Vision-Based Mechatronic System For Classification and Sorting Colored Objects

Ahmed Salah Bayoumi
Military Technical College, Egypt, beso4377@gmail.com

Supervisor: Dr. Abdelrahman Zaghloul, *Supervisor:* Dr. Ehab Said, Head of Mechatronics Engineering Department
Military Technical College, Egypt, asalah@mtc.edu.eg, Military Technical College, Egypt, ehab_said@mtc.edu.eg

Abstract– Nowadays, all aspects of life mainly depend on mechatronics systems and automation process. Computer vision &machine learning are widely used in the life. the Mechatronic System use of machine learning to recognize and holding the different colors of the object. The main goal of paper is to obtain a prototybe the experimental process is to automate the process of identify, manipulating, selecting and sorting objects by using many methods such image processing for many image using three colored objects (Red,Green ,Blue) with many shapes (Cylinder, qubic ,Triangel) and the another methodes inverse kinematics to obtain the desired location to set the objects.

I. Introduction

Robot is computer-generated machine. It is typically an electro-mechanical machine which it is directed by the microelectronic software design, therefore capable of doing jobs on it's individual. Robot is used to carry out, pick and place tasks; for example, placing the parts from and to a conveyor belt or using in (CNC) machines.

Image processing is a method of converting an image into a digital form and implementing certain operations on it in order to get the enhanced image or to obtain some information from the image, Image processing is applied in MATLAB software
, the Canny edge detection algorithm is used for shape identification in image processing.

Several methods have been needed to overcome the classification and sorting colored objects issue, such as machine learning, artificial Intelligence, and so on.

This paper is organized in many sections. First, a methodology that concern on programming language and related tasks focuses on image processing and inverse kinematics algorithms. Then, an overview of the hardware setup including the mechanical design and the electrical components' connections. Finally, conclusions and the proposed future work are presented.

II. Methodology

Matlab is a programming language with many supporting resources and has many libraries such Machine learning and image processing In machine learning, matlab is beginner-friendly and easy to read So, it has been chosen as the programming language in this study.

There are many Sequance Functions that clearify the whole of the system as shown in Fig.1

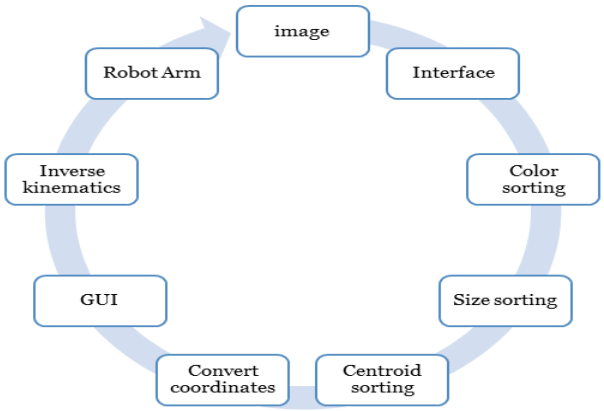

Figure 1: Methodology

A. digital image processing:

The first step in an image processing task is to have a picture to recognize the color. Image taken from the web camera , the original image is shown in Fig 2

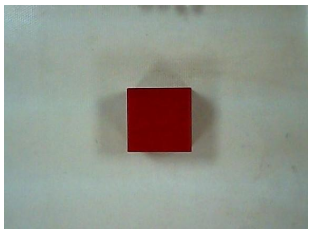

Figure 2: Orignal image

The second step in an image processing task is to Generating red, green and blue color bands of the image , Subtracting gray scale from band Images and we can ploting The histogram of the image by using imhist ( ) function in Matlab Program ,all shown in Fig 3.

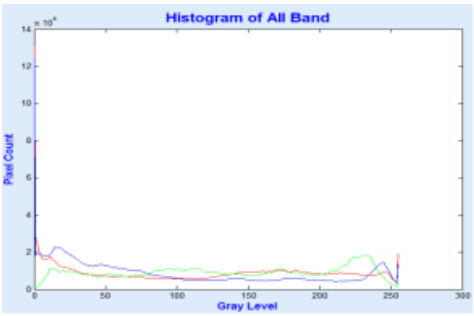

Figure 3: The Histogram

The Third step in an image processing task is to applying Median filtering to get rid of unwanted noise from the image to protect the originality of the image ,throughout this method the picture element value is regenerate to the median of the 3x3 sampling window, whereas the picture element worth remains unchanged at the sampling window boundary which is shown in Fig 4.

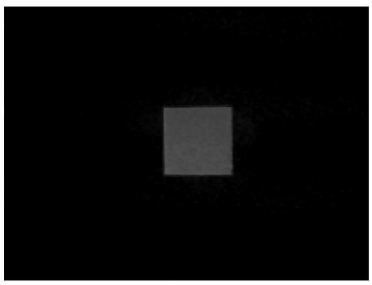

Figure 4: Image after median filtering

The Fourth step in an image processing task is to get the image in binary form (0,1) and by using bwareaopen ( ) function in Matlab Program ,This operation is known as an area opening that removes all connected components (objects) that have fewer than P pixels from the binary image , producing another binary image ,The binary image shown in Fig 5.

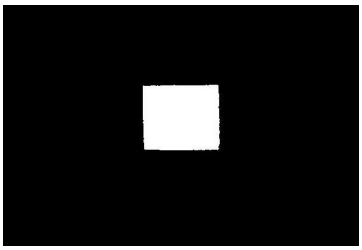

Figure 5: Binary image

The Fifth step in an image processing task is Recognize the boundaries of an object ,getting the color of objects and getting centroid of object by the units of pixels and then by using camera calibration converts this coordinates into cm and resultant image shown in Fig 6

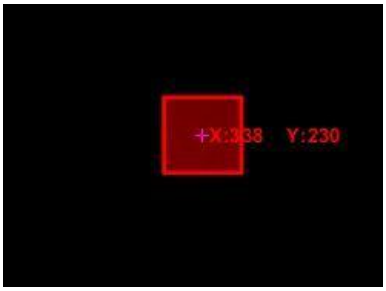

Figure 6: Desired image

B. Camera Calibration :

All measurements are performed on the image using image processing measured by pixel, and the dimensions of objects captured are measured in millimeter, hence, calibration was used to convert these dimensions from pixel to millimeter unit. The camera has angle of view and the distance between the lens and image is known by the depth of the image which be constant at 23 cm and by compare the real distance and the resolution of camera (640x480) at this high we get the scale factor to covert pixel then the scale factor = 0.23437mm/pixel.

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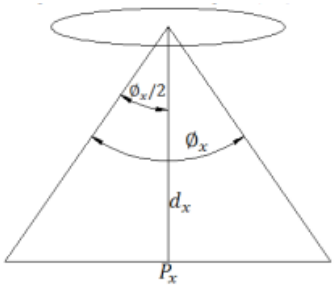

Figure 7: The camera angle of view

C. Inverse Kinematics:

In order for the system to operate it should solve functions using inverse method to get the position of selected objects placed in the workspace of the robotic arm and translate to angular positions for the robotic arm

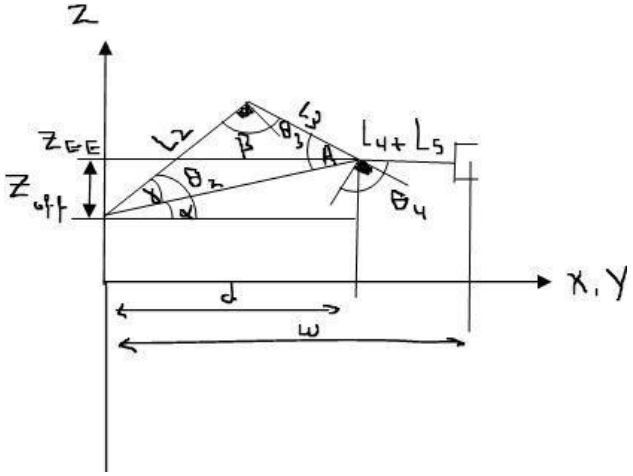

Figure 8: Side view of kinematic diagram

The derivation of the equation is given below:

$\theta_1 = \tan^{-1}(Y_{EE}/X_{EE})$

$\omega = (X_{EE}^2+Y_{EE}^2)^{0.5}$

$d= \omega - (L_4+L_5)$

$Z_{off} = Z_{EE} - L_1$

$R= (d^2+ Z_{off}^2)^{0.5}$

$\alpha = \cos^{-1}(d / R)$

$L_3^2 = L_2^2 + R^2 - 2*L2*R*\cos(\gamma)$

$\gamma = \cos^{-1}((L_2^2+R^2-L_3^2) / (2*L_2*R))$

$\theta_2 = \alpha + \gamma$

D. Interfacing Arduino with matlab

Matlab and Arduino communication are used to interface the computer and the experimental setup. It allows sending data back& forth between pc and Arduino through serial communication method. This is the simplest method for automating the process of Color detection and to run the process easly . Arduino Mega is used to control actuators and sensors; its software language is simple to learn.

III. Hardware Setup

To validate the image processing and inverse kinematics On the model, the hardware setup is built to handle a real-life problem. The hardware can be divided into two essential titles: Mechanical design & Electrical connections.

A. *Mechanical Design*

The mechanical design of the experimental setup is constructed as a proof of concept. So that, fast fabrication methods are adopted, like 3D printing of parts such (Dc motor holder, IR sensor holders, camera holder, wheels of delivery units) from polylactic acid (PLA), as shown in Fig 9 The main frame of the hardware is fabricated using v-slot bars connected by c-brackets, bolts, and t-nuts, The machine consists of Three major mechanisms :

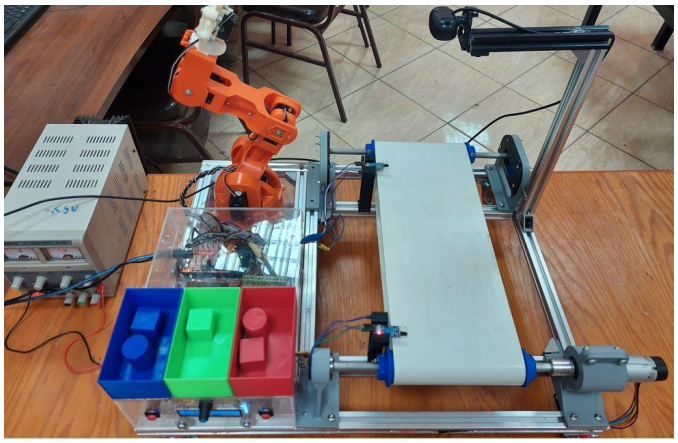

Figure 9:The main components the experimental setup

First is called the Camera holding mechanism , the camera is supposed to be integrated with holder which designed by SolidWorks and manufactures in a 3D printer , Vision source has to be located at the end of conveyer belt to to take picture at object height (230mm)

The second is called the delivery unit consist of rubber conveyer belt used to deliver the objects with color (R,G,B) to the final stage of coveyer belt using IR sensor to operate the motor connected by Arduino Mega (on , off) , The third is called Robotic Mechanism to take the reached object putting in final destination according to their color , The delivery unit consists of a roller rod, coupler, Bearing, and friction wheels. DC motor is responsible for producing rotary motion for the roller rods. It is held by a DC motor holder which is fixed to the v-slot bar Shown in Fig 10

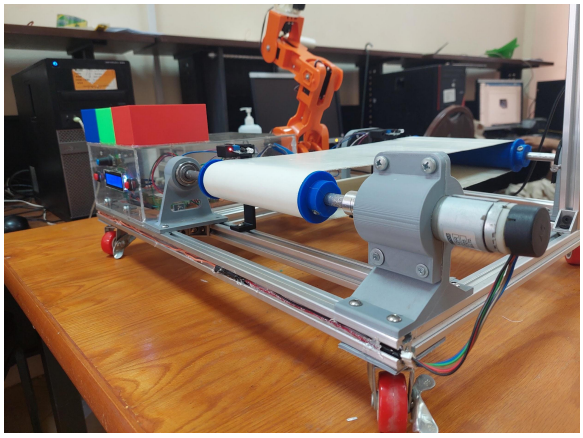

Figure 10: Delivry Units

The third is called Robotic Mechanism to take the reached object putting in final destination according to their color., The Braccio can be assembled in many different ways like attaching a solar panel, camera, but in this project six servo motors are used to move an object The Tinker Kit Braccio Robotic Arm is used through the Arduino Mega board for six different motion control. The 'C' source code is uploaded to the Arduino Mega board , Tinker Kit Braccio Robotic Arm shown in Fig 11

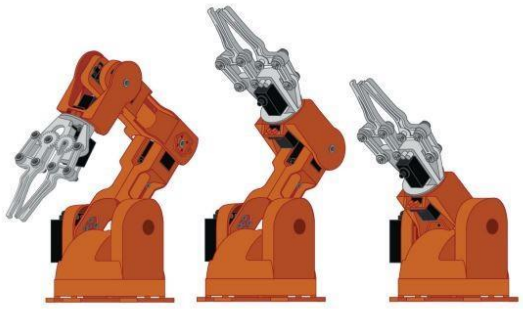

Figure 11:Tinker Kit Braccio Robotic Arm

B. *Electrical Connections*

The Process of color detection is done on the PC. The communication between the PC and the hardware setup microcontroller, which is Arduino Mega, is done by using the Arduino library with Matlab using serial communication. Motors are used for Rolling of the Rod. This part will illustrate the electrical connection of sensors (IR sensor, LCD, LED, push buttons) and actuators (DC motor) to the Arduino Mega and their main specifications. The electrical connection of the whole circuit is shown in the Fig 12 In addition, pushbuttons are connected to pin (A0). These buttons are used to control the machine's manual mode and there are automatic modes when pot sensor getting 0 and manual if get 1 by mapping.

Motors are used as the source of motion in the experimental setup. For DC motor, (L-293D IC) is used as the motor driver that makes it easy to control the motor speed by using Pulse Widths Modulation and control direction of motion by using H-Bridge

Liquid Crystal Display (LCD) is a tiny circuit board with 16 male header pins soldered to it. These pins are meant to be connected directly to the 16-pin connection on the LCD 16 x 2 display. The device also has a 4-pin connector (VCC, GND, SDA, SCL) for connection to the I2C bus, Arduino Mega uses two of them D20, D21 as SCL and SDA In addition, there is a

small trim potentiometer on the board, this is the LCD brightness control.

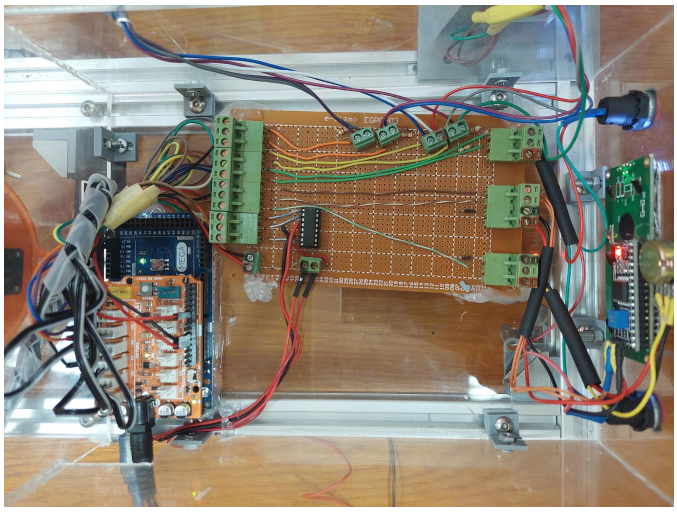

Figure 12:The electrical connection of the whole circuit

IV. Result and discussion

In This section illustrates the performance of Robotic arm to detect the color and pick the objects to the final position without any error, This process is repeated for each category in each parameter 25 times. Tabel 1 displays the results of our experimentation.

Table 1: Accuracy of Color Selection

color	**Attempts**	**Success**	**Failure**	**Success(%)**
Red	25	24	1	96
Green	25	22	3	88
Blue	25	23	2	92

V. Conclusion

The main objective of this research to presents a design and implementation of a robotic vision system to determine their desired object, which is then picked up and placed by a robotic arm according to it's color detected by using image processing methods into the target location using inverse kinematics. Finally, an experimental setup was designed as shown in lasted figures In the future

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