ISSN 2250-3153

# Design of an Optically Controlled Robotic Arm for Picking and Placing an Object

**Shyam.R.Nair**

Department of Electronics and Instrumentation, Hindustan University, Chennai

***Abstract-*** This paper focuses on design of an optically controlled robotic arm for picking and placing an object. The arm has 2 links and 3 joints. An optical panel is used to control the arm. The panel is made of IR transceivers in the form of an array. The coordinates from which the object is to be picked and placed is selected using panel and the robotic arm uses inverse kinematics to execute the task.

***Index Terms***- DOF, Inverse kinematics, Optical panel, Robotics, Robotic arm

## I. Introduction

Robot is a machine to execute different task repeatedly with high precision. Thereby many functions like collecting information and studies about the hazardous sites which is too risky to send human inside. Robots are used to reduce the human interference nearly 50 percent. Robots are used in different types like fire fighting robot, metal detecting robot, etc.

The first robotic arm to be used in an automobile industry was "UNIMATE" in GM motors USA in 1950s. From then there has been tremendous improvement in the research and development in robotics. Now robots are an integral part of almost all industries. Robots have to do different tasks including welding, trimming, picking and placing etc. These robots are controlled in different ways like keypads, voice control, etc.

In this paper, we introduce optical control of the robotic arm. The optical panel is made up of IR transceivers in the form of an array. This panel is connected to a PIC microcontroller through multiplexers. The array represents the working environment of the robotic arm. The panel is divided as 4 sectors representing the 4 quadrants. To select the real time object, the corresponding coordinate in the array is selected. The first selection is taken as source and the second selection is taken as destination. Once the robot gets the coordinates, it uses the inverse kinematics to calculate the required rotation.

## II. HARDWARE

### A. Mechanical

The robotic arm has 2 links and 3 joints. It is mounted on the center of a table or the platform on which it is supposed to deal with the objects. The end point of the second link has an electromagnet and all objects are magnetically attractive. The range of the arm is the total length of the two links. The length of each link can be designed as per requirement. It can be of equal or different lengths. The arm has 3 degrees of freedom. Each joint has a dc geared motor for the link movement.

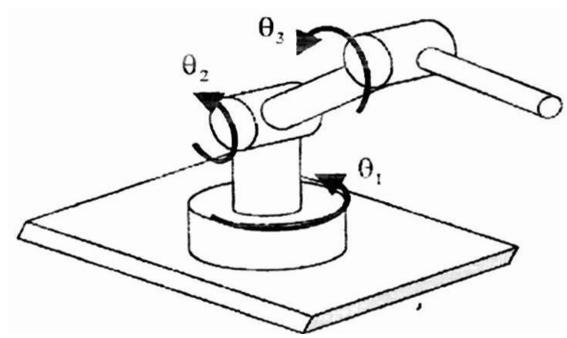


Figure1: Robotic Arm

### B. Electronics

The robot electronics consists of a PIC microcontroller, optical panel, motor driving unit and a power supply.

The optical panel is made of IR transceivers in the form of an array. According to the number of coordinates and accuracy required, the number of IR transceivers may be increased.

For instance, if we take 10 units of X and Y coordinates in one quadrant, we use 80 (10*2*4) IR transmitters and 80 IR receivers. And if each of these are placed 1cm apart, then a total area of 400cm² can be covered with 1cm accuracy.

The optical panel is connected to the PIC microcontroller through multiplexers. The first interpretation is taken by the robot as the source and the second interrupt is taken as the destination. For example, if the first interrupt occurs at (-1,-2) and the second at (1,-5), then the object at (-1,-2) is picked and placed at (1,-5).

The motors used are dc geared motors with appropriate torque and rpm. Solenoid type relay is used as the motor drive unit.

A lead acid battery is used as power source for the entire system.

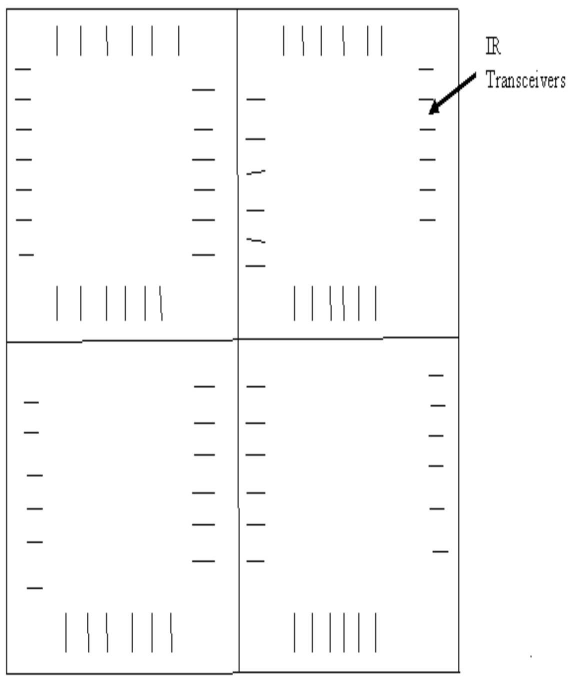


Figure2: Optical panel

## III. MATHEMATICAL MODELING

### A. Inverse Kinematics

O is the point to be reached.
'c' and 'a' are lengths of first and second link respectively.

From figure1 and figure3;
$\theta 1 = \theta$
$\theta 2 = A$
$\theta 3 = B$

By Pythagoras theorem,

$b^2 = x^2+y^2$ (1)
$\theta = \tan^{-1}(y/x)$ (2)

We know that area of a triangle is given by;

Area = $(s*(s-a)*(s-b)*(s-c))^{1/2}$ (3)

Where, $s = (a+b+c)/2$ (4)

We also know that the area of a triangle is given by;

Area = ½*base*altitude (5)

From figure (2);

Area = ½*b*h (6)
But h = c*sinA (7)

Now, by substituting (7) in (6), we get;

Area = ½*b*c*sinA (8)

As we know values of a, b and c, the area is calculated as per equations (3) and (4)

Hence, from equation (8);

sinA = 2*Area/ (b*c)

Or

$A = \sin^{-1} (2*Area/(b*c))$ (9)

Similarly,

$B = \sin^{-1} (2*Area/ (a*c))$ (10)

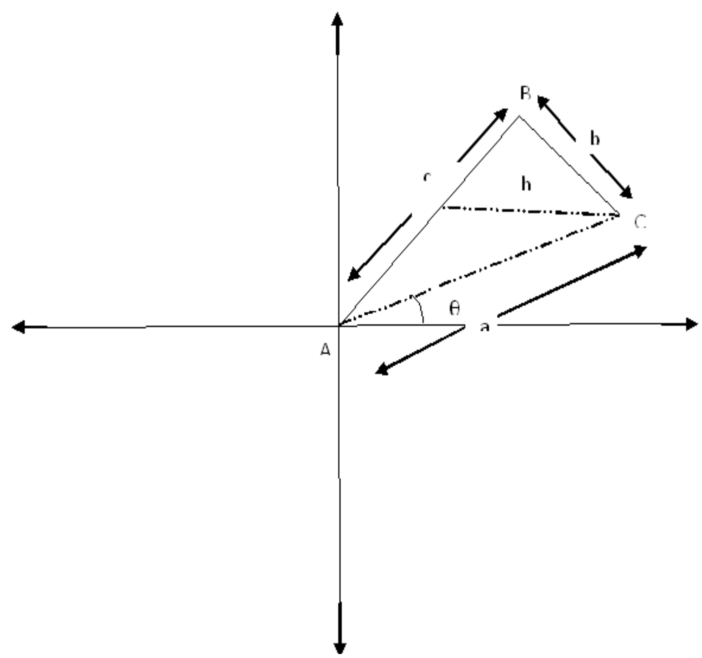


Figure3: Schematic of working environment

### B. Motor Rotation

From equations (2), (9) and (10), the values of θ, A and B are obtained.

Θ is the angle of rotation for the base motor. A is the angle of rotation for the motor connecting the first link and B is the angle of rotation for the motor connecting the second link.

Here, we consider that all motors are of 10rpm. And hence, all the motors cover 60° in one second.

ISSN 2250-3153

To improve accuracy, the motor is turned on only for 1ms in one on loop in the program.

Hence the motor covers an angle of 0.06° in one on loop.

Once the angles are calculated by using the inverse kinematics, the PIC microcontroller decides the number of on loops to be executed for each motor.

For example, if the angle to be covered by the base motor is 24°, then the PIC microcontroller will execute the on loop 400 times.

## IV. SOFTWARE

Onboard software is mainly developed with micro C. This software interfaces between the optical array and the robot by receiving interrupts to control all robot functions. Simulations have been executed both in Mat lab and PIC simulator. In Mat lab the approaches were implemented under ideal hypothesis, more realistic settings.

## V. SAMPLE WORKING

If we have an object at a coordinate (1, 5), and we have to move it to a coordinate (3,-6), we first touch the corresponding coordinate of (1, 5) and then the coordinate corresponding to (-3,-6) in the optical panel. These data are taken by the PIC microcontroller through multiplexers and the first touch is taken as source point and the second is taken as destination.

Now using the equations (2), (9) and (10), the controller calculates the values of $\theta$, A and B respectively. These values are stored in separate variables and then the number of on loops to be executed are calculated and executed one by one.

When all the motors are rotated accordingly, the tip of the second link is magnetized and this helps in holding the magnetically attractive object. Once the destination coordinate is reached, the tip is demagnetized to place the object.

## VI. CONCLUSION

Optically controlled robotic arm for picking and placing an object was successfully designed. The robot control was found to be user friendly. The accuracy and range is improved as more IR transceivers are installed.

In future, instead of using IR array, capacitive or resistive type touch screen may be implemented.

## ACKNOWLEDGMENT

The research in this paper was carried out at Hindustan Institute of Technology and science, Chennai. This work was supported by the e-MEN Robotic Research Centre Palakkad.

## REFERENCES

[1] Amon Tunwannarux, and Supanunt Tunwannarux "*Design of a 5-Joint Mechanical Arm with User-Friendly Control Program*" World Academy of Science, Engineering and Technology 27 2007

[2] Redwan Alqasemi and Rajiv Dubey "*Control of a 9-DoF Wheelchair-Mounted Robotic Arm System"* 2007 Florida Conference on Recent Advances in Robotics, FCRAR 2007

[3] Jegede Olawale, Awodele Oludele, Ajayi Ayodele and Ndong Miko Alejandro *"Development of a Microcontroller Based Robotic Arm"* Proceedings of the 2007 Computer Science and IT Education Conference.

[4] Brandi House, Jonathan Malkin, Jeff Bilmes *"The VoiceBot: A Voice Controlled Robot Arm*" CHI 2009, April 4-9, 2009, Boston, Massachusetts, USA.

[5] Dr.R.K.Bansal *"a textbook of engineering mechanics"* page no 195-199,page no 205-209

[6] Principles of Robotics page 24-38, pg54-57

## AUTHORS

**Shyam R. Nair,** PG Scholar, Hindustan University, Chennai, shyamieee@gmail.com