Scale=0.758 | Score=0.835 Scale=0.762 | Score=0.859 Scale=0.759 |
| 240° | Score=0.801 Scale=0.758 | Score=0.809 Scale=0.761 | Score=0.853 Scale=0.760 |
| 300° | Score=0.791 Scale=0.755 | Score=0.806 Scale=0.755 | Score=0.901 Scale=0.758 |
| Total | Score=81.80 % Scale=0.754 | Score=80.43 % Scale=0.762 | Score=86.64 % Scale=0.759 |

*Pointing Result*

After the matching results are obtained whether it is success or not, the pointing application will takes place to identify the edges of process object. Two types of function being used to accomplish the hypothesis of this paper: 1) Harris Corner Detector and 2) applying equation of straight line. This two function integrate together to produce new algorithm in industrial application used as a vision sensor optimization Fig. 6, 7 and 8 shown all the new point generated with the displaying of the coordinates from the point that generate using both functions and displayed using Graphical User Interface (GUI).

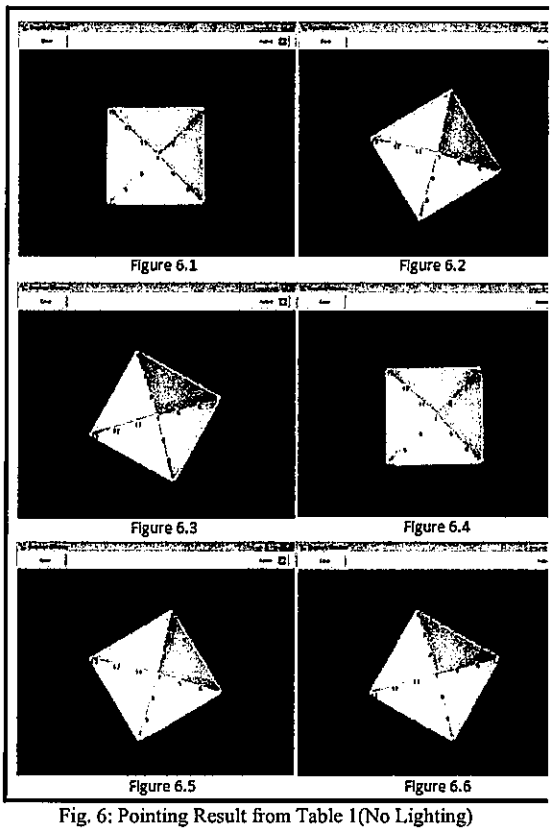


Fig. 6: Pointing Result from Table 1(No Lighting)

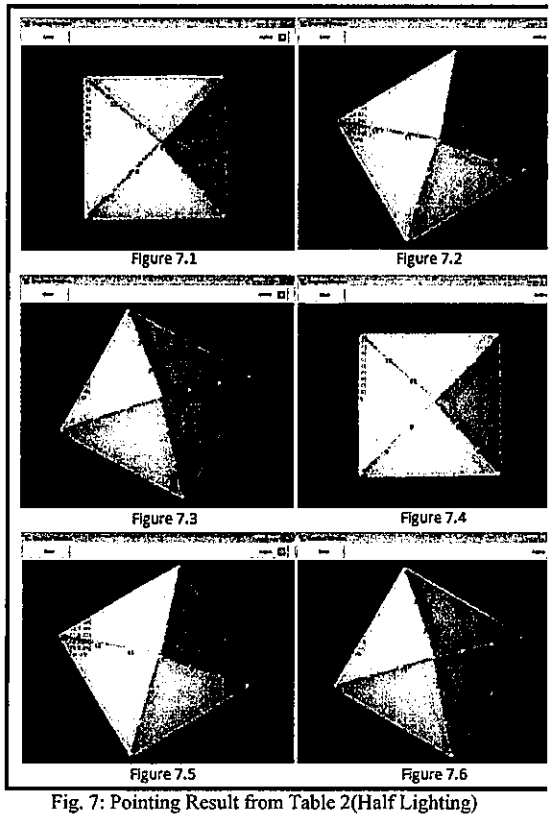


Fig. 7: Pointing Result from Table 2(Half Lighting)

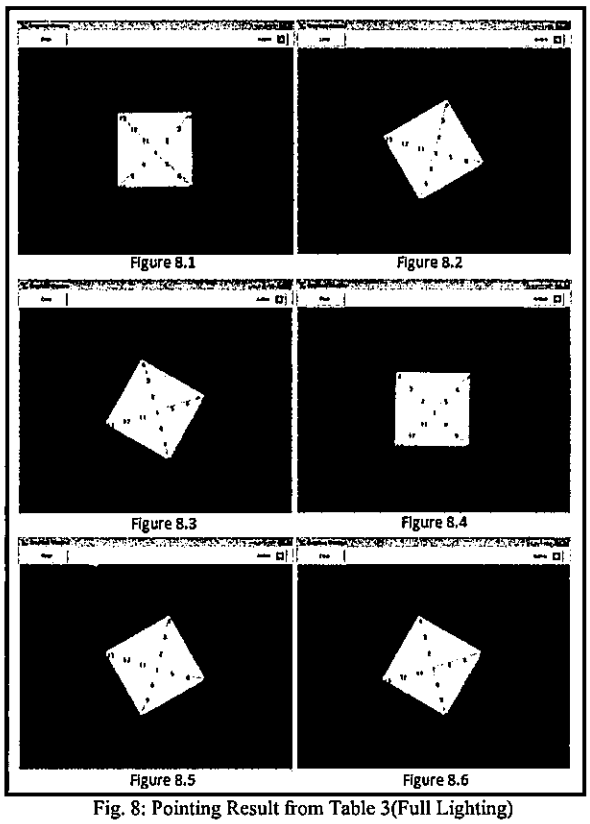


Fig. 8: Pointing Result from Table 3(Full Lighting)

## DISCUSSION

According to the results obtained, an average of 91.42% achieved success in the first experiment, an average of 86.47% for the second experiment and 82.96% an average for third experiment. In the first experiment involving the position of the webcam with base at a distance of 60 cm same as the reference image. This indicates a high probability of success is due to the ratio of the scale of the process image is a reference image. Compared with the experiments 2 and 3, which involves changes in the scale of the image gives results lower than the first experiment. This is because the image is captured by the camera are not able to process the images as accurate as the human eye despite changes in image scale varies. Thus, the success rate of the image processing approach is able to generate 90% point better position to use in a given task.

## CONCLUSION

In this paper, the integration of shape based matching with the Harris point gives more additional data to be process. The effectiveness of the shape based matching in detection of the object and Harris point in localize object coordinate improves the system to be more relevant in industrial application. Additional data obtained instead of using the edge

coordinate gives precise accuracy in develop a system that involves a whole object's region.

In future, we aim to combine these features with additional of arm robot in developing a glue process system. Arm robot is used as a main equipment to integrate with Halcon software in giving the task and the coordinate each point needs to be glue.

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