COLOUR AND TWO DIMENSIONAL SHAPE RECOGNITION SYSTEM SOFTWARE FOR AN INTELLIGENT PICK AND PLACE ROBOT ARM

R. Arunthavanathan[1], G. D. M. Pathmika[2], S. Balasuriya[3]

[1] Department of Electrical and Computer Engineering, Faculty of Engineering, Sri Lanka Institute of Information Technology (SLIIT), Sri Lanka. Email: rajeevan.a@sliit.edu.lk
[2] Department of Mechanical Engineering, Faculty of Engineering, Sri Lanka Institute of Information Technology (SLIIT), Sri Lanka. Email: mihiran.g@sliit.edu.lk
[3] Faculty of Technology, Engineering and the Environment, Birmingham City University (BCU), UK, Email: b.balasuriya@mail.bcu.ac.uk

ABSTRACT

A novel software development, through an innovative algorithm, which can be applied to control an industrial level robot arm for pick and place operations is presented. Image Processing Software was successfully developed provided with a user friendly GUI. The software identifies circles, rectangles and triangles and their colours using digital image processing. Identification of basic shapes is done through Contours and Hough transformation algorithms. Colours of each shapes are extracted from three dimensional RGB image and it is initially converted to two-dimensional grayscale image. Gaussian functions for digital noise filtering, RGB colour pixel information analysis and classification for colour recognition are later applied to complete the colour recognition process. The developed algorithms are then successfully utilised in developing image processing tool using Visual Basic 10.0 including EMGU Cv 3.0 which can communicate shape and colour details through serial port.

***Key words*:** Image Processing, Shape and Colour Recognition, Digital Noise Filtering

1. INTRODUCTION

The human skill is not identical person to person and not perfect. Up on that, a sizable labour shortage is emerging in manufacturing industries in Sri Lanka [1]. Workforce nullity is attacted to skilled jobs by unskilled workforce. Therefore, the production and cycle times may vary person to person and the accurate predictions are almost impossible. Maintaining a consistent quality would be difficult when conventional methods are used which will lead to lower productivity of the entire production line. Safety of the unskilled workers is difficult to assure when the people are directly involved with the production line. It will be an additional burden to the establishment to have training sessions and workshops for the employees in a timely manner. To avoid labour base problems in industries, factory automation is applied to increase production rate, reduce labour cost, mitigate labour shortage, improve product quality and improve labour safety[2][3][4]. At the moment, factory automation is engaged with industrial robot technology where the labour workforce was applied. In industrial robotic application, sensors play the major role. Sensors communicate with robot controller to provide the required information to execute a proper operation for manufacturing process. Sensors like visual sensors are used where need to identify objects or movement based on visual identification.

This paper describes an innovative algorithm for basic geometrical shape and colour identification. Paper attempts to demonstrate image-processing tool, which is compatible with industrial robot controllers as image processor to extract information for robot operation in manufacturing process.

2. METHODOLOGY

2.1. Procedure

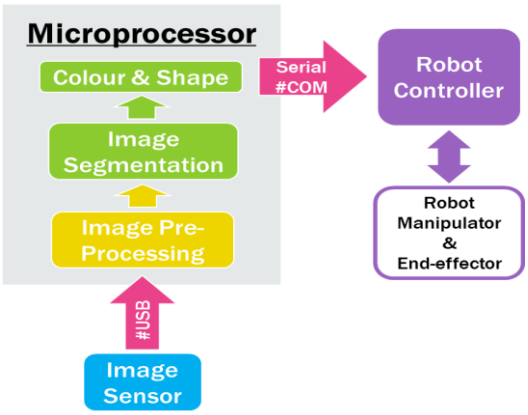

Figure 1: System block diagram

Figure 1 shows the block diagram of image processing system. The image sensor to the

microprocessor-based system sends input visual frame. CMOS image sensor is preferred for high-speed frame rates [5] to detect moving objects. Because CMOS technology has been accelerated for high frame rates which is faster than CCDs sensors[6].Image pre-processing step is applied to enhance the visual appearance for image segmentation by image resampling, greyscale contrast enhancement, noise filtering and removal, mathematical operations, manual correction[7]. Image thresholding, edge-based segmentation and region-based segmentation methods are applied to extract the colour and shape from the input image frame. Colour and shape details are sent through serial port to the robot controller for robot operation.

Figure 2 shows the flow chart of the image-processing tool. Parallel computing method is followed for shape and colour recognition procedure due to image pre-processing and image segmentation methods [8][9]. CPU usage of 1% and RAM usage of 513 MB was monitored by Microsoft Visual Studio Diagnosis Tool for image processing tool development in parallel computing method. After shape and colour are recognized pre-defined alphabetic characters for identified colour and shape is sent via serial port in ASCII format to the robot controller for operation.

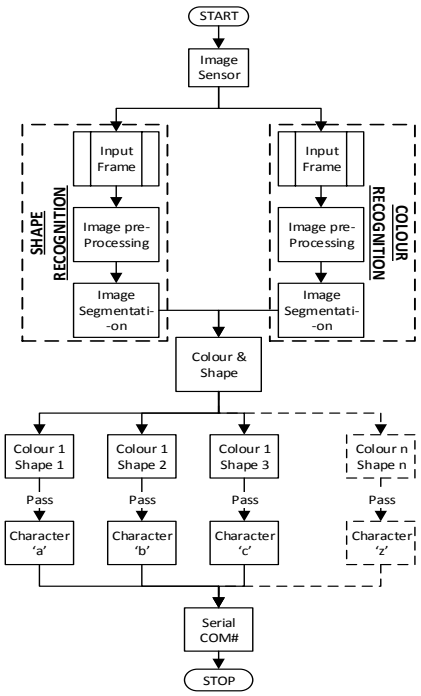

Figure 2: Image processing tool flowchart

2.2. Shape Recognition

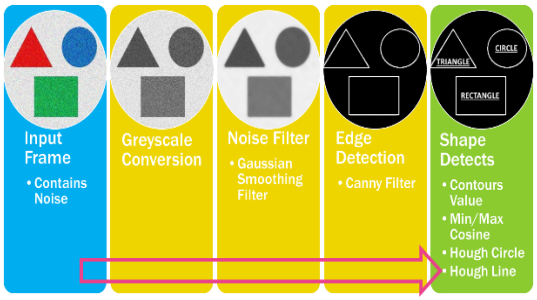

Figure 3: Image pre-processing and segmentation Algorithm for shape recognition

Under image pre-processing, averaging grayscale algorithm [10] is applied in RGB to grayscale conversion to improve visualisation of input frame by brightening. Low pass filter, Gaussian Smoothing Filter is applied to reduce Gaussian noise and salt and pepper noise [11][12] in input image which can affect for edge detection. Canny edge detector is used to detect continuous edges for image segmentation process [13][14].

In image segmentation, triangles are detected by counting the continuous contour from input image. If contour value is equal to 3, shape marked as 'Triangle' for contour area greater than 250 in pixel range. Rectangles are recognized by image processing tool considering general properties of rectangle. If continuous contour is equal to 4 and if the four angles are right angled and opposite sides length ratio is equal (measure by min/max cosine) shape is marked as 'Rectangle' for contour area greater than 250. Hough transformation is used [15] to recognize circles in input image circle radius between 10 to 400 in pixel range. Hough transformation line detection algorithm [16] is applied to identify and draw lines of detected shapes edge in software interface.

2.3. Colour Recognition

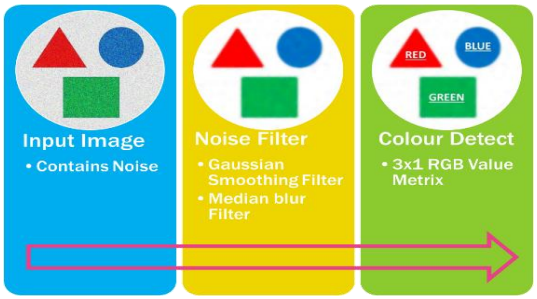

Figure 4: Image pre-processing and segmentation algorithm for colour recognition

Under image pre-processing Gaussian smoothing Filter and Median Filters are simultaneously used to reduce the Gaussian noise, salt and pepper noise, speckle noise, and gamma noise[12].Colour level changes due to noise filtering will be minimized by median filter [11]. In image segmentation colour is recognised by comparing RGB values in form of matrix where the rangers are fed to the program. Table 1 shows the minimum and maximum RGB colour values for selected colours range under colour recognition.

Table 1: RGB values for selected colour range

	RGB Colour Space					
	Blue		Green		Red	
	Min	Max	Min	Max	Min	Max
Blue	150	255	0	100	0	100
Green	0	100	150	255	0	100
Red	0	100	0	100	150	255

3. RESULTS

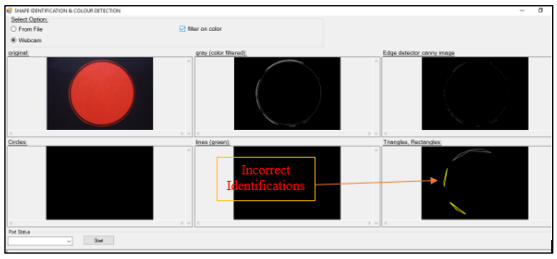

Figure 5: Test Result 1

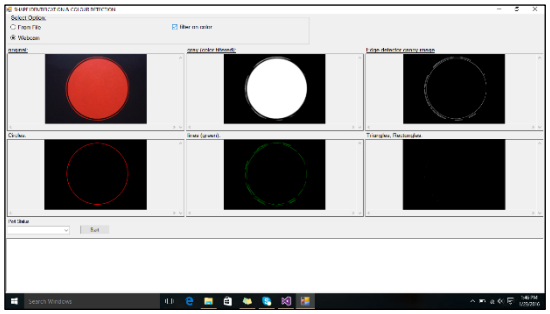

Figure 6: Test Result 2

Light condition and reflections are handled and controlled by physical objects and materials. Figure 5 shows the test result of serial computing methods, which is commonly used for algorithm development. Results shows incorrect results and mal-operations obtain under bulk identifications attempts. Figure 6 shows the proposed algorithm test of parallel computing method. Accurate results were obtained under general conditions.

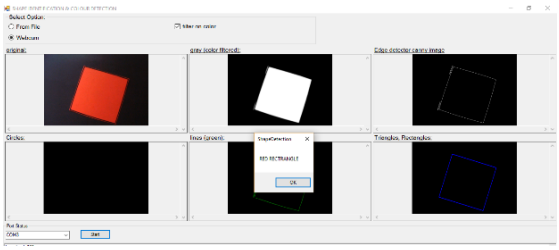

Figure 7 - Test Result 2

Figure 7 shows the test result for orientated objects. System is tested for red rectangle as shown. The correct orientated object is identified.

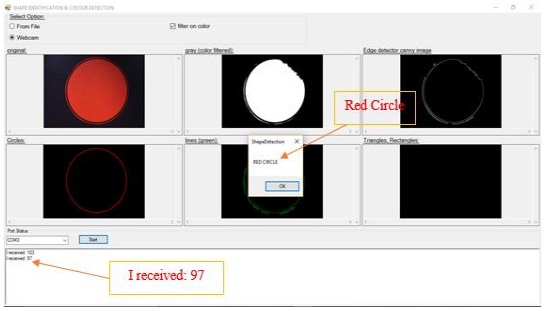

Figure 8: Test case 01

Test result of dummy, red circle is shown in Figure 8. Software has been tested for Windows 10; 64-bit operating system. From the option selector web cam is selected as input video frame. The original video frame from web cam can be seen in first window which labelled as 'Original'. The processed video frames are shown in other window. Character 'a' is passed from the format of ASCII to the Arduino via virtual serial port. The deliver message from Arduino board is received "I received: 97" as shown. Table 2 shows test results Circle (Blue, Green), Rectangle (Red, Blue, Green), Triangle (Red, Blue, Green) as blow.

Table 2: Test Results

Tests Case	Results	
	Message box	**ASCII**
Red Circle	Red Circle	97
Blue Circle	Blue Circle	98
Green Circle	Green Circle	99
Red Rectangle	Red Rectangle	100
Blue Rectangle	Blue Rectangle	101
Green Rectangle	Green Rectangle	102
Red Triangle	Red Triangle	103
Blue Triangle	Blue Triangle	104
Green Tringle	Green Triangle	105

4. CONCLUSION

The innovative algorithm is intelligent to detect basic geomantic shape which are rotated from generic orientation and differs from size and dimensions. Parallel computing method helps to get rid from mal-operations and increase the accuracy of shape and colour identification. Colour rangers under colour identification can be modified to secondary and intermediate colour rangers. The software is capable of controlling industrial robots, controlled by shape and colour identification details via serial communication.

5. REFERENCES

[1] Sunday-times, "*Sri Lanka has a shortage of skilled and unskilled workers, BT-RCB poll reveals",* The Sunday Times, 04 05 2014. [Online]. Available: http://www.sundaytimes.lk/140504/business-times/sri-lanka-has-a-shortage-of-skilled-and-unskilled-workers-bt-rcb-poll-reveals-94200.html. [Accessed 26 02 2016].

[2] E. Csanyi, "*9 Reasons for Automation of Manufacturing Process",* 11 01 2016. [Online]. Available: http://electrical-engineering-portal.com/9-reasons-for-automation-of-manufacturing-processes. [Accessed 26 02 2016].

[3] A. Gupta and S. Arora, "*Industrial Automation and Robotics"* 3rd ed., Mohali: Laxmi Publications, pp. 1-9, 2013.

[4] B. Carlsson, "*Technological Systems and Economic Performance",* The Case of Factory Automation, Sweden: Kluwer Academic Publisher, pp. 369-401, 1995.

[5] M. El-Desouki, M. J. Deen, Q. Fang, L. Liu, F. Tse and D. Armstrong, *"CMOS Image Sensors for High Speed Applications",* Sensors, vol. 2, no. 9, pp. 430-442, 2009.

[6]M. Bigas, C. E, J. Forest and J. Salvi, *"Review of CMOS image sensors",* Microelectronics, vol. 1, no. 37, pp. 433-451, 2005.

[7] S. Bhattacharyya, "*A Brief Survey of Color Image Pre-processing and Segmentation Techniques",* Pattern Recognition Research, vol. 1, no. 11, pp. 120-129, 2011.

[8] B. Barney and L. Livermore, *"Introduction to Parallel Computing",* National Laboratory, 17 08 2015. [Online]. Available: https://computing.llnl.gov/tutorials/parallel_comp/. [Accessed 1 3 2016].

[9] W. M. Eddy, and M. Allman, "*Advantages of Parallel Processing and the Effects of Communications Time",* NASA Glenn Research, Ohio, 2000.

[10] C. Kanan and G. W. Cottrell, *"Color-to-Grayscale: Does the Method Matter in Image Recognition",* PLoS ONE, vol. 7, no. 1, pp. 1-7, 2012.

[11] P. Patidar, M. Gupta, S. Srivastava and A. K. Nagawat, *"Image De-noising by Various Filters for Different Noise",* International Journal of Computer Applications, vol. 9, no. 4, pp. 45-50, 2010.

[12] A. K. Boyat and B. K. Joshi, *"Noise Models In Digital Image Processing",* Signal & Image Processing (SIPIJ), vol. 6, no. 2, pp. 63-73, 2015.

[13] S. Saini, B. Kasliwal and S. Bhatia, *"Comparative Study of Image Edge Detection Algorithms",* Computing Science and Engineering, p. 5, 2013.

[14] M. R and M. Radha, *"Edge Detection Techniques For Image Segmentation",* International Journal of Computer Science and Information Technology (IJCSIT) , vol. 3, no. 6, pp. 259-266, 2011.

[15] C. F. Olson, *"Constrained Hough Transforms for Curve Detection",* Computer Vision and Image , vol. 73, no. 3, pp. 329-345, 1999.

[16] C. Singh and N. Bhatia, *"A Fast Decision Technique for Hierarchical Hough Transform for Line Detectionz',* Punjabi University Journal, pp. 7, 2010.