PC CONTROL CARD FOR 3 DOF MANIPULATOR CONTROL

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Key words: PC card, Robot, Control, Trajectory Planning

ABSTRACT

Robots used in the industry for manufacturing purposes have been rapidly developing. For this purpose, first of all, an antromorfic manipulator is designed and manufactured. Then control hardware is designed as a PC card which consist of PC communication interface circuits, Motor drivers and real time position readers. After that, a computer software has been developed to control the manipulators. After experiment, it is seen that the manipulator tracks the desired trajectory by tracking error that is large. But, errors was corrected by the close-loop control.

I.INTRODUCTION

Recently, robot manipulators contribute to manufacturing in some industries by doing job of the man. There are a lot of advantages of using robot manipulators. More important of them are;

- They don't have restricted working time that like men has.
- They work safely in environments that man can't work (such as radioactive, poisonous gas etc).
- Fast and quality production can be obtained in assembling line and in duties that require very sensitive work.
- They can be used in different work and environments [1].

Structures of the robot manipulators used in industry have been formed in 4 separate parts.

1. Manipulator (Mechanic parts)
2. Excitation (Electric motor, Hydraulic and pneumatic excitation)
3. Control unit (Electronic hardware and software)
4. Gripper (To hold, to screw drive, weld apparatus, etc.)

The most important part of the robot manipulator is control unit. Using a good software that supports a good electronic hardware can control robot manipulator sensitively and fastly. [2].

II. STRUCTURE OF THE DESIGNED ROBOT MANIPULATOR

In this study, for 3 degree of freedom (3 DOF) Antromorfic model robot manipulators, mechanic that shown in Fig.1 and Mechanic structure that shown in Fig.2 has been designed and controlled by doing kinematical analysis according to a mathematical model [3].

Figure 1. A picture of manipulator

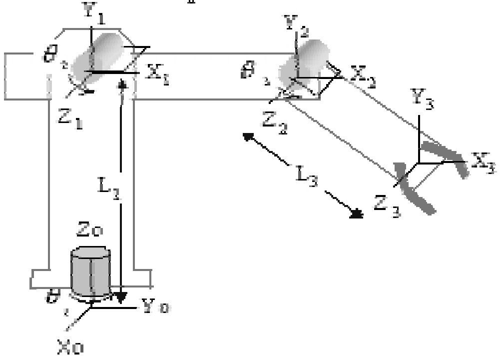

Figure 2. Robot manipulator model

Robot manipulator that shown in figure 2 has different joint lengths.L_1 joint length is 350mm. L_2 joint length is 270mm. and L_3 joint length is 120mm. In kinematical analysis, (θ_1, θ_2, θ_3) joint angles that assure TCP (Tool Center Point) come to desired target point P(Px,Py,Pz) can be solved by inverse kinematical analysis. To calculate coordinates of P point that used in forward kinematical analysis, method in below can be applied. Denavit-Hartenberg D-H parameters and homogen transformation matrices of robot manipulator model ;

Joint number	α_i	a_i	d_i	θ_i
1	$\pi/2$	0	0	θ_1
2	0	L_2	0	θ_2
3	0	L_3	0	θ_3

Table 1 . Denavit-Hartenberg D-H parameters

$$T_3^0(q)=\begin{bmatrix} C_1C_{23} & -C_1S_{23} & S_1 & C_1(L_2C_2+L_3C_{23}) \\ S_1C_{23} & -S_1S_{23} & -C_1 & S_1(L_2C_2+L_3C_{23}) \\ S_{23} & C_{23} & 0 & L_2S_2+L_3S_{23} \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (1)$$

By abbreviating sine as $S_i=\sin\theta_i$ and cosine as $C_i=\cos\theta_i$ and by using Denavit-Hartenberg parameters transformation matrices is obtained, and after that coordinate equations of TCP is found like that ;

$$Px=C_1(C_2L_2+C_{23}L_3) \quad (2)$$

$$Py= S_1(C_2L_2+C_{23}L_3) \quad (3)$$

$$Pz= S_2 L_2+S_{23} L_3 \quad (4)$$

Also, by means of inverse kinematical analysis, (θ_1, θ_2, θ_3) rotation angels of manipulator joints is obtained by equations in the following [4].

$$\theta_1 = \arctan(P_y / P_x) \quad (5)$$

$$\theta_2 = \arctan(S_2 / C_2) \quad (6)$$

$$\theta_3 = \arctan(S_3 / C_3) \quad (7)$$

$$C_3=\frac{p_x^2+p_y^2+p_z^2-L_2^2-L_3^2}{2L_2L_3} \quad (8)$$

$$S_3=\mp\sqrt{1-C_3^2} \quad (9)$$

$$S_2=\frac{(L_2+L_3C_3)\,p_z-L_3S_3\sqrt{p_x^2+p_y^2}}{p_x^2+p_y^2+p_z^2} \quad (10)$$

$$C_2=\frac{(L_2+L_3C_3)\sqrt{p_x^2+p_y^2}+L_3S_3\,p_z}{p_x^2+p_y^2+p_z^2} \quad (11)$$

III. HARDWARE

As shown in figure 3, robot manipulator control system is formed in 3 parts. These are robot manipulator, Computer and Software.

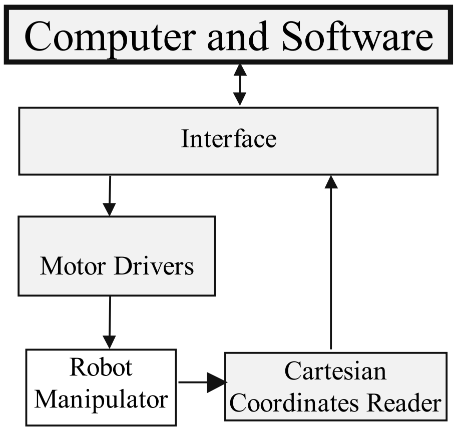

Figure 3. A Block Diagram of Control System[5]

Stepper motors that excite the robot joints are controlled by a software and a PC board that shown in figure 4. The software learns real coordinates in Cartesian spaces of robot manipulators by mean of circuits that on the PC board and read real time encoder knowledge. Thus, hardware that required for real time feedback control has been obtained.

On computer control board there are 3 8255 PPI (Programmable Peripheral Interface) that have features 72 bit programmable directional input/output. On the circuit, to move a stepper motor, 4 bit is used. On the board there are two spare motor capacity for driving different motor models or controlling extra joint or moving parts. Namely 5 stepper motors can be driven. Motors can be controlled faster by using 2 different potential level in the step motor control system. Especially, 5x4=20 port in 5 motor controlling for motor rotate algorithm, 5 port for 2 level driving, totally 25 port of 8255 are used.

In each algorithm step, stepper motors have moving ability in 1.8 degrees for full-step, in 0.9 degrees for half-step. 0.07 degrees moving can be obtained by using reductors. Thus, in the same time motor power is increased by using reductors. 3 position reader circuit that has count ability as independently from real time computer are used for feed back control.13 bit port of 8255 PPI are used, each count mechanism that is used to read position needs 12 bit data for communicating to PC , 1 bit for count reset. Totally 39 bit PPI port is necessary for 3 position. As a result, 25 port for motor controlling and 39 port for reading position are used. Rest of the PPI ports (72-39+25=8) are reserved to read data that received from limit switch on robot manipulator. [5].

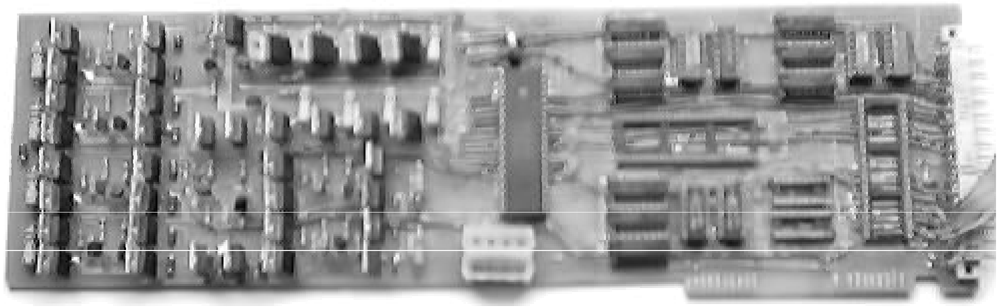

Figure 4. PC Based Controller Card

IV.CONTROL

Pascal programming language and Intel 80286 Assembler programming language are used to control robot manipulator computer card [8,9]. The processes such as fundamental moving and reading position data are formed function or procedure as a Pascal language command in the Pascal Programming Language and a proper base is prepared to access different control algorithm. 3. Order polynomial equations are used to assure necessary smooth in motor rotation during trajectory planning [10,3,11]. Also, 1 and 2 interval defined minimum time trajectory planning for experimental control is applied. Theoretical analysis has been simulated by using Matlab program before obtaining practical data of the system.

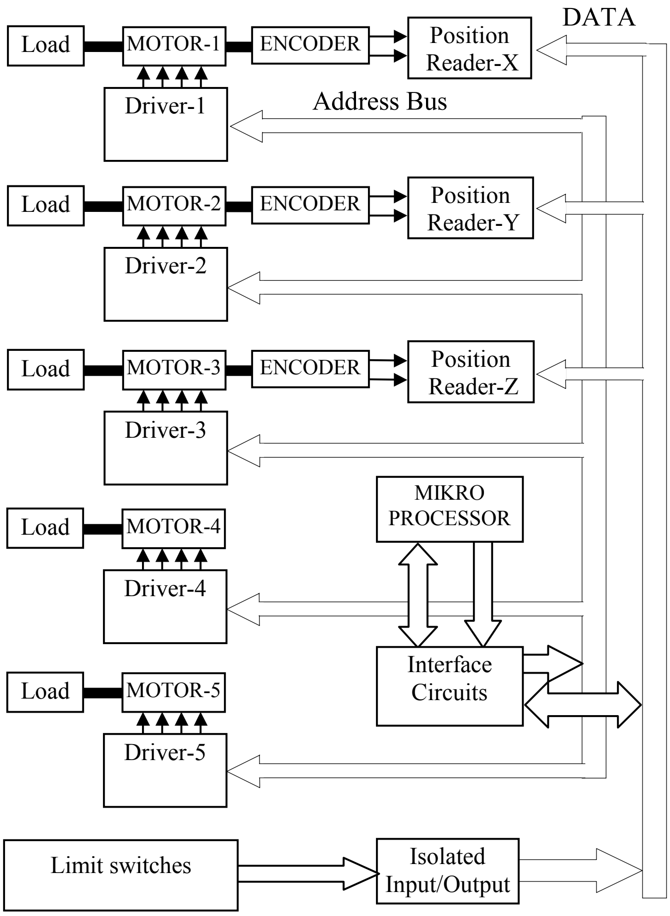

Figure 5. Block Diagram of the Computer control card[5,6]

Comparasation of orbit moving are done fastly and sensitively by investigating simulations for calculated torque method, PD control with weight force compensation, inverse dynamic control, robust and adaptive control methods [3]. Block schema of the designed system is shown in Fig.5.

V.CONCLUSION

Robot manipulator that designed to run automatically without man help and controlled computer program has freedom degrees that equivalent to waist, shoulder and elbow moving of the man and it can reach any place in reachable distant. Thus, it can especially move the materials sensitively in any flexible production system or industry.

In this study, multi input and multi output robot control methods are simulated sensitively and fastly by using computer as depend on parameters of robot manipulator model by taking advantage of using computer hardware and software. Computer simulation results is good in any coordinate that given to manipulator, in performed examination. But, on experimental result, trajectory error was observed due to insufficient manipulator mechanism. Errors can be corrected by using close-loop error correction algorithms . As a result, close-loop control is certainly necessary in control systems. In open-loop control, trajectory error can be appeared. In Fig.6 and Fig 7, graphs of trajectory planning data for open-loop and close-loop controls is shown.

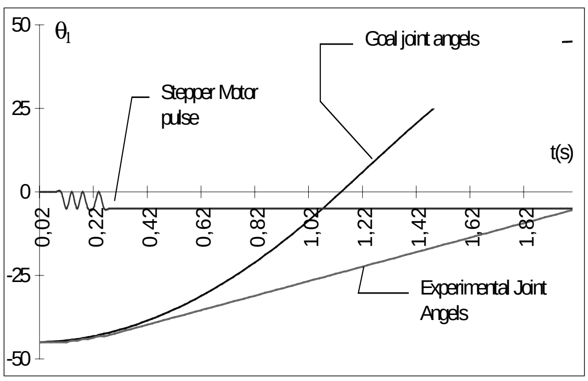

Figure 6. Open-Loop Control

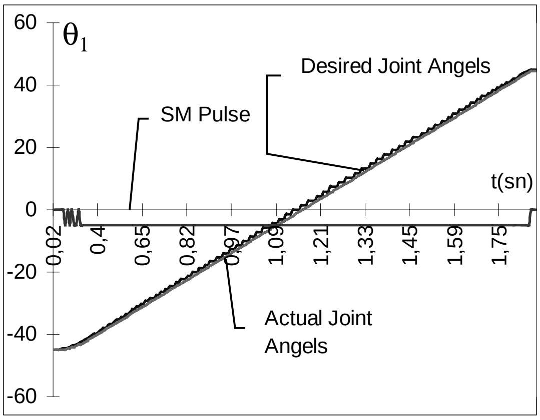

Figure 7. Close-Loop Control

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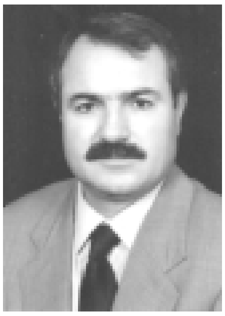

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