International Journal of Mechatronics, Electrical and Computer Technology

Vol. 4(13), Oct, 2014, pp. 1416-1435, **ISSN**: 2305-0543
Available online at: http://www.aeuso.org

Design & Development of a low Cost Robot for Assistance of Disabled as well as Aged Person

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Abstract

People are now using robotic manipulator for industrial purpose in car manufacturing and automation industry. This paper is dedicated to give a concept of utilizing mobile manipulator for the assistance of aged people and partially paralyzed person. The robot will be controlled with a simple TV remote controller or with a simple PC based system to make the system handy, user-friendly and cost-effective. Here all the functions of manipulator are being configured according to a particular switch of Philips remote controller. Control will be done following RC5 protocol which is generally used by Philips. It is a simple control system where joints are being controlled independently without taking care of proper dynamics. It will make computational work easy and will take less time to perform. It is basically a prototype which is been manufactured for the analysis purpose. Forward and inverse kinematics is being done to find the mobility and range of manipulator. A simulink model of manipulator is being designed in sim-mechanics platform to analyze the torque level of particular joint. In the next section embedded system required for make system working is shown with detailed figures.

Keywords: Mobile manipulator robot, RC5 protocols, Remote control, Kinematics, Embedded system, GUI.

1. Introduction

There are many standard manipulators in the market till now like PUMA [1], KUKA [8], and Stanford arm [9]. But those are basically used for industrial purpose. Now

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Vol. 4(13), Oct, 2014, pp. 1416-1415, **ISSN**: 2305-0543
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people are thinking of using those manipulators with a mobile base in hospital as well as in home for social purpose [3], [4]. It is quite unfortunate to say that we cannot provide 24 hours nurse facility to a patient in a hospital. So it is therefore very much needed to be something that can help them in any crucial condition or for assisting him to do daily activities [14]. Also it is difficult to provide 24 hours human assistance to an aged old person in home for assisting him to help in his daily activities. If any robot can perform their work, then it can take care of the person all the time without any break. Therefore a co-operative interaction between man and machine should be presented to execute those tasks in a better way as discussed in paper [2], [5], [13]. Already researchers have analyzed the performance of robotic assistance to an aged person through some experiences [5], [16] and acceptance of that technology for them [7]. In some cases it is being found that the robot will take proper decision if any wrong happening will take place in domestic environment [15]. Researchers have already built some mobile robots as an assistive device like a bio-mimetic robot [6], Pearl [10], autonomous mobile robot [11], ASTRO [12]. Some optimization technique is used for designing and control system purpose [9]. Here a cost effective manually controlled robot manipulator is been developed to provide 24 hours assistance to the patient in a hospital, aged person in home or a partially paralyzed person. The robot can perform small works like pick & place a glass of water or medicine, switch on the fan and light and bring other things. It is a wireless controlled mobile robot with having gripping facility. It can be controlled through Philips remote control which follows the RC5 protocol. Person can easily perform any task by pressing any switch in remote controller. It is already been preconfigured and embedded in microcontroller which is controlling the mobile robot. As it is using a simple TV remote for controlling purpose, it will make the whole system cost effective and affordable for normal people. In the next portion a brief idea is given regarding the design, kinematics, embedded system and control.

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2. Mechanical design analysis

A mobile platform is used to move the whole system from one place to another as shown in Fig. 2. As it is a prototype, it is being made of hard plywood. Simple DC gear motors are used for actuation. All the structures are being designed using simple mechanism. It has 4 degrees of freedom with a mobile base as shown in figure 1. The whole structure is divided into four sections. Rotational base platform is orthogonal with the upper revolute joint. This is analogous to a shoulder joint with two degrees of freedom. Also there is one revolute joint at the upper arm is same like elbow joint. At the end point, an actuator is used to act as wrist joint with gripping facility. A human like behaviour is been imposed in this manipulator for better flexibility.

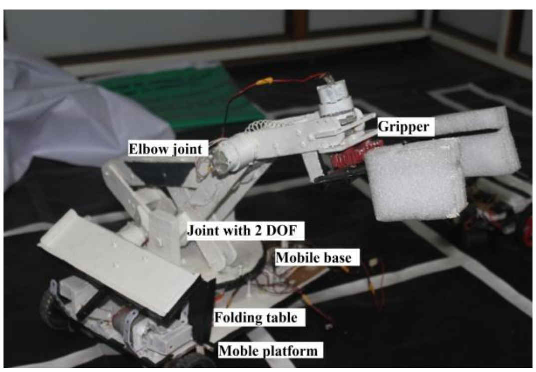

Figure 1: Mobile manipulator

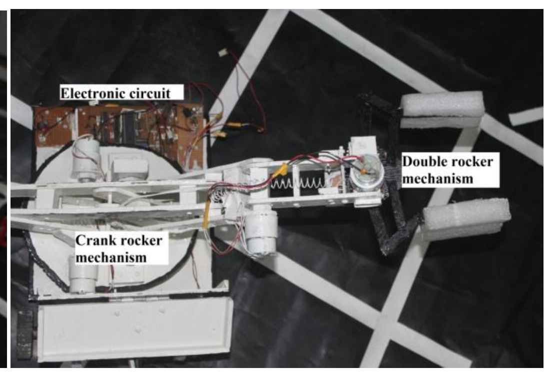

Figure 2: Base platform

In place of gripper, a double-rocker mechanism is used to give a linear translation motion. It can grip any object like a human hand. In this case when the two gear moves in opposite direction, the two arms connected with two gears move in a linear way as shown figure 2. Two gears are used to transmit the circular motion into linear one. In case of closing the two arms, the gear connected to the motor move anticlockwise, as a result other gear move clockwise. It can move the two arms close to each other. In other case it will act in opposite way. Another crank-rocker mechanism is used to control the motion of the shoulder arm

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(figure 1). A coupler is connected to the middle of the arm to reduce the torque of the motor. If the motor is connected at the end point of the shoulder, torque required to lift the end effectors will be very high. But its motion is restricted. A motor is fixed at the base of the whole system to move the whole base at 360 degree clockwise or anti-clockwise. There is another motor connected to upper portion of the arm to increase dexterity of the workspace. It has a folding table which can be opened or closed according to the signal. This table can be used to bring more than one item at a time.

3.Kinematic analysis

The mechanical structure is being represented by a co-ordinate system shown in figure 3. It is used to calculate the froward and inverse kinematics which is describing the mobility of the mobile manipulator.

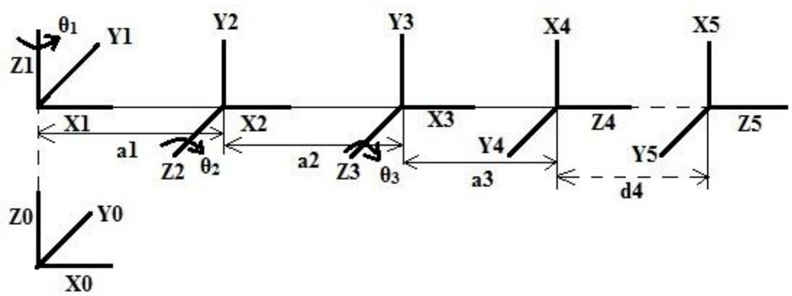

Figure 3: Co-ordinate system

3.1. D-H Parameter of the 3D model

To do kinematic analysis of the whole system it is very much needed to derive D-H parameter of the whole system. The co-ordinate system of the whole structure is shown in figure 3. D-H parameter of the structure is given in the table 1 below. It is essential for calculation the position and orientation of the end point in 3D space with respect to the reference coordinate

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Table 1: D-H parameter of whole system

i	a_i	α_i	d_i	θ_i
1	**-6**	**90**	**0**	Θ_1
2	**21**	**0**	**0**	Θ_2
3	**13**	**90**	**0**	Θ_3
4	**0**	**0**	**d4**	**0**

3.2 Forward and Inverse kinematics calculation

For getting the position and orientation of the end point of the robot at any fixed position, homogeneous transformation matrix should be calculated. Each homogeneous matrix is given the position and orientation of present frame with respect to the previous frame. It is a 4x4 matrix. The column $^{i-1}d_i$ is position of the end point and $^{i-1}R_i$ is the orientation of end point in 3D space. The transformation matrix will be $^{i-1}A_i$.

$$^{i-1}A_i = \begin{bmatrix} ^{i-1}R_i & ^{i-1}\mathbf{d}_i \\ 0 & 1 \end{bmatrix}_{4x4}$$

The homogeneous matrix is being explained as

$$^{i-1}A_i = D_{z_{i-1}, d_i} * R_{z_{i-1},\theta_i} * D_{x_{i-1},a_i} * R_{x_{i-1},\alpha_i}$$

$$= \begin{bmatrix} \cos\theta_i & -\sin\theta_i \cos\alpha_i & \sin\theta_i \sin\alpha_i & a_i \cos\theta_i \\ \sin\theta_i & \cos\theta_i \cos\alpha_i & -\cos\theta_i \sin\alpha_i & a_i \sin\theta_i \\ 0 & \sin\alpha_i & \cos\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$^{i-1}\mathbf{d}_i = \begin{bmatrix} a_i \cos\theta_i \\ a_i \sin\theta_i \\ d_i \end{bmatrix}$$

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$$^{i-1}R_i = \begin{bmatrix} \cos\theta_i & -\sin\theta_i\cos\alpha_i & \sin\theta_i\sin\alpha_i \\ \sin\theta_i & \cos\theta_i\cos\alpha_i & -\cos\theta_i\sin\alpha_i \\ 0 & \sin\alpha_i & \cos\alpha_i \end{bmatrix}$$

For calculating the homogeneous matrix due to 4 degree of freedom 4 homogeneous matrixes are multiplied serially. The final matrix will be T.

$T = {}^0A_1 * {}^1A_2 * {}^2A_3 * {}^3A_4$

The transformation matrixes are described given below.

$$^0A_1 = \begin{bmatrix} \cos\theta_1 & 0 & \sin\theta_1 & -6*\cos\theta_1 \\ \sin\theta_1 & 0 & -\cos\theta_1 & -6*\sin\theta_1 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$^1A_2 = \begin{bmatrix} \cos\theta_2 & -\sin\theta_2 & 0 & 21*\cos\theta_2 \\ \sin\theta_2 & \cos\theta_2 & 0 & 21*\sin\theta_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$^2A_3 = \begin{bmatrix} \cos\theta_3 & 0 & \sin\theta_3 & 13*\cos\theta_3 \\ \sin\theta_3 & 0 & -\cos\theta_3 & 13*\sin\theta_3 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$^3A_4 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & d4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

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Final transformation matrix can be represented as T= $\begin{bmatrix} nx & ox & ax & px \\ ny & oy & ay & py \\ nz & oz & az & pz \\ 0 & 0 & 0 & 1 \end{bmatrix}$

By multiplying all the matrices T can be determined.

nx= $\cos\theta_1 * \cos(\theta_2+\theta_3)$;----------------------(i)

ny= $\sin\theta_1 * \cos(\theta_2+\theta_3)$;----------------------(ii)

nz= $\sin(\theta_2+\theta_3)$;---------------------(iii)

ox= $\sin(\theta_1)$;---------------------(iv)

oy= $-\cos(\theta_1)$; ---------------------(v)

oz= 0; --------------------(vi)

ax= $\cos\theta_1 * \sin(\theta_2+\theta_3)$; ----------(vii)

ay= $\sin\theta_1 * \sin(\theta_2+\theta_3)$; -------------(viii)

az= $-\cos(\theta_2+\theta_3)$; ---------------(ix)

px= $21 * \cos\theta_1 * \cos\theta_2 + d_4 * \cos\theta_1 * \sin(\theta_2+\theta_3) + 13 * \cos\theta_1 * \cos(\theta_2+\theta_3)$;
------------(x)

py= $21 * \sin\theta_1 * \cos\theta_2 + d_4 * \sin\theta_1 * \sin(\theta_2+\theta_3) + 13 * \sin\theta_1 * \cos(\theta_2+\theta_3)$;
-----------(xi)

pz= $21 * \sin\theta_2 + 13\sin(\theta_2+\theta_3) - d_4 * \cos(\theta_2+\theta_3)$;
------------(xii)

The last three points px, py, pz are representing the points in 3D spaces due to different motions. Values of θ_1 from can be get either eqn. no. (i) and (ii) or (vii) and (viii). By dividing eqn. no (ii) by eqn. no. (i) it will give

$\tan\theta_1 = {}^{ny}/_{nx}$ ------------------- (xiii)

$\theta_1 = \tan^{-1}{}^{ny}/_{nx}$

By dividing eqn. no (viii) with (ii) it will give

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$\tan(\theta_2 + \theta_3) = {}^{ay}/_{ny}$ ----------------- (xiv)

$(\theta_2 + \theta_3) = \tan^{-1} {}^{ay}/_{ny}$

By putting the value of $\sin\theta_1 * \sin(\theta_2 + \theta_3)$, $\cos\theta_1 * \sin(\theta_2 + \theta_3)$, $\cos\theta_1 * \cos(\theta_2 + \theta_3)$ and $\sin\theta_1 * \cos(\theta_2 + \theta_3)$in eqn. no (x) and (xi) we get

$-21 * oy * \cos\theta_2 + d_4 * ax + 13 * nx = px$ ----- (xv)

$-21 * oy * \cos\theta_2 + d_4 * ax = px - 13 * nx$ And

$21 * ox * \cos\theta_2 + d_4 * ay + 13 * ny = py$ ------- (xvi)

$21 * ox * \cos\theta_2 + d_4 * ay = py - 13 * ny$

By subtracting eqn. no (xv)*ay and (xvi)*ax we get

$-21 * oy * ay * \cos\theta_2 + 21 * ox * ay * \cos\theta_2 = ay(px - 13 * nx) + ax(py - 13 * ny)$ -------------------- (xvii)

$\cos\theta_2\big((21 * ox * ay) - (21 * oy * ay)\big) = ay(px - 13 * nx) + ax(py - 13 * ny)$

$\cos\theta_2 = {}^{ay(px - 13 * nx) + ax(py - 13 * ny)}\big/_{\big((21 * ox * ay) - (21 * oy * ay)\big)}$

$$\theta_2 = cos^{-1}\left({}^{ay(px - 13 * nx) + ax(py - 13 * ny)}\big/_{\big((21 * ox * ay) - (21 * oy * ay)\big)} \right)$$

By adding eqn. no (xv)*ox and (xvi)*oy we get

$d_4 * ax * ox + d_4 * ay * oy = ox * (px - 13 * nx) + oy * (py - 13 * ny)$--------- (xvii)

$d_4 * (ax * ox + ay * oy) = ox * (px - 13 * nx) + oy * (py - 13 * ny)$

$d_4 = {}^{ox * (px - 13 * nx) + oy * (py - 13 * ny)}\big/_{(ax * ox + ay * oy)}$

By putting the value of $\theta_2$in eqn. no (xiv), we can get the value of θ_3

$\theta_3 = \tan^{-1} {}^{ay}/_{ny} - \theta_3$

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From those above equation he values of $\theta_1, \theta_2, \theta_3, d_4$. can be determined. It will help us to find the joint parameter for particular point in 3D space.

4. Simulink model & data analysis

Simulink model of manipulator is shown in figure 4. It is been designed in sim-mechanics platform. Every subsystem consist of a body with its particular mass moment of inertia and a joint actuator where we can provide different actuation signal. There is a body sensor attached with each body segnment to measure 3D locations for different movements. Also a joint sensor is attached to the joint block to show the measurment of joint torque needed for any actuation signal. Figure 5 and 6 will show the torque level for rotation in verticle dirction because it is very much needed to determine proper actuator.

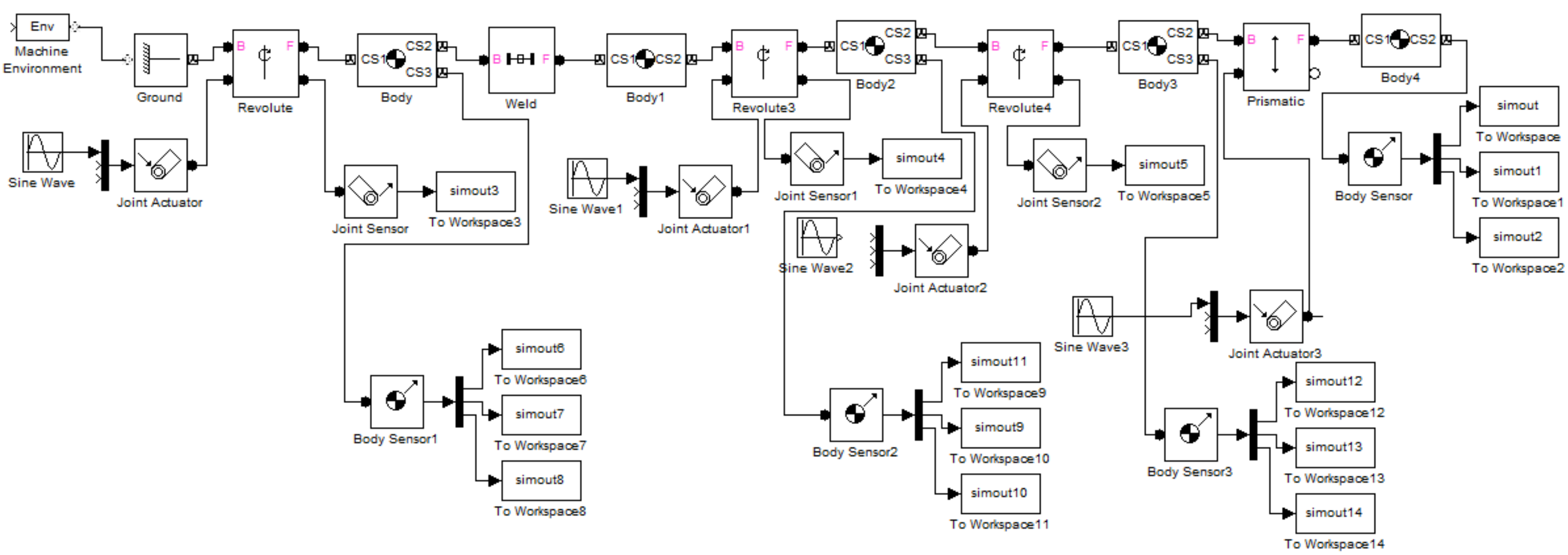

Figure 4: Block diagram of simulink model represent manipulator

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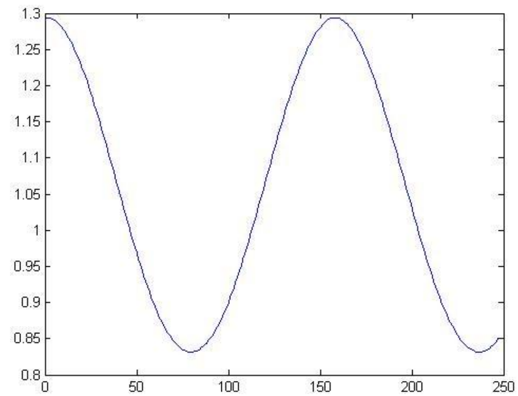

Figure 5: Joint torque in shoulder joint

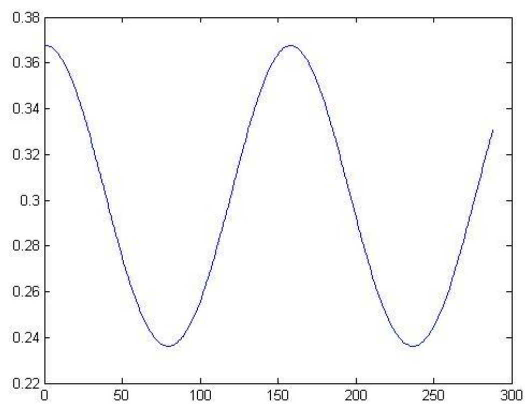

Figure 6: Joint torque in elbow joint

5. Embedded system

An electronics board consisting an 8051 microcontroller is used to control the whole circuit. It needs a power supply of 5 volt for operation. Four motor drivers L293D are being used here to control the whole mechanical system. The mobility or the degree of freedom is increased according to the no of joints.

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1st driver is used to control the motion of the car

2nd driver is used to control the motion of the base and the gripper.

3rd driver is used to control the motion of shoulder joint.

4th driver is used to control the motion of the elbow joint and folding table.

According to driver connection, six port pins of a microcontroller are necessary to control a single motor driver. That means 24 pins of a microcontroller are being utilised to control 4 motor drivers. A microcontroller has 32 pins as I/O ports. If 24 of them will be used only for driver circuit interfacing then it doesn’t have enough pins to control the other functions. That’s why a multiplexing technique would need to control those 4 motor driver using 8 pins. Here daisy chain network is been implemented to control the circuit without using multiplexer. 4 port pins are used to control the enable of 4 motor drivers. A motor driver has two enable pins. Two enable pins are shorted to one pin and connected it to a single microcontroller port pin. Each enable signal can be selected at a time. 4 inputs of 4 motor are connected to the 4 port pins of the microcontroller. Each driver has a particular enable pin as an activating signal. When the master controller will send the activation signal, those drivers will get the same input. But the particular motor driver will be activated which is being enabled. 4 pins of port 1 are used to connect the comparator where it can compare the sensor output. Here proximity sensor can be connected for obstacle detection. It will make the system a sophisticated one. Block diagram of control scheme is shown in figure 7.

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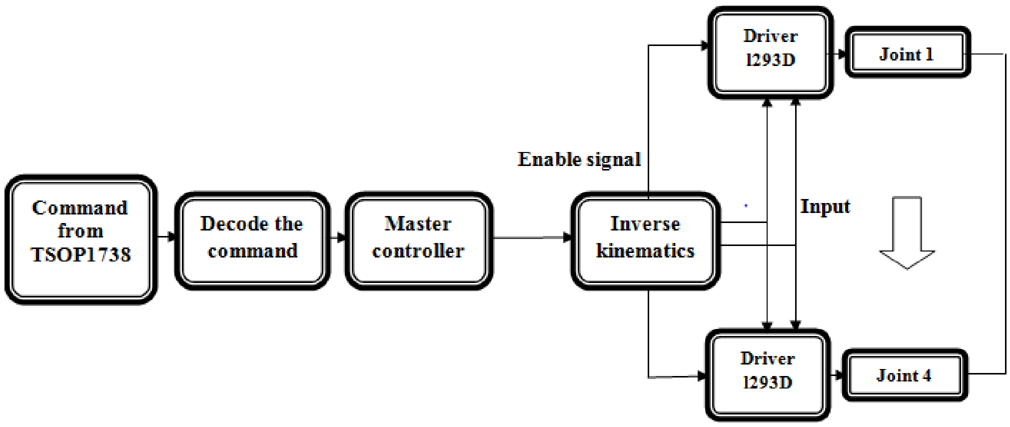

Figure 7: Block diagram of control block

The schematic diagram and original circuit is shown in figure 8 and 9. Table 2 is showing interfacing port pin with peripheral circuit.

Table 2: Different pin configurations of Microcontroller

Microcontroller port pins	Peripheral circuit
P0.0	D1_ENABLE
P0.1	D2_ENABLE
P0.2	D3_ENABLE
P0.7	D4_ENABLE
P0.3	M1_A
P0.4	M1_B
P0.5	M2_A
P0.6	M2_A
P1.7	RC5

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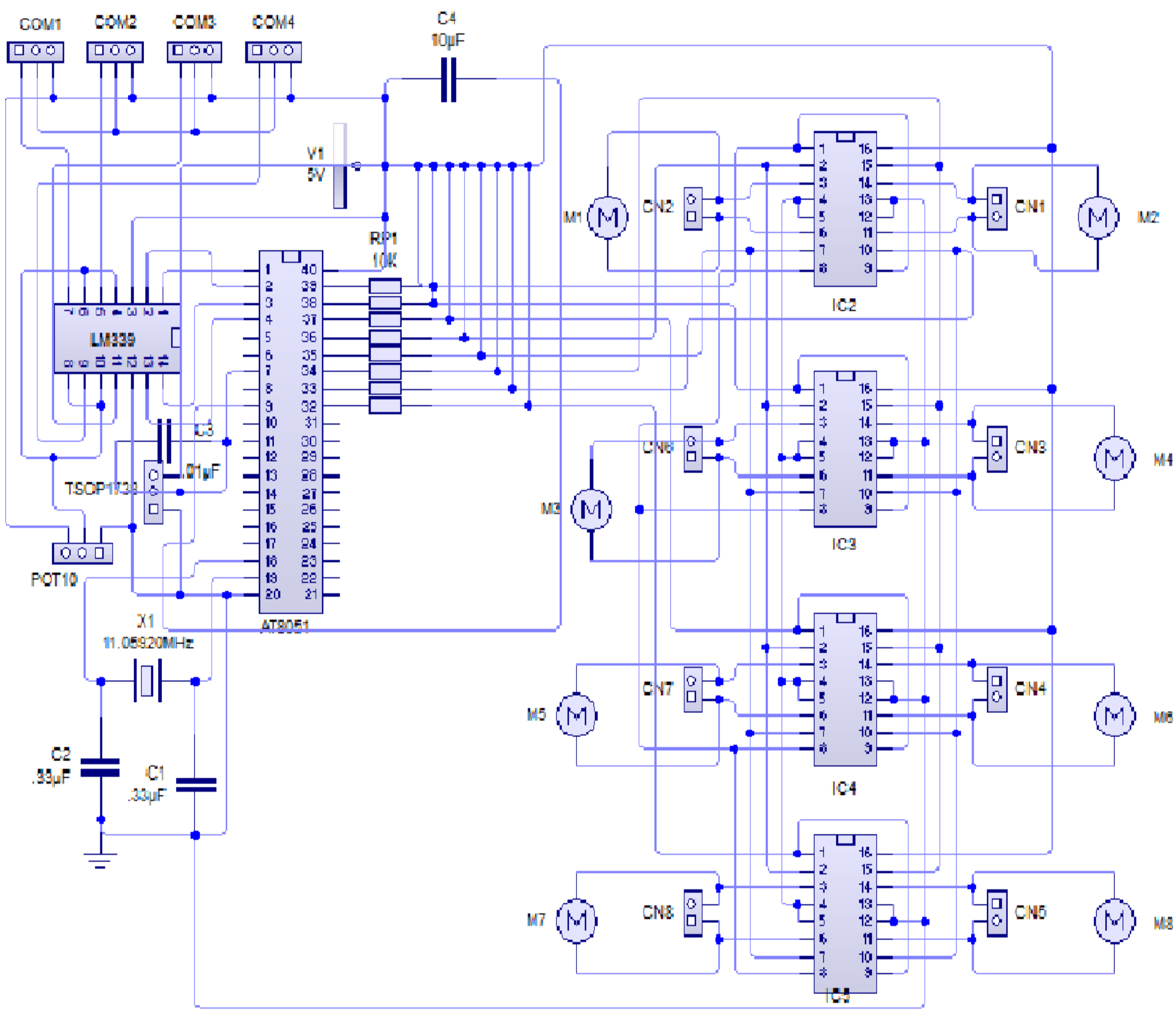

Figure 8: Schematic diagram of circuit

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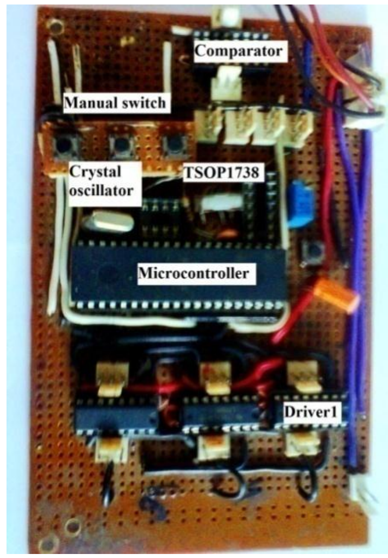

Figure 9: Main control circuit

The system can be controlled in two ways. First one is the PC based control where all the motions are being controlled from a GUI designed in Microsoft visual studio platform. Here it will be a predefined control where all the motions are fixed. First of all user has to select the serial configuration by proper selection of the baud rate & communication port. After that he or she can control each movement in clockwise & anticlockwise direction by selecting top-up menu list of the API (figure 10). Also there is a provision for controlling each motion in different speed with the help of pulse width modulation technique.

All the motions are

1) Wheel motion
2) Wheel direction
3) Base motion
4) Lower arm motion
5) Middle arm motion
6) Gripper motion

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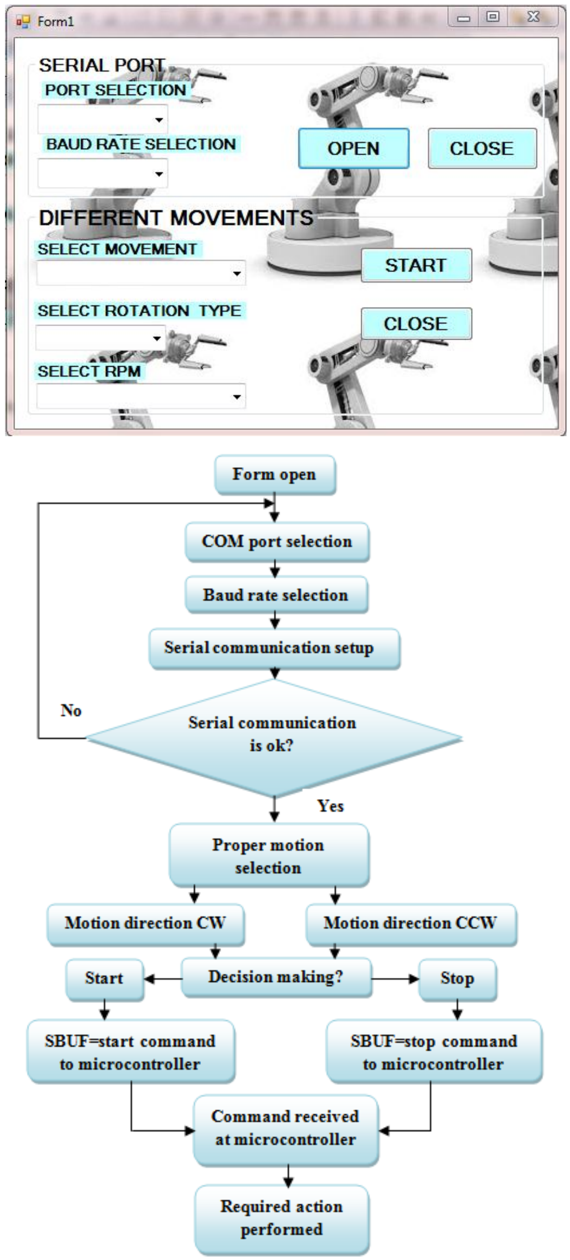

Figure 10: GUI and flow-chart of PC based control

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To make the device user friendly we have implemented the remote control unit in the system. The system can be controlled easily by using a simple remote controller. Here we have used the Philips remote which is basically following the RC5 protocol (figure 11). When someone will press any bottom, a 14 bit unique digital code will be transmitted. The microcontroller circuit have a TSOP38 receiver for receiving the proper code which is already being per-programmed. Finally the system will behave in a different way depend upon the bit pattern. The proper technology of the RC5 protocol is shortly being described below. When someone press any switch in remote, it will send the control signals modulated by a carrier signal of 36 KHz frequency. TSOP 1738 is a demodulator. It will receive the command signal to demodulate it and send the control output to the controller serially. Therefore proper operation will be taken place according to the proper control bits.

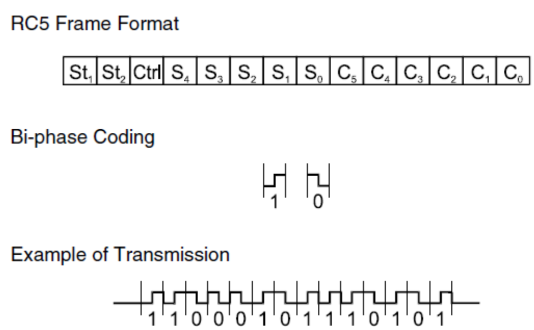

Figure 11: RC5 protocol

The RC5 protocol is a 14-bit word bi-phase coded signal (Figure 11). The two first bits are start bits, always having the value one. The next bit is a control bit or toggle bit, which is inverted every time a button is pressed on the remote control transmitter. Five system bits hold the system address so that only the right system responds to the code. Usually, TV sets have the system address 0, VCRs the address 5 and so on. The command sequence is six bits long, allowing up to 64 different commands per address. The bits are transmitted in bi-phase

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code (also known as Manchester code). The bit length is approximately 1.8 ms. The code is repeated every 114 ms. To improve noise rejection, the pulses are modulated at 36 kHz. The data is inverted compared to the transmitted data. When the detect subroutine is called, it first waits for the data line to be idle high for more than 3.5 ms. Then, a start bit can be detected. The length of the low part of the first start bit is measured. If no start bit is detected within 131 ms, or if the low pulse is longer than 1.1 ms, the routine returns indicating no command received.

Table 3 will described proper operation related to proper bottom in remote control as it is been configured. Figure 12 will show flow chart of total operation.

Table 3: Remote control operation

Remote control switch	Command bits	Operation
PROG+	32	CAR FORWARD
PROG-	33	CAR BACKWARD
MUTE	13	ALL STOP
VOL+	16	CAR LEFT
VOL-	17	CAR RIGHT
0	0	GRIPPER OPEN
1	1	GRIPPER CLOSE
2	2	LIFTUP
3	3	LIFT DOWN
4	4	MOVE CLOCKWISE
5	5	MOVE ANTICLOCKWISE
6	6	MOVE OVER
7	7	MOVE DOWN
8	8	TABLE OPEN
9	9	TABLE CLOSE

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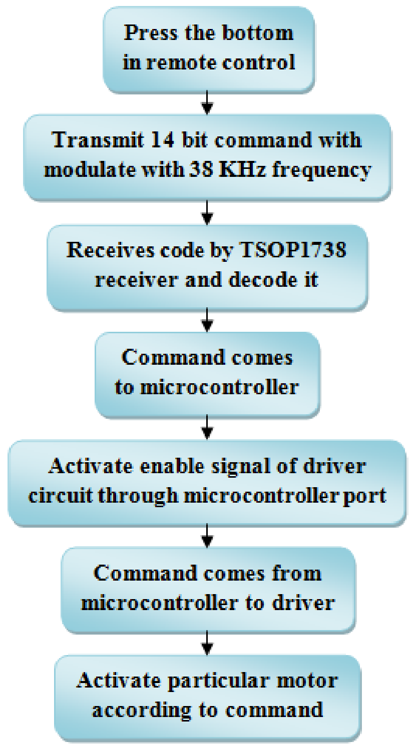

Figure 15: Flow chart of total operation

Conclusion

Design, kinematics, and control portion of the manipulator are being discussed here. It is a cost effective system. As it does not include much more expensive components, normal people can afford it easily. Only the user should be familiar with the proper function of remote control or a list is given to the user where particular operation to a particular switch is enlisted. For proper safety measures, mechanical barrier is there. Also a limit switch is attached at every joint. The controller will deactivate the power supply upon getting the signal from limit switch. A potentiometer is connected at every joint to monitor particular joint movement. On board Li battery can easily give power to the controller board. Total

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current rating is near to 1 amp. By attaching IR detector, the robot can detect any obstacle around it. Simple predefined control system is used. Next we will figure out the dynamics to make the system working in a better way.

References

[1] Different Structure Based Control System of the PUMA Manipulator with an Arm Exoskeleton by YANG Can-Iun, NIU Bin, ZHANG lia-Fan, CHEN Ying in Proceedings of the 2004 IEEE Conference on Robotics, Automation and Mechatronics Singapore, 1-3 December, 2004

[2] Human-Robot Interaction for Cooperative Manipulation: Handing Objects to One Another by Aaron Edsinger and Charles C. Kemp a work was sponsored by Toyota Motor Corporation

[3] Ethical Reflections on Health Care Robotics by Edoardo datteri and Guglielmo tamburrini

[4] Defining Socially Assistive Robotics by David Feil-Seifer and Maja J Matari´c in 9th International Conference on Rehabilitation Robotics June 28 - July 1, 2005, Chicago, IL, USA pp- 0-7803-9003-2

[5] Understanding the Potential for Robot Assistance for Older Adults in the Home Environment by cory-ann smarr ,cara bailey fausset ,wendy a. Rogers published in Technical Report HFA-TR-1102
Atlanta, GA: Georgia Institute of Technology

[6] Remote control of a biomimetics robot assistance system for disabled persons by Yves Rybarczyk, Omar Ait Aider, Philippe Hoppenot, Etienne Colle published in Modelling Measurement and Control, 2002

[7] Older adults' preferences for and acceptance of robot assistance for everyday living tasks by Cory-Ann Smarr1, Akanksha Prakash1, Jenay M. Beer1,

[8] The Fast Research Interface for the KUKA Lightweight Robot by Günter Schreiber, Andreas Stemmer, and Rainer Bisch off in ICRA 2010 workshop

[9] A Low-cost Compliant 7-DOF Robotic Manipulator by Morgan Quigley, Alan Asbeck, and Andrew Y. Ng in ICRA,2011

[9] Optimum Design and Simulation of a Mobile Robot with Standing-up Devices to Assist Elderly People and Paraplegic Patients by Guangming Xiong, Jianwei Gong, Junyao Gao, Tao Zhao, Dongxue Liu, Xijun Chen in International Conference on Robotics and Biomimetics December 17 - 20, 2006, Kunming, China

[10] Pearl: A Mobile Robotic Assistant for the Elderly by Martha E. Pollack,Laura Brown, Dirk Colbry, Cheryl Orosz, Bart Peintner, Sailesh Ramakrishnan, Sandra Engberg, Judith T. Matthews, Jacqueline Dunbar-Jacob, Colleen E. McCarthy, Sebastian Thrun, Michael Montemerlo ,Joelle Pineau,Nicholas Roy

[11] Use of an Autonomous Mobile Robot for Elderly Care by Karsten Berns, Syed Atif Mehdi

International Journal of Mechatronics, Electrical and Computer Technology

Vol. 4(13), Oct, 2014, pp. 1416-1415, **ISSN**: 2305-0543
Available online at: http://www.aeuso.org

[12] On the design of ASTRO robot for assistance of elderly people by F. Cavallo*, M. Aquilano, M. Bonaccorsi, I. Mannari, M.C. Carrozza, P. Dario in euRobotics Forum 2011 – Workshop on “Assistance robots for the elderly” Västeras, Sweden - April 08, 2011

[13] Mobile robot command by man-machine co-operation - Application to disabled and elderly people assistance by Philippe HOPPENOT, Etienne COLLE in submitted version to Journal of Intelligent and Robotic Systems, 1999

[14] Towards robotic assistants in nursing homes: Challenges and results by Joelle Pineau a, Michael Montemerlo a, Martha Pollack b, Nicholas Roy a, Sebastian Thrun in Robotics and Autonomous Systems 42 (2003) 271–281

[15] Monitoring elderly people with the robocare domestic environment: interaction synthesis and user evaluation by amedeo cesta,1 gabriella cortellessa,1 riccardo rasconi,1 federico pecora,2 massimiliano scopelliti,1 and lorenza tiberio1 in Computational Intelligence, Volume 27, Number 1, 2011

[16] Experiences with a Mobile Robotic Guide for the Elderly by M. Montemerlo, J. Pineau, N. Roy, S. Thrun and V. Varma.