

Colour-based PBEJCT Sorting in a Wide Range and Dense Target Points using Arm Robot

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Abstract— The sorting system using arm robot is very complex as it involves pick and place mechanism. The complex parts of the system come from the mechanical parts and also the electronic-based control. The complexity will increase as higher the degree of freedom (DOF). This paper report the development of the sorting system using 4 DOF and employs a CCD camera for detecting the object. The movement principles of the arm is using kinematic both forward and inverse. The camera will differentiate the object using its colour. The result shows that the arm can place the object in the 5 mm distance while the coverage area is a square of 30 cm.

Keywords— *sorting system, arm robot, 4 DOF, colour detection;*

I. INTRODUCTION

Automated sorting system is a complex system. This system involves pick and place tasks based on features detection of the sorted object. Recently, various sorting systems have been developed. One of the sorting system that has been developed is an automated object sorting systems based on programmable logic controllers (PLCs) that utilizing proximity sensors to detect items [1]. An intelligent worm sorting has been developed using robotic vision based on worm body postures analysis [2]. A charge-coupled device (CCD) camera was used on automated sorting system to detect object shape and position. The system was also equipped by target tracking that work based on synchronous conveyer and servo motor [3]. A CCD camera was also used in sorting system to classify gear based several feature including number of teeth, number of holes, or its colour. The system includes three processes, including colour, holes number, and teeth number extraction [4]. A machine vision based sorting system was also used to sort Date fruit based on its maturity. In this system, a conveyor belt was used to feed a Date fruits into sorting system. The Dates fruits were sorted based on its maturity using its colour features [5].

Besides using a mechanical system, the sorting system can implement a robot to move the object from the sorting system into its container. The robot has advantages for its flexibility to handle/pick objects with various shape and size. The robot that has been used in the research also varied from industrial robot to low cost arm robot [6] – [8]. An arm robot has been used to pick food in meal assistance based on Brain-Computer Interfaces (BCI) system that is used by person that unable to pick the food by him/herself [6]. In

sorting system, a robot can be combined with other system such as conveyor and object detection. A 3 degree of freedom (DOF) parallel mechanism robot can be combined to develop a sorting system. This robot can perform repeating position with accuracy ± 0.01 mm in space, and can conduct more than 120 times/min pick-and-place operations [3]. A coordination system between 5-DOF anthropomorphic robot and stationary vision system can be implemented to handle an object [7].

Based on the background above, a colour-based object sorting in a wide range and dense target points using arm robot has been developed.

II. BASIC THEORY

A. Camera Vision

Image processing is signal processing where the input is an image, such as a photo or video frame, while the output of the image processing can be an image or a number of characteristics or parameters related to the image. Most image-processing techniques assume images as two-dimensional signal therefore the researcher can apply standard-signal processing techniques to it. The term digital image processing is generally defined as processing two-dimensional images with a computer. In a broader definition, digital image processing also includes all two dimensional data. Digital imagery is a sequence of real or complex numbers represented by certain bits.

The basic concept of image processing is simple enough. An image is basically a collection of colour dots on a screen often referred to as pixel. The more pixels that an image has, the better the image quality will be. Although the human eye is unable to distinguish images above 5 megapixels of the same size, the large number of pixels in the image is still useful. For images with a large number of pixels, enlarging the image size will not unduly reduce image quality. While on the image with a little pixel, enlarging the image size will cause the image look broken and plaid. Each pixel of this image is essentially representative of a colour vector on the screen.

Generally on the current colour display, the colour vector consists of 3 layers, each layer representing the sub colour red, green, and blue (red, green, blue). A colour vector element will be valued between 0 and 255 so that the later black colour will represent the vector [0 0 0], while the clean

white colour will represent [255 255 255]. The other colours are variations of these three elements with different values. In image processing basically display the pixel value of the image, extract the RGB pixel value, convert RGB to Grayscale, and convert RGB to binary.

B. Arm Robot Kinematic

Robot arm is one of the most widely used robot types by industrial society. Robot arm is also commonly called the industrial robot manipulator consisting of links and joints. Robot arms can be moved at certain positions in accordance to desired command using the principle of robot kinematics. This robotic kinematics can be defined as the movement of a robot (motion) regardless of force or other factors affecting the movement of the robot. The kinematics of robots is generally divided into two, the forward kinematic and inverse kinematic.

The forward kinematic is a kinematic analysis for obtaining the position coordinates (x, y, z) if the angles of each joint are known. For example, if you have a n-DOF robot and the angle of each joint can be used forward kinematic analysis to get the coordinates of the robot position. The forward kinematic is used to obtain the position and orientation of the end effector by inserting some angular values for each arm robot joint. To obtain a direct kinematic equation of arm robot, Denavit-Hartenberg (D-H) method can be implemented [9]. The D-H method is a method for analyzing the relationship of rotational motion and translational motion between the corresponding arms in a manipulator.

Inverse kinematic is a kinematic analysis to obtain the angle of each joint if position (x, y, z) is known [10]. Using the application of inverse kinematic algorithms, the combination of joint's angles that produces a certain position of the end of the arm robot can be computed. By using inverse kinematic, the programmer (human) does not need to set up the combination of joint's angles on the robot, but simply determine the position coordinates of the end of the robot arm, or other parts of the robotic arm to achieve a certain movement of the robot arm. This is possible because software that has been implementing inverse kinematic of the robot will automatically calculate the combination of joint's angle for each input of the given point coordinates.

III. METHODS

The developed robot consists of three main parts, that is, object detector, controlled-actuators, and processor. Object detector has function to detect coloured-objects using Pixy CMU Cam5. Controlled-actuators consist of 4 servos to develop 4 degree of freedom (DOF) as arm robot. On the other hand, Processor has function to interpret the information from Pixy CMU Cam5 and decide action control for servos. These parts are shown in Fig. 1.

A. Coloured-Object Detector

Objects were built from styrofoam with dimension of 3x3x2 cm, since the weight is not considered in paper. The objects have three colour, i.e., red, green, and blue. In order to detect object, Pixy CMUcam5 is used. It has explained before that the embedded colour vision uses Pixy CMUcam5. This device has a dual core processor, i.e., NXP LPC4330 working on 204MH with omni-vision image

sensor 1280x800. The data output can be transferred using Universal UART serial, Serial Peripheral Interface (SPI), I2C, USB, or digital/analog output [11].

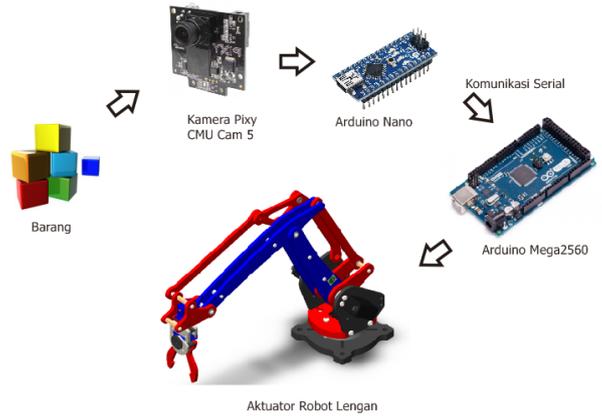


Fig. 1. The system components

Pixy CMUcam5 is used to detect coloured-objects, where data are interpreted by micro-controller, here Arduino is used. In the implementation, Pixy CMUcam5 uses a colour-based filtering algorithm, which determines the primary filtering parameters using the colour (hue) and saturation of each red-green-blue (RGB) pixels. In this process, the coloured codes are transferred as area of pixels, so it can be used to determine the size of objects [12]. Pixy CMUcam5 can detect more than 7 colours using colour codes (CC). So object detected can be indentified according to CC.

B. Controlled-Actuators

The arm robot is developed using 4 DOF, which means that it need 4 servo motors; here, the type of servo motors is TowerPro MG966. The design of robot is shown in Fig. 2 consisting of base, shoulder, elbow, and wrist. The base has ability to turn horizontally in range of 180°, so robot can turn to left or right. Shoulder and elbow are used to turn vertically, so it could turn up/down and forward/backward, respectively. Wrist is used to turn the end joint, so it could be used to control the end joint turn right/left. The end joint is built as a gripper, which could open/close in range of 1-40mm.

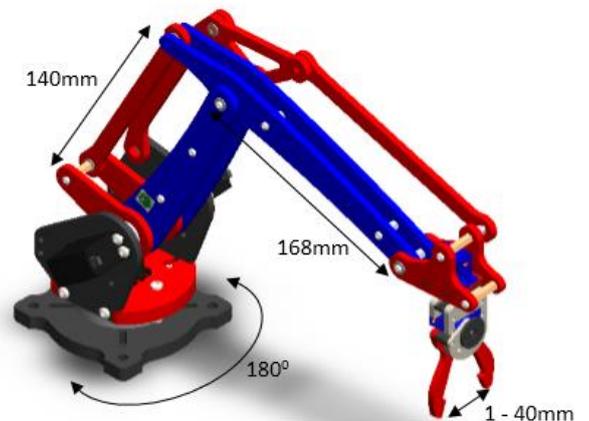


Fig. 2. Design of arm robot

C. Processor

Here processor of arm robot is separated into two part, the first part works as the sensor processing, which process information from sensor, i.e., Pixy CMUcam5, and send data to the second part. The second part of processor works as the main processor to determine actions which should be done by actuators considering data sent by the first part. These actions determine motion of arm robot.

IV. EXPERIMENT CONDITION

The arm robot is implemented to the environment as shown in Fig. 3.

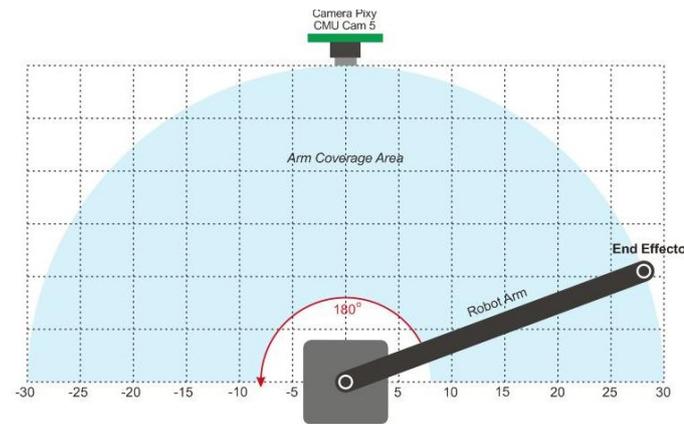


Fig. 3. Experimental condition

Considering the experimental condition, the object is placed 10 cm in front of camera firstly, then it would be moved to the somewhere in the arm coverage area as shown in Fig 3. Here, the object is detected based on the colours, i.e., red, green, and blue. The number of pixels detected is taken 10 times, then it would be counted as mean, min, and max.

The coverage area for moving the object is calculated using invers kinematics (IK). Regarding Fig 3, the coordinates for placement have distance of 5mm, while the covered area can be -30 until 30 cm.

V. EXPERIMENTAL RESULTS

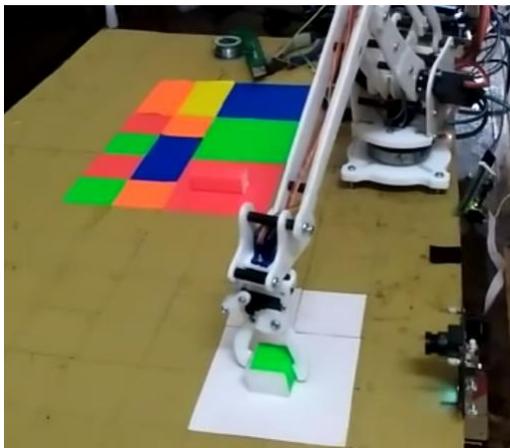


Fig. 4. Experiment results

A. Colour Detection

Firstly, experimental results were done by detecting coloured-object. In this experiment, the sensor can detect three colours as shown in Fig 5. Here, the number of pixels averaged from 10 experiments is shown in Table 1.

TABLE I. REPRESENTATION OF DETECTION OBJECT DATA HASIL PERCOBAAN

No.	Colour	Colour Code	Number of Pixel Average		
			Mean	Min	Max
1.	Red	1	1612	1589	1624
2.	Green	2	1608	1501	1659
3.	Blue	3	1631	1597	1662

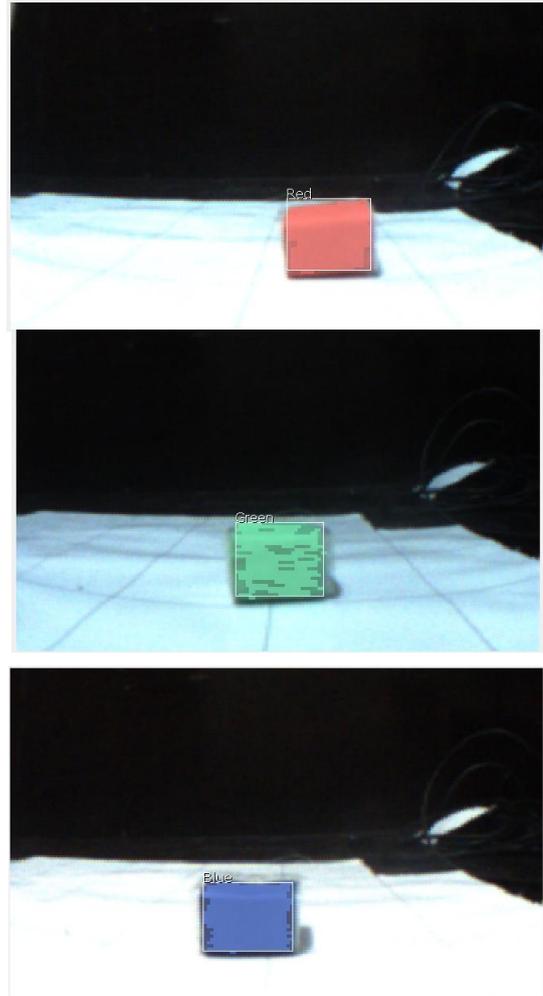


Fig. 5. Coloured object detection with Red-Green-Blue colours

VI. CONCLUSION

Combining 4 DOF arm robot and camera, the sorting system based on the object can performed selection and placement at almost accurate target. The arm robot can move in 4 degrees freely in a range of 60 cm. The object can be detected using camera at almost equal number of pixels. The research could be extended for various distance between camera and object, marker based detection e.g. QR code, and random placement of object and placement target.

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