Praise Worthy Prize

International Review on Computers and Software (I.RE.CO.S.), Vol. 8, N. 8
ISSN 1828-6003
August 2013

A 3D Gluing Defect Inspection System Using Shape-Based Matching Application from Two Cameras

Marizan Sulaiman, Hairol Nizam Mohd Shah, Mohamad Haniff Harun, Lim Wee Teck, Mohd Nor Fakhzan Mohd Kazim

Abstract – *This research is regarding the application of a vision algorithm to identify the operations of a system in order to control the decision making concerning jobs and work pieces recognition that are to be made during system operation in real time. These paper stresses on the vision algorithm used which mainly focus on the shape matching properties to identify defects occur on the product. A new supervised defect detection approach to detect a class of defects in gluing application is proposed. Creating of region of interest in important region of object is discussed. Gaussian smoothing features in determining better image processing and template matching in differentiates between reference and tested image are proposed. This scheme provides high computational savings and results in high defect detection recognition rate. The defects are broadly classified into three classes: 1) gap defect; 2) bumper defect; 3) bubble defect. The defects occur provides with information of height (z-coordinate), length (y-coordinate) and width (x-coordinate). This information gathered from the proposed two camera vision system for conducting 3D transformation. Information gathers used in new correction technique known as Correction of Defect (CoD) where rejected object will be altered to reduce rejected object produced from the system.*

Keywords: *Gaussian Smoothing, Recognition Rate, Region of Interest, Template Matching*

I. Introduction

Machine vision is the process of applying a range of technologies and methods to provide imaging-based automatic inspection, process control and robot guidance in industrial applications. Machine Vision inspection plays an important role in achieving 100% quality control in manufacturing, reducing costs and ensuring a high level of customer satisfaction.

Machine vision system inspection consists of narrowly defined tasks such as counting objects on a conveyor, reading serial numbers, and searching for surface defects. Manufacturers often prefer machine vision systems for visual inspections that require high speed, high magnification, around-the-clock operation, and/or repeatability of measurements.

II. Background

In machine vision system, 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 [1]. 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 [2].

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 [2], edge-based features [3], feature extraction [4], shape context [5]-[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 introduced by [10] as shown in Fig. 1.

In the area of Machine Vision inspection area, a lot of different approaches have been studied intensively mostly on the defect of welding and texture with plenty of machine vision algorithms are available.

Manuscript received and revised July 2013, accepted August 2013

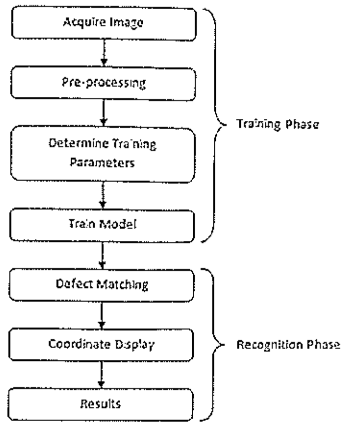


Fig. 1. Basic Framework for Matching Application

As being introduced J. Peng [11] 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. Other types of algorithm being described by [12] where the development based on the assumption that a line profile of defect less weld image can be approximated by a Gaussian distribution curve. The line profile variations of weld defect caused by defects are classified into three different patterns. By according to the result, the development of defect inspection system achieved successful recognition rate of 95 percent based on 24 tested images and consists of 61 defects.

According to [13], present a new approach to texture defect detection based on a set of optimized filter. The wavelet transform provide an excellent framework to deal with multi-scale defects. The first level of the wavelet packet decomposition divides the power spectrum into four square parts and the second level divides the same spectrum into sixteen parts and the third level in sixty four parts. Therefore the filter applied in higher wavelet those results in easier to detect defect by analysing only a small part of the spectrum.

The other research that contributes on the defect inspection system such as Gabor filters as main approach for texture defect detection [14], Fourier series analysis [15], adaptive two-dimensional filter [16], fuzzy clustering method [17] and as being introduced by [18] a review of recent techniques that being used in surface inspection using computer vision and image processing techniques for the purpose of visual inspection and decision making schemes that are able to discriminate the features extracted from normal and defective regions.

III. Proposed System

This research is design a system that can be adopted into industrial automation for gluing process of windscreen car.

The system is developed to cope with the environment such as lighting condition, scaling and rotating of the object.

Pyramid object developed from plain cardboard is created based on the shape object that has a contour that involves height, length and width. Plain cardboard is design exactly like pyramid to get the data from the Defect Shape Matching (DSM) whether the system recognized it or not. KUKA act as arm robot in providing gluing service each time they got data from system through Defect Shape Pointing (DSP). Two cameras will be placed as an ideal position to generate information x, y and z coordinate.

There There are three types of defect can be occur while in Defect Inspection Monitoring (DIM); 1) Gap defect; 2) Bumper defect; 3) Bubble defect. Result obtained from DIM will decide whether the object is successful gluing or needs to be corrected through Correction of Defect (CoD). Fig. 2 shows the overall system of this research.

3D representation (z-coordinate transformation)

Gluing process involves x, y and z-axis in determining the position according to the working space of the KUKA robot arm. In previous experiment, matching process involves one camera placed at the top of the object as a purpose in identifying the object that need to go for gluing process.

Renovation of this system is created by applying another camera in front of the object for purpose in reviving the z-coordinate in the image. Gluing process involves x, y and z-axis in determining the position according to the working space of the KUKA robot arm.

In previous experiment, matching process involves one camera placed at the top of the object as a purpose in identifying the object that need to go for gluing process.

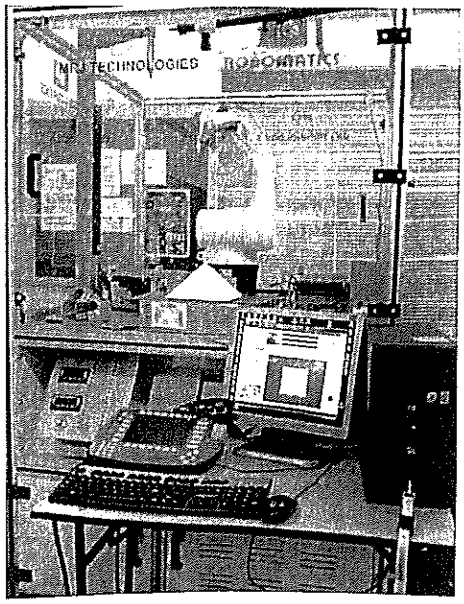


Fig. 2. Overall System Design

Renovation of this system is created by applying another camera in front of the object for purpose in reviving the z-coordinate in the image.

According to [19] the method used are to find the 3D object recognition defining as x, y and z-axis by using evaluation function in order to determine better position and orientation for camera placement. Fig. 3 shows the proposed method by using two cameras from the researcher.

This configuration has the ability to reproduce the 3D transformation according to the model template that being created in the system. The measurements of the camera takes account all the side of the object which will be process in determining the exact value of transformation with the original.

From this application, the development of new proposed method by using two cameras with different positions and orientations in purpose of determining x, y and z-coordinate for further process in this research. The renovation of this new method being proposed is used in creating a z-coordinate according to the x and y-axis from images captured. Fig. 4 shows the new proposed method developed in this research.

Camera placement has been developed according to the needs of the system requirement as described before.

The arrangement helps in determining z-coordinate by applying two-dimensional image. The z-coordinate are based on pixel coordinate of CCD camera. In order to develop system that involve with 3D transformation all the x, y and z-coordinate must be appointed which means the image should have length, width and height.

The transformation of z-coordinate in 3D involves of two images which are taken from both camera, top and front. Before the z- coordinate are determined, two type of image must be taken through the top and front cameras as shown in Figs. 5.

Both coordinates are generate by using mathematical approach of straight line [20] according to the object specimen 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, the system should identify all the edge point within both images.

Then, identified the two points needed to be calculated and labelled as (x_{n-1}, y_{n-1}) and (x_n, y_n). Then, the points Camera placement has been developed according to are applied it into the equation to define the slope of the line in pixels coordinate.

$$m_n = (y_n - y_{n-1})/(x_n - x_{n-1}) \quad (1)$$

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

$$y_n = m_n x_n + c_n \quad (2)$$

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 Eq. (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. The pointing results of both images are shown in Figs. 6.

In applying glue application, the point of each coordinate must be accurate for precise operation.

Therefore, the findings of this z- coordinate provide an additional data in order to minimize error of the system.

In real operation, the shape of object is not exactly the same as the image taken. So, by providing a mathematical approach of straight line helps in rebuilding the z-coordinate based on their own characteristic taken through the systems.

Matching in vision application

The main idea of this research is to recognize defects after the robot finish perform glue operation accord ng to the specification given by the vision sensor.

In order to develop a system that required intelligent in detecting defects, it 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 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. Fig. 7 below shows the project development of defect inspection system by using two cameras placed at top and front position for detecting all the three coordinates known as height (z-coordinate), width (x-coordinate) and length (y-coordinate).

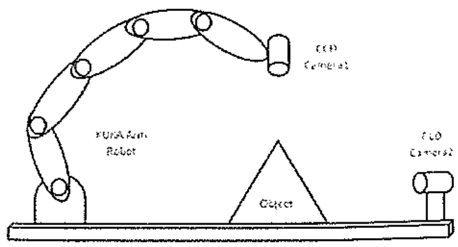


Fig. 3. Proposed Position of two Camera Placements in 3D

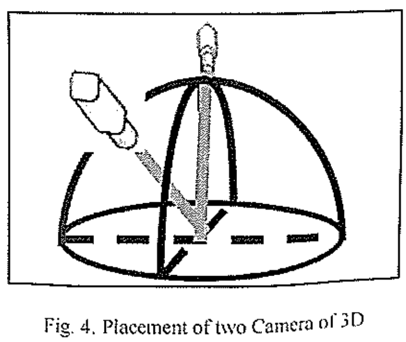
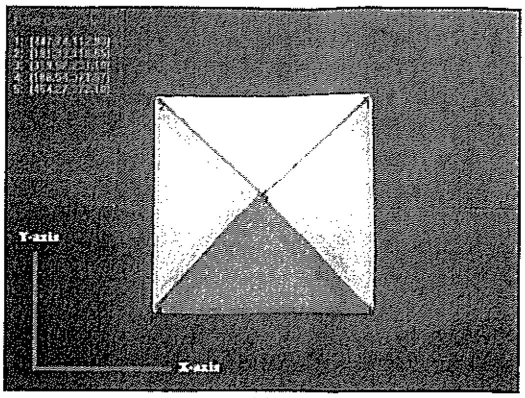
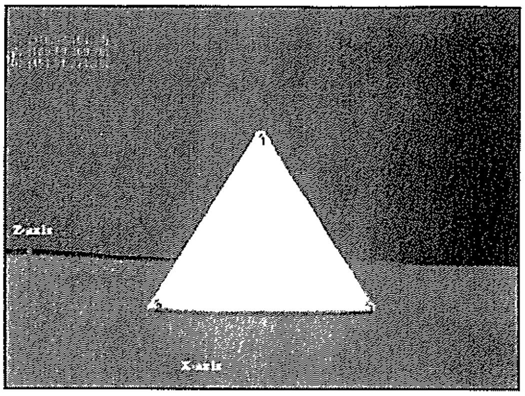


Fig. 4. Placement of two Camera of 3D



(a)



(b)

Figs. 5. (a) Captured Image from Top Camera and (b) Captured Image from Front Camera

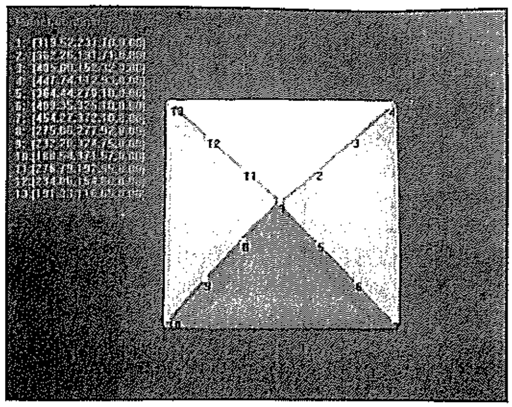
This research are based on HALCON software that provides a wide range of library that will helps mostly on image processing algorithm. This is important and very useful that can be manipulate into the system that meet our requirement.

This approach helps to make the data more amenable to machine learning how to draw the ROI based on human perception. Then the creation of ROI is to pick out the approximate region needed in the system by identifying the types of glue defects of the image.

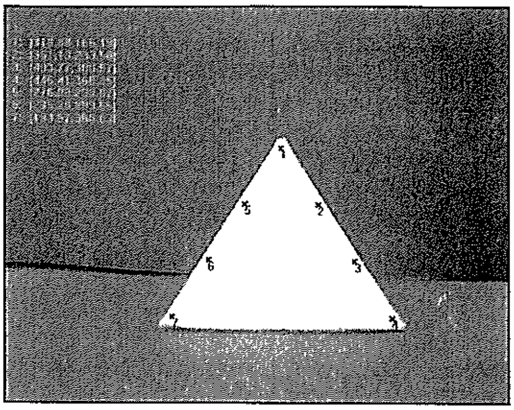
Once the approximate region is identified, the information needed must be separated with the model image and its background to ensure there is no other disturbances that might occur in the system. Fig. 8 shows the process of Region of interest and saved as defect template for recognition phase.

The basic of shape based matching application as shown in Fig. 8 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.

This step is known as *template creation*. In order to get the better shape of the defect, the *Region of Interest* (*ROI*) is introduced as one of tools to reduced size of image.



(a)



(b)

Figs. 6. A New Point Appointed from Top and Front Camera

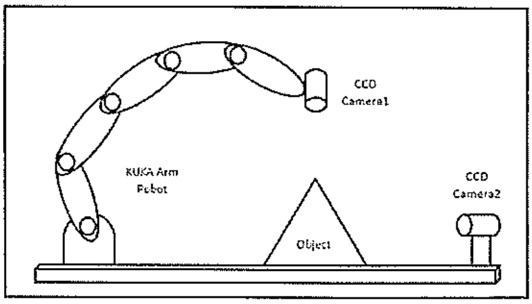


Fig. 7. Project Development

This approach helps to make the data more amenable to machine learning how to draw the ROI based on human perception. Then the creation of ROI is to pick out the approximate region needed in the system by identifying the types of glue defects of the image.

Once the approximate region is identified, the information needed must be separated with the model image and its background to ensure there is no other disturbances that might occur in the system.

Fig. 8 shows the process of Region of interest and saved as defect template for 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 Fig. 10 is developing according to the needs of the task required in determining the glue defects after the glue application is applied.

Once the template has been created through training phase, template matching takes placed. Template matching is an algorithm that compares portions of images against one another. Before hand, the template of an object must be classified first before used it in recognize similar objects in source image [21]-[22].

According to Fig. 9 shows the process evaluation of the template matching by using correlation method in representing relationship between template and source images. Correlation is a measure of the degree to which two variables (pixel values in template and source images) agree, not necessary in actual value but in general behaviour.

In correlation method, results of combination of differences between template gray level image, x_i with average gray level in the template image, $\dot{x}$ and difference between source image sections, y_i with the average gray level of source image, $\dot{y}$ are compared to the square root summation of the pixel differences between two images. Correlation value is between -1 and +1, with larger values representing a stronger relationship between the two images. Equation 3 shows the correlation relationship.

$$cor = \frac{\sum_{i=0}^{N-1}(x_i - \dot{x}) \cdot (y_i - \dot{y})}{\sqrt{\sum_{i=0}^{N-1}(x_i - \dot{x})^2 \cdot \sum_{i=0}^{N-1}(y_i - \dot{y})^2}} \quad (3)$$

where:

$$N = template\ image\ size = column \times row$$

Correlation value totally depends on template creation throughout the system. Without proper contribution on it, may result to poor recognition rate. The important of ROI extraction method that delivers the precise region helps in findings the same object from various types of images. Fig. 10 shows the proposed algorithm that being developed through this research.

Correction of Defect

Correction of Defect (CoD) offers service in correcting defects occurs in Defect Inspection Monitoring (DIM) application. Correction done according to the data available consists of position, types and total number of defect.

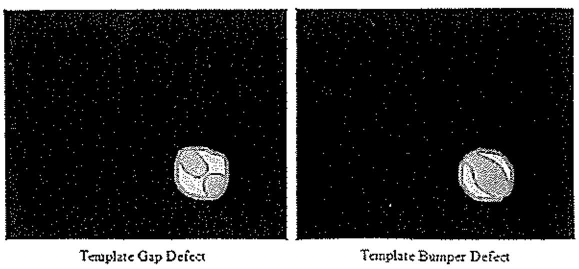
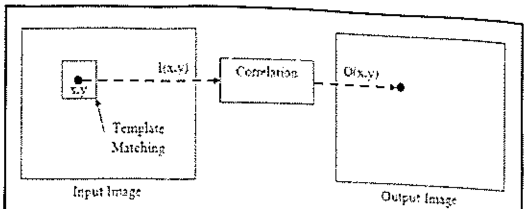


Fig. 8. Region of Interest Before and After Process



Description: The matching process moves the template image to all possible positions in larger source image and computes a numerical index that indicates how well the template matches and the image in that position. Match is done on a pixel by pixel basis

Fig. 9. Template Matching Process Evaluation

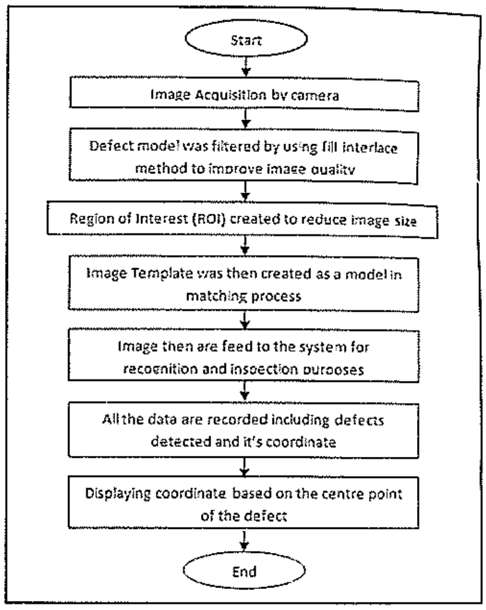


Fig. 10. Proposed System Algorithm for Defect Inspection System

The characteristic of each defect describes based on the appearance and shape of defects occurs in gluing process. Two defect types are available in this research:

1. Gap Defect
   a. Has a gap along gluing line (one straight gluing line) that makes it look like there are two lines in gluing line.
   b. Correction: glue again where there is a gap by using hot glue gun from upper value to lower value according to the defect's data coordinate.
2. Bumper Defect
   a. Has a round shape (hemisphere shape) at both sides that looks like a "tumor".
   b. Correction: trim the bumper shape by using glue gun to remove the "tumor" by separating it until it forms a straight gluing line

In this experiment, it focused on the system can detect any defect after gluing process. Not only that, it also focused on the correcting the entire defects occur using Correction of Defect (CoD) application. This system correct any of defects including gap and bumper defects by using KUKA arm robot with the guidance of position (x, y and z coordinates) of them.

Then, the system once again will be checked after the 1[st] CoD using DIM application to identify whether the object clear with any defects or not. If yes, the object classified as quality gluing while the system will go to 2[nd] CoD if the result is otherwise. Fig. 11 shows the experimental setup for Correction of Defect (CoD) application.

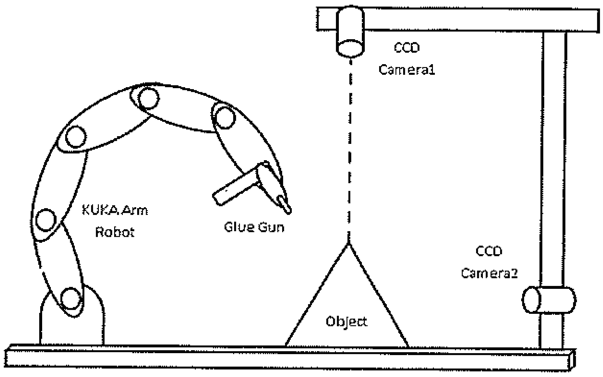


Fig. 11. Correction of Defect (CoD) application

IV. Results

The potential of the proposed visual algorithm system was the flexibility of the program to accommodate changes. 50 tested images are being tested 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 in training phase and fed into the system for recognition purposes. 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.

According to the Fig. 12 shows the result of defect detection where there is total of 8 defects and all of it has been detected through the proposed system. Each of defects provides with their own location for further process. Differ from previous results, Fig. 13 shows that there is one defect that is not being detected because of the bright illumination that disturbs the system from complete its task.

The contour of the defects has been eliminated by the brightness itself and the system recognized it as a perfect gluing line.

The aim of this paper is to present a flexible visual system for shape based matching. Addition of feature extraction, Gaussian smoothing, template creation and template matching are proposed through this paper. Experimental results are used to verify the proposed approach. In this experiment, three defects models and their corresponding samples are used to examine this approach.

This system has been tested with 50 tested images and consists of 236 defects to determine system accuracy and efficiency in detecting glue defect along gluing line. Each tested image has its own defect to be recognised by this system. All the data are recorded into Table I.

Table I shows the result of defect matching by using 50 tested images. According to the results, the recognition rate of the experiment about 95.76% based on 3 model defects created through the system.

This result is compared with literature review of 'A Method for Recognition of Defects in Welding Lines' [10] where it considered the problem in detecting welding defects in welding lines where the past researchers put an effort on more complex algorithm or limited in efficiency.

The main objectives of this research is to classify 6 types of defect might occur in welding lines such as air hole, crack, strip inclusion, round inclusion, lack of penetration and metal inclusion. The suggested computer auto-recognized welding defect is put forward to define the capable of this algorithm. The algorithm is tested with 500 welding defect consists of all six type of defect to evaluate the defect detection capabilities.

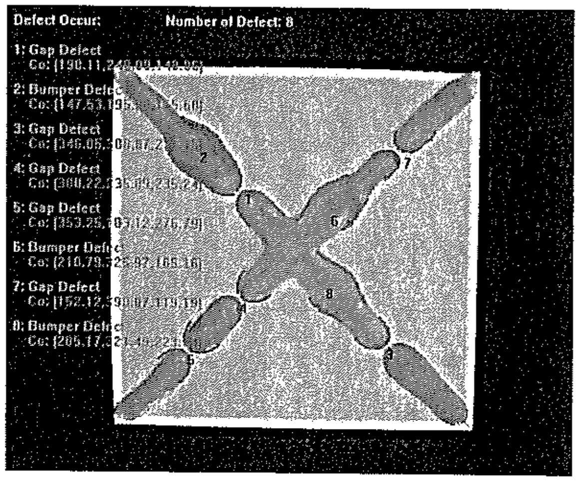


Fig. 12. First Tested Image

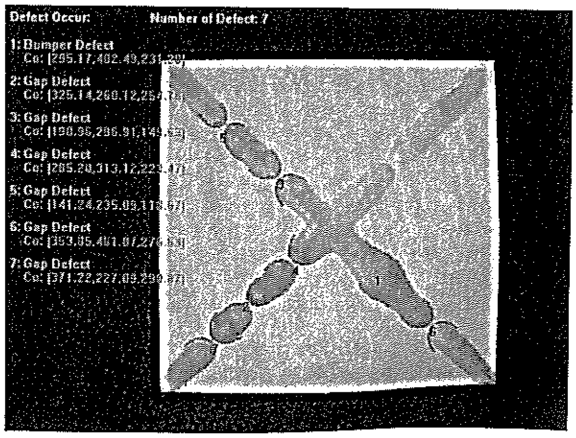


Fig. 13. Second Tested Image

The results of this experiments represents defect detection of each defect's type but overall this system able to generate 94.3 % success rate in classifying defect's type. Although the experiments setup, objective and methods are not entirely similar but basically the goal of each experiment is to develop a vision system in inspection for defect detection in industry. Even though gluing application is still new, but the technique in inspection is still the same with welding application, just difference in how to analyze characteristic of each defects. Table II below shows the result compared from both research. In this research, the inspection system is expanding through to another application where it combines with Correction of Defect (CoD). The experimental develop as describes in Experimental 3 where the gluing object need to be corrected if there is at least one defect occur. CoD consist of two phase known as 1st CoD (first time alter) and 2nd CoD (second time alter). Each CoD process comes along with Defect Inspection Monitoring (DIM) to define whether the object is completely corrected or not. Table below shows the recorded data for CoD and DIM application.

According to Table III, 1st CoD recognition rate recorded 84.75 percent where it covers about 50 defects while the remaining is altered completely from 2nd CoD where it recorded to 100 percent recognition rate.

So, the Correction of Defect (CoD) combined with Defect Inspection Monitoring (DIM) provide services to alter defects of gluing object from being automatically rejected.

TABLE I
RECOGNITION RATE FOR PROPOSED DEFECT INSPECTION SYSTEM

Total Defect in Image	Total Image (Total Defect)	Defect Detected	Defect Undetected
1	2 (2)	2	0
2	7 (14)	14	0
3	6 (18)	18	0
4	10 (40)	39	1
5	7 (35)	32	3
6	5 (30)	28	2
7	7 (49)	47	2
8	6 (48)	46	2
Total	50 (236)	226	10
Percentage (%)		95.76	4.24

TABLE II
COMPARISON OF RESULTS

	Weld Defect Detection	Glue Defect Detection
Number of Samples	500 samples defect	236 samples defect
Variation of Samples	6 types	3 types
Correct Recognition Rate (%)	94.3%	95.76%
Error Rate (%)	5.7%	4.24%

TABLE III
RESULTS FOR COD PROCESS

Total Image Tested	Total Defect Detected	1st CoD (Defect Detected)	2nd CoD (Defect Detected)
15	59	9	0
Recognition Rate (%)		84.75	100

V. Discussion

From the results, it can be seen that the system's efficiency is very good produced about 95.76% recognition rate.

This is because of the detection scheme that compares only the required features which are being trained according to the specific type of defects. Another advantage of the system is its simplicity and ease of use, since the matching algorithm uses a single edge detection method that was built to process the current environment during training phase instead of predetermined environment setting.

This greatly reduces the time used for setting and tuning of the vision system whenever there are any changes. Not only that, this system provides an additional data such as height, length and width from the origin of the vision sensor. With this information, the application of correcting the defect will be easier in commanding the KUKA robot arm to do so. Correction of Defect (CoD) offers two types of services where 1st CoD (first time correction) and 2nd CoD (second time correction).

This application integrates with inspection system in order to define the system effectiveness. From 15 tested images, recognition rate recorded 84.75% for 1st CoD percent where 50 out of 59 defect able to alter and 100% for 2nd CoD to complete for the remaining defects.

VI. Conclusion

The aim of this paper is to present a shape based matching vision system for automatic defect detection by using 2 vision sensors as its core. In this paper a concept for a flexible ROI creation visual system was presented where the parameters and characteristics can be easily determined by the user. The proposed visual algorithm concept is easily adaptable and extendible, so that this program 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.

Additionally combine with 2 vision sensors provide the system with more precise location as its fit to x (width), y (length) and z (height) pixel coordinate. This system also introduced with inspection system and combined with correction of defect for further improvement.

VII. Future Planning

In order to further investigation the effectiveness of this system, a configuration of Flexible Manufacturing System (FMS) can be implemented. FMS is a system that is able to respond to changed conditions. In general, this flexibility is divided into two categories and several subcategories. The first category is the so called machine flexibility which enables to make various products by the given machinery. The second category is routing flexibility enabling to execute the same operation by various machines. FMS usually consists of three main parts: CNC machine tools, transport system and control system. So, in this research it is suggested that a FMS system using robotic arm is more efficient rather using conveyor belt to transport object from one station to another because it offer more flexibility and agility to the system.

Acknowledgements

The authors are grateful for the support granted by Universiti Teknikal Malaysia Melaka (UTeM) in conducting this research

References

[1] R. Gonzalez, "Richard. E. Woods,"Digital Image Processing"," *2nd International Edition Prentice Hall*, 2002.
[2] C. Gu, *et al.*, "Recognition using regions," 2009.
[3] K. Mikolajczyk, *et al.*, "Shape recognition with edge-based features," 2003, pp. 779–788.
[4] Salam, R.A.; Talib, A.Z.H.; Sumari, P.; Rodrigues, M.A., "Feature extraction in automatic shape recognition system," Information and Communication Technologies: From Theory to Applications, 2004. *Proceedings. 2004 International Conference on*, vol., no., pp.467,468, 19-23 April 2004.
[5] S. Belongie, *et al.*, "Shape matching and object recognition using shape contexts," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, pp. 509-522, 2002.
[6] A. A. Sewisy, Detection of Lines in Images by Curve Fitting Using Hough Transform, *(2007) International Review on Computers and Software (IRECOS)*, 2 (4), pp. 342-349.
[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," in *Conference on Innovative Technologies in Intelligent Systems and Industrial Application (CITISIA)*, 2009, pp. 205-208.
[10] X. Xu, *et al.*, "HALCON application for shape-based matching," 2008, pp. 2431-2434.
[11] J. Peng, "A method for recognition of defects in welding lines," in *International Conference on Artificial Intelligence and Computational Intelligence*, 2009, pp. 366-369.
[12] Y. Li and T. W. Liao, "Weld defect detection based on Gaussian curve," 1996, p. 227.
[13] J. L. Sobral, "Optimised filters for texture defect detection," 2005, pp. III-565-8.
[14] A. Kumar and G. K. H. Pang, "Defect detection in textured materials using Gabor filters," *Industry Applications, IEEE Transactions on*, vol. 38, pp. 425-440, 2002.
[15] C. Chan and G. K. H. Pang, "Fabric defect detection by Fourier analysis," *Industry Applications, IEEE Transactions on*, vol. 36, pp. 1267-1276, 2000.
[16] R. Meylani, *et al.*, "Texture defect detection using the adaptive two-dimensional lattice filter," pp. 165-168 vol. 3.
[17] T. Liao, *et al.*, "Detection of welding aws from radiographic. images with fuzzy clustering methods," *Fuzzy sets and Systems*, vol. 108, p. 158, 1999.
[18] X. Xie, "A review of recent advances in surface defect detection using texture analysis techniques," *Electronic Letters on Computer Vision and Image Analysis*, vol. 7, pp. 1–22, 2008.
[19] T. Takahashi, *et al.*, "Planning of Multiple Camera Arrangement for Object Recognition in Parametric Eigenspace," *Proceedings of the 18th International Conference on Pattern Recognition (ICPR'06)*, vol. 1, pp. 603-606, 2006.
[20] S. Sastry, *Engineering Mathematics*.
[21] F. Jurie and M. Dhome, "Real time robust template matching," 2002, pp. 123–131.
[22] Elhachloufi, M., El Oirrak, A., Aboutajdine, D., Kaddioui, M.N., 3D object recognition using classification and invariants, (2011) *International Review on Computers and Software (IRECOS)*, 6 (5), pp. 735-739.

Authors' information

Prof. Dr. **Marizan Sulaiman** received B.Sc, MSc. And Ph.D in Electrical Engineering from the University of Missouri-Columbia, USA. He is a professor of Electrical Engineering at the University Technical Malaysia Melaka, Ayer Keroh Melaka. His primary interests related to electrical power engineering, control and mechatronic engineering.

Hairol Nizam Mohd Shah received the Diploma (Electric-Electronic) from University Technology Malaysia in 2000, B.Eng. (Electric-Electronic) from University Malaysia Sabah in 2004. He received the M. Eng. (Mechatronics) at University Technical Malaysia Melaka in 2008. Currently he is a lecturer at the University Technical Malaysia Melaka, Ayer Keroh Melaka. His primary interests related to vision systems and image processing.

Mohamad Haniff Harun received the B.Eng (2010)., Msc.(2013) from University Technical Malaysia Melaka. Currently he is a lecturer at the University Technical Malaysia - Melaka, Ayer Keroh Melaka. His primary interests related to vision systems and mechatronic engineering.

Lim Wee Teck received the B.Eng (2007)., Msc.(2012) from University Technical Malaysia Melaka. Currently he is a lecturer at the University Technical Malaysia Melaka, Ayer Keroh Melaka. His primary interests related to image processing, underwater and control system.

Mohd Nor Fakhzan Bin Mohd Kazim received his B.Eng. (Mechatronics) from International Islamic University Malaysia 2006. He received the M. Eng. (Mechatronics) at International Islamic University Malaysia in 2012. Currently he is a lecturer at the University Malaysia Perlis, Pauh Putra, Perlis. His primary interests related to green energy and energy scavenging.