Performance Analysis of Neural Network Model for Automated Visual Inspection with Robotic Arm Controller System

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***Abstract*— The concept of Automated Visual Inspection (AVI) have emerged as a powerful platform for industrial machine vision where it used to inspect a large number of products rapidly. However, a major problem with this kind of application is the quality produced by the recognition process. In this paper, a system with the capability of identifying and categorizing a product based on image processing has been implemented. The image was processed by using Radial Basis Function (RBF) based on output center and spread values optimization. Robotic arm controller developed for pick and place the product based on their categories. Two performance measures are used to validate the model classification range and the spread values. The results of this project indicate that the model used able to identify the product and classify it according to their shape.**

***Index Terms*— Automated Visual Inspection; Neural Network; Product Identification; Radial Basis Function; Robotic Arm Controller.**

I. Introduction

The concept of Automated Visual Inspection (AVI) has emerged as a powerful platform for industrial machine vision where it used to inspect a large number of products rapidly. The past decade has seen the rapid development of AVI in many sectors such as manufacturing, construction, marine engineering, aerospace, etc. [1]. However, a major problem with this kind of application is the quality of classification produced by the recognition process. The quality of the classification depends on the shape or the size of product for examples bottles, plastic or glass in a sorting operation. The longer time taken in recognition process will lead to increase the cycle time to produce the product in manufacturing lines.

A method of camera calibration of a stereo pair for stereo vision application is introduced using Jean-Yves Bouquet tool that produces the intrinsic and extrinsic parameters of the stereo pair [2]. [3] proposed a controller that communicates with a smartphone to run an electric powered wheelchair.

Regarding the issues, this paper describes the design and implementation of robotic arm controller system using Radial Basis Function (RBF) neural network where the aim is to identify the category of the products in real time situation based on the classification range. The model is able to identify the products in a real-time situation by capturing the image using a webcam connected to a computer for image acquisition. These processes such as image processing and product identification will be done in Matlab. RBF will classify the images based on the shape and allocate the objects based on their criteria in categories. The goal of this project is a system with the capability of identifying and categorizing a product based on image processing. The rest of this paper is organized as follows. Section 2 describes the methodology of this project. Section 3 elaborates the result and discussion. Section 4 concludes and suggests a few new ideas in the development of the AVI system.

II. Methodology

The development the robotic arm controller system using Radial Basis Function (RBF) neural network consists of four main components where three components involved with software development; image processing, neural network classifier and radial basis network, while only one component in hardware development; robotic arm controller.

A. *Image Processing*

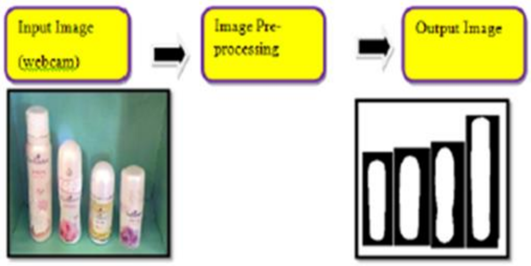


Figure 1: Block diagram of pre-processing image

The image detection and classification developed using canny edge detection technique for 50 input samples for each three type of products that variably in shapes. The image will be converted to the grayscale format, processed with the histogram equalization and later converted to matrix format for feature extraction as shown in Figure 1.

B. Neural Network Classifier

The extracted data from the image processing will be used as an input data for RBF to perform the learning process in the model. The RBF model needs to be trained so that the network can classify the product based on classification range and categorize the product according to the sizes as shown in Table 1.

Table 1
Classification range for three products

Type of Products	Number of Training	Recognition Values	Classification Range
Product A	50	1	0.80-1.22
Product B	50	10	9.00-11.00
Product C	50	100	99.00-100.40

C. Radial Basis Network

RBF (newrb) function has been used to create an RBF network with zero error on training vector where it will add the neuron to the hidden layer where the hidden layer acts as a detector for a different input vector until it meets the specified mean squared error goal [4]. Large spread value means many neurons are required to fit for a fast-changing function while small spread value means many neurons are required to fit for a smooth function.

For completing this project, a few methods have been applied to achieve the target, which is:

a) Identify the parameters that need to be use.
b) Develop the software for the system
   1.Pre-processing image
      i. Read the image from webcam
      ii. Thresholding process
      iii. Edge detection
      iv. Extract image
   2.Pre-processing image
      i. Morphological based approach
   3.Neural network system
      i. Train neural network
      ii. Test neural network
      iii. Graphical user interfaces (GUI)
   4.Simulation result
   5.Hardware result

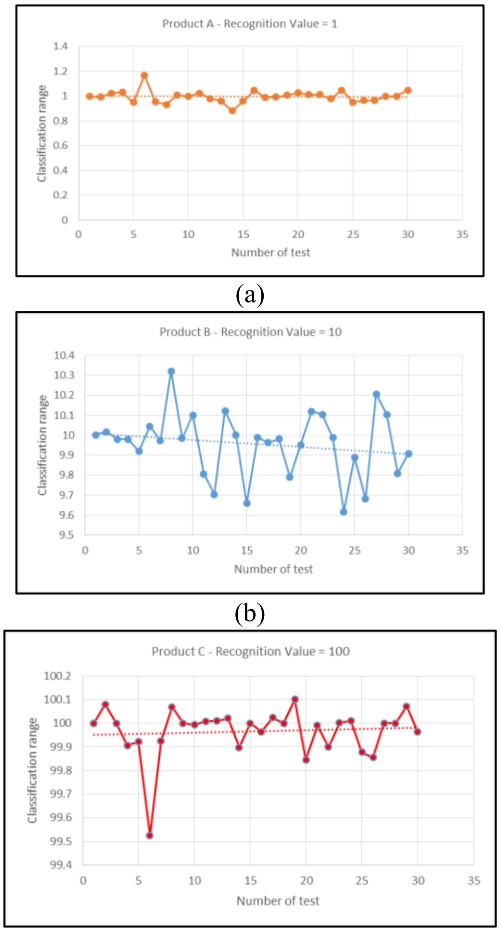
D. Robotic Arm Controller

The robotic arm controller has been developed consists of Programmable Logic Controller (PIC), a webcam and robotic arm that run using Matlab [5]. The system transmits and receives data between the Matlab and a robotic arm for product inspection. The product image captured from the webcam are processed by filling the holes in the image template as a result. This project aims to develop a system that can classify and categorizes three type of products with variably shape using the RBF and robotic arm.

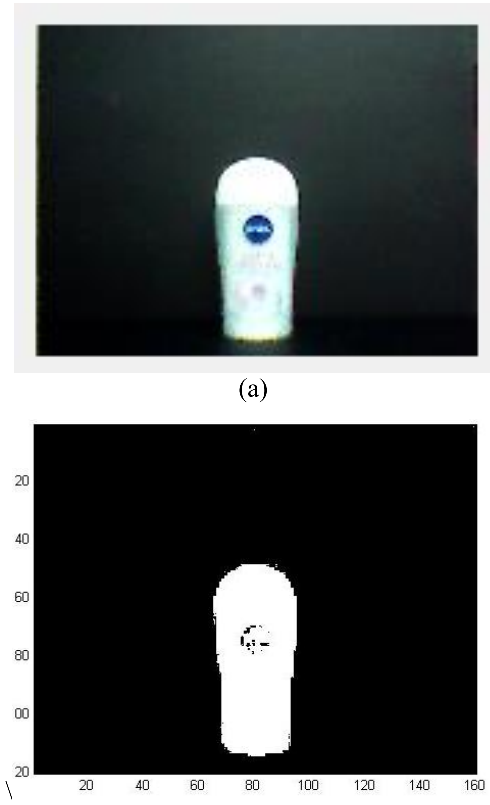
III. Result & Discussion

Two performance measures are used to validate the efficiency and accuracy of this model; classification range and the spread values. The classification range will provide the accuracy result while the spread values will tell how much data samples is spread out or scattered. A classification system developed to present an overview of the overall system that provides a remarkable outcome in running the pre-processing image, edge detection, image extraction, feature extraction, RBF training, and RBF testing.

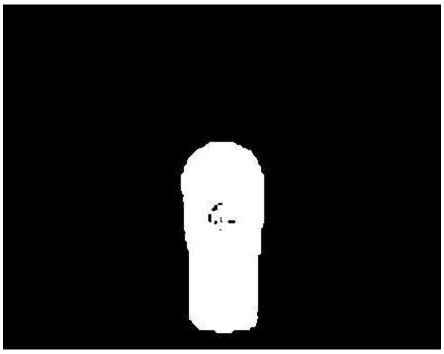
Figure 2 provides the inter-correlations between the product shape and classification range for 30 tests. Further analysis showed that the present results are significant in one major aspect; classification significant with the product shape. The larger the product shape, the classification range will be scattered. This is an interesting finding.



(c)
Figure 2: Classification range (a) Product A (b) Product B (c) Product C



(b)



(c)

Edge Image

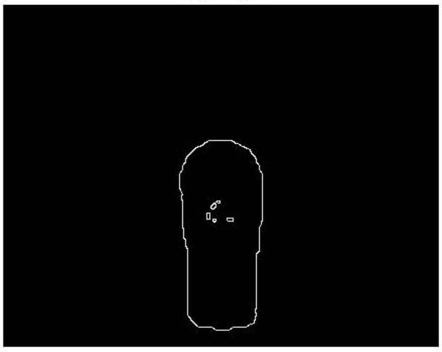


Figure 3: Image extraction (a) Original image (b) Image segmentation (c) Filtering image (d) Canny Edge detection

The spread function has been used in the training process where only 10 samples read from one row. Spread values in this project indicate that for all products the higher spread value, the result of classification range, which is the data samples, is spread near to the target as shown in Table 2 and Table 3. This provides an important key feature of a data sample to understand the data population where the sample comes. Figure 3 shows the segmentation process and the filtering image using Canny Edge detection method.

Table 2
The spread values

Spread	Product A	Product B	Product C
15	0.8616	9.9834	100.0585
20	1.0066	9.9953	99.9968
25	0.9778	9.9883	99.9511
30	0.9970	9.9966	99.9958
35	1.0674	9.9374	99.9494
40	0.9924	10.0066	100.0054

One controller chip PIC16F877A and a regulator LM7805 is needed to stabilize the input voltage with the required value. The circuits need to be completed with ones of 20MHz crystal, four 1μF, 50V capacitor, one 100μF, 25V capacitor, and one LED to indicate of the good operating circuit. The power management for PIC and servo motor need to be on the same ground for both circuits to operate.

Angle measurement and testing are needed to validate the performance of each servo motors. The PULSOUT command is dependent on the oscillator frequency, so that the pulse will be increased. The minimum and maximum position values are taken so that the system can send a servo, and divide each one by actual pulse resolution value as follows as shown in Table 3. The full left position for a servo requires a pulse of 2mS or 0.002 while for the full right, a pulse of 1mS or 0.001 is needed as shown below.

- Data for full left =

$$\frac{2ms}{10us} = \frac{0.002}{0.00002} \equiv 1000$$

- Data for full right =

$$\frac{1ms}{2us} = \frac{0.001}{0.00002} = 500$$

Table 3
Servo motor rotation at specified PULSOUT

PULSOUT	Degree (°)
200	45
300	35
400	20
500	145
1000	145
2000	180

Table 4
Servo motor movement angle for each instruction

Program	Base	1st Joint	2nd Joint	3rd Joint	4th Joint	Gripper
Pick	150º	70º	180º	150º	100º	50º (open) 45º (close)
Place	180º	120º	80º	180º	180º	50º (open) 45º (close)

IV. CONCLUSION

In this project, an AVI system operated with using RBF and robotic arm has been developed for product identification based on shape and classification range. The performance analysis shows that the model used able to identify the product and classify it according to their shape. It was concluded that the RBF model of identification could provide accurate performance in product categorization. Hence, the results can provide the preliminary studies and guidelines for engineers in implementing image-processing technique into the manufacturing system.

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