International Journal of Advanced Research in

Robotics and Development

Volume: 1 Issue: 1 08-Dec-2013,ISSN_NO: 2348-2338

KINEMATIC ANALYSIS & MODELLING OF A CRUTCH ROBOT

*R.Vijayaraghavan,*Ravi Jagdale

#Dr.P.Vivekanada Shanmuganathan

School of Mechanical and Building Sciences ,VIT University, Vellore

Abstract

Technologies have advanced to the extent that the human inability to walk can be restored and made to walk like normal people. On the Other hand cost incurred on such devices should be made bearable considering the value of the product. Our aim is increase a 4 legged crutch robot user friendly for the disabled .It has one pair of Passive and active legs. The support pair has no knee joints but helps in movement as a hold up. The Robot is passive when it moves on the crutch pair and swings its legs generally. The model is built mathematically, simulated and valuation of the leg posture is facilitated. Kinematic analysis is performed to calculate its walking pattern and its behavior at links. Velocity, Acceleration of each joint and link is calculated and the position of the coordinates with respect to the origin. The work aims to offer autonomous control of the leg joints using servo motor control.

This task proposes to use ADAMS and Simulink as the analysis tools to facilitate tracking of a moving object and Physical model is made to trace the same.

Keywords- Crutch , Kinematic Analysis ,Behaviour at Links ,Servo Motor Control

1. INTRODUCTION

Recent advances in the field of robotics technology have led to experimentation with robot as a potential means of helping the disabled with the automated assistance. Our application is such which uses motor control systems at the joints and links helping in movement of the the legs and the assisted leg in coordination . The Open loop Mechanism is used in controlling the Legs of the Robot. The synchronization between the Active and the Passive Legs are very important so that after the movement of the Passive Legs, The active legs should move and step forward. Gait Control is another limit in the movement of the Leg that is controlled , which determines the torque that is obtained during movement of each of the legs and control motion along its path. The Model is Physically modelled using Solid works and imported into simulink and Adams for simulation and experimentation.

2. PROPOSED ARCHITECTURE

Components:

Components of the systems are explained in details which play a vital role in helping the autonomous control and coordination between the active and the Passive Legs of the Robots. Servomotor is and simulation is carried out using simulink and the mathematical model is being developed which is used as base reference in carrying out this project.

Power Supply :

The robot is powered by 12V of 2 Battery Packs. Then supply current limit for the battery 1800 mAh. Battery pack B1 will power the motors and B2 will power the microcontroller. The supply lines are filtered with two 10µF capacitors (C1 and C2), one capacitor on each line. The batteries are connected to the circuit through a double pole, double throw switch (SW1).The motor supply line includes two fuses (F1 and F2).The fuses are used to protect the Motor from drawing too much of power. In case of too much power is drawing fuses stall the proceedings.

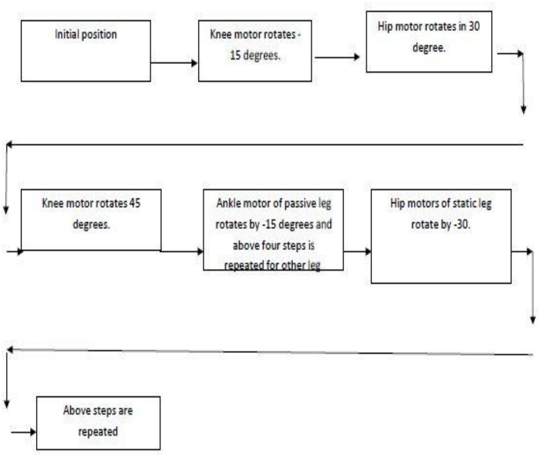
Servo Motors :

A Servo Motor consist of Gear Train, 3 Wire DC Motor, an Integrated Circuit, is connected to the Power supply, Another for Control and the third for grounding. The 8 servo motors (M1-M8) are controlled by the microprocessors (U1) pulse width modulator through the opt isolators (U2A&B and U3A&B). The opt isolators are used to limit noise to the microprocessor from the motors and to protect the microprocessor from any back electromagnetic force from the motors. The motors have a 180° range of motion. The scale of motion is controlled by the width of the pulse sent to it from the pulse width modulator.

Microcontroller :

The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density non volatile memory technology and is compatible with the industry-standard MCS-51 instruction set and pinout. The on-chip Flash allow the program memory to be reprogrammed in system or by a conventional non volatile memory programmer. Combining the versatile 8-bit CPU with Flash on a monolithic chip. Atmel AT89C51 is a powerful microcomputer which provides a highly flexible and cost-effective solution to many embedded control applications.

3. Working :



4.Kinematic Modelling:

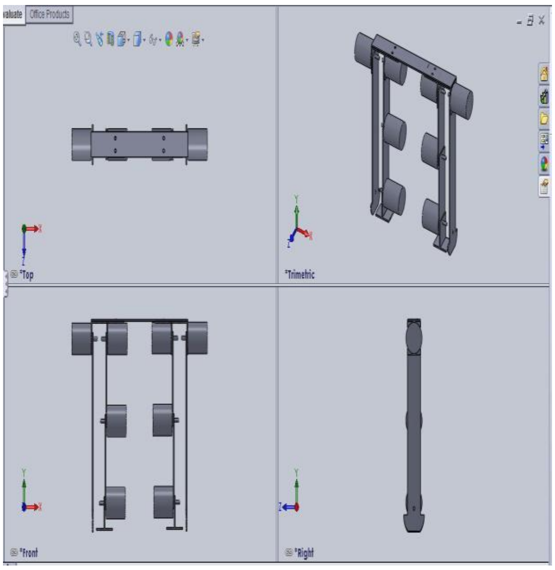


Figure 2 : The Views of the Modelled 4-Legged Crutch Robot

Output coordinate System: -- default -- Mass = 1204.19 grams Volume = 1204189.18 cubic millimetres Surface area = 299148.14 square millimetres Center of mass: (millimetres) X = 62.90 Y = -96.36 Z = 4.42
Principal axes of inertia, principal moments of inertia: (grams * square millimeters) Taken at the center of mass. Ix = (0.99, 0.14, 0.00) Px = 14784049.89 Iy = (-0.14, 0.99, -0.00) Py = 15420896.12 Iz = (-0.00, 0.00, 1.00) Pz = 29838853.64
Moments of inertia: (grams * square millimeters) Taken at the center of mass then aligned with the output coordinate system. Lxx = 14795922.57 Lxy = 86135.12 Lxz = 5683.32 Lyx = 86135.12 Lyy = 15409029.04 Lyz = -7035.75 Lzx = 5683.32 Lzy = -7035.75 Lzz = 29838848.03
Moments of inertia: (grams * square millimeters) Taken at the output coordinate system. Ixx = 26001449.93 Ixy = -7213104.91 Ixz = 340609.65 Iyx = -7213104.91 Iyy = 20197281.39 Iyz = -520122.17 Izx = 340609.65 Izy = -520122.17 Izz = 45785541.70

Table 1 : Mass properties of assembly

Volume: 1 Issue: 1 08-Dec-2013,ISSN_NO: 2348-2338

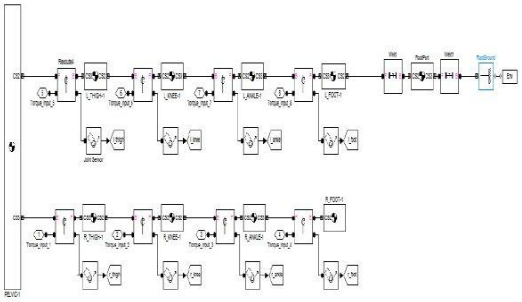


Figure 3 : Simu-link Model for the Control of the Legs

The Physical representation is First developed in Solid works with our assumptions and the simulink model for the same is made using simulink toolbox using Matlab .The Main aim is achieved by controlling the servo motors which help in moving the leg, & way of walking control helping in path of the motion in which robot is moving and torque required from the motor .The coordination between both the legs is times using the Microcontroller with a time delay that helped in moving it smoothly without any trouble.

5. EXPERIMENTATION :

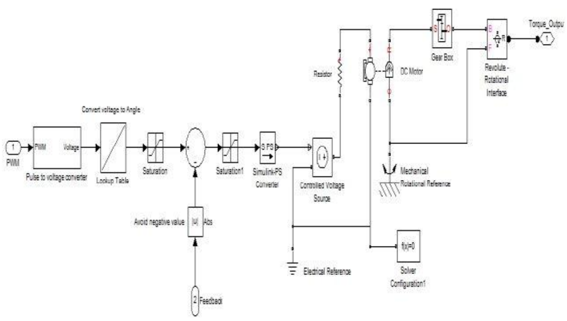


Figure 4 : Servo Motor Control of the Legs

High Torque servo motors are chosen carefully which are located on the knee, ankle and hip of each of the robot .The Servo Motors used HS-5645 MG with a programmable circuit and metal custom made gear box with the gear train technology helping in variable transmission ratio. This sort of stepper motor delivers high torque and high resolution.

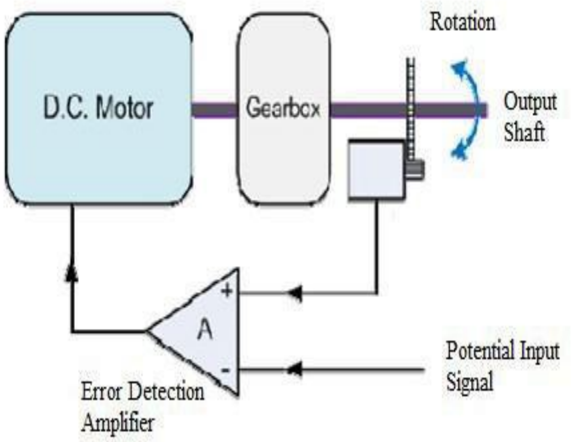


Figure 5: Servo Motor Control

Gait Control :

The Gait Pattern Control for all the 4 legs consists of both electrical and mechanical subsystems. Each Motor present at the linkages receive all the control signals that are needed to actuate the torque required for input mechanical part to work ,set the joints properly into spinning action The real time models are produced and compared with the ideal one that is calculated mathematically.

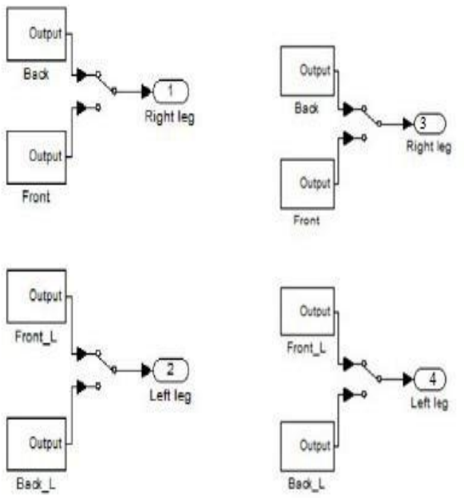


Figure 6: Gait Control for all the 4 Legs (a) Active Legs (b) Passive Legs

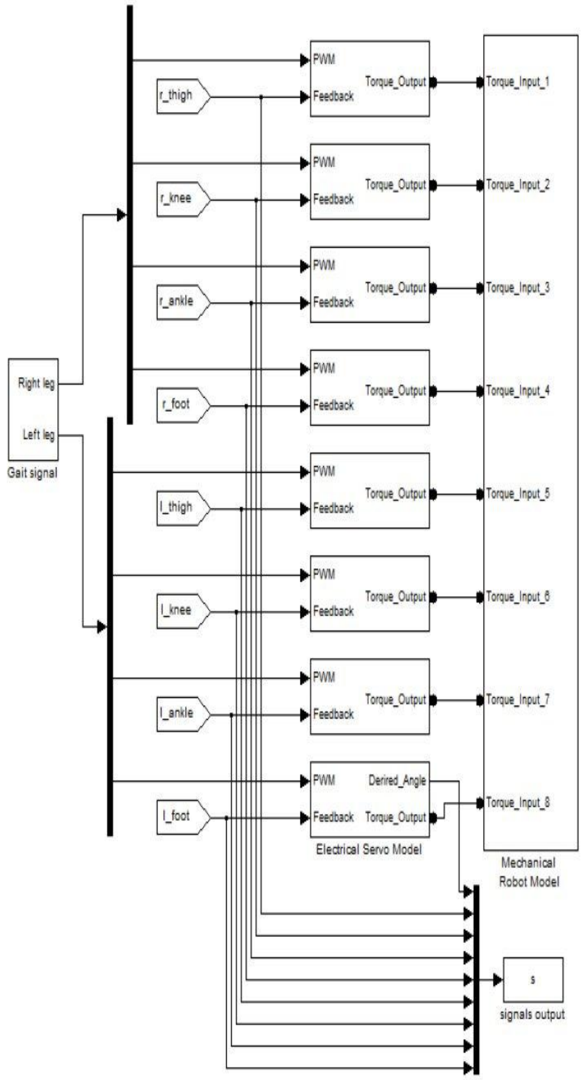


Figure 7: Servo Motor Control for all the Joints Using Simulink

Volume: 1 Issue: 1 08-Dec-2013,ISSN_NO: 2348-2338

Figure 8: Servo and Stepper Motor Control

5.RESULT :

The Experimentation part was carried out for image processing in MATLAB R2009a/b using Simulink Toolbar and Adams and the output for the simulation is obtained .The outcome are tabulated and compared with the previous models that were available and necessary changes and the modifications needed for the them is done.

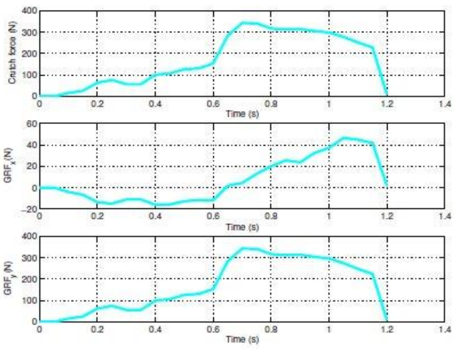


Figure 9: The Ground effect Forces that are observed with simulation results.

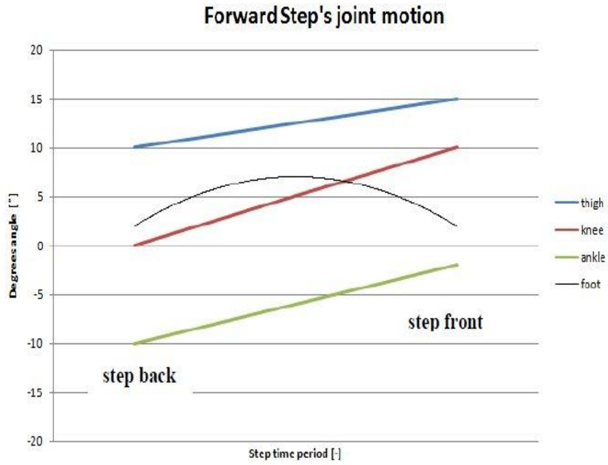


Figure 10: Simulation Results of the range of Degree Angle Control of the Servo Motor.

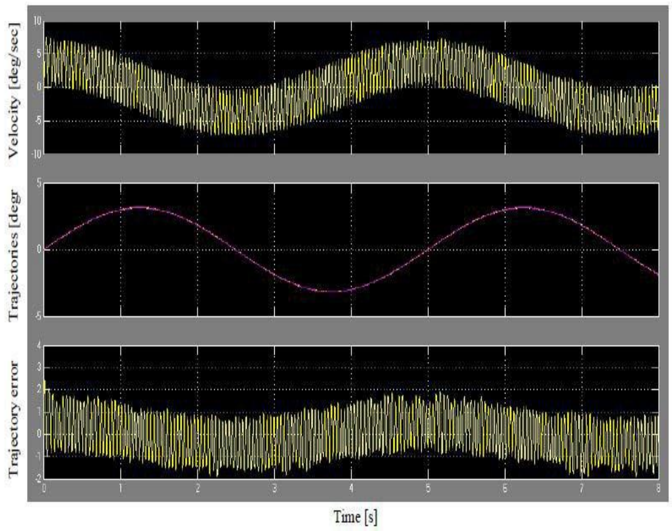


Figure 11: Servo Speed Control Graphs

6.CONCLUSION :

The Position and the Motion of the Servo Motor is controlled using the Servo Controller circuit which in turn controls the Position, Acceleration and Velocity at the Joints .The Gait control is controlling the path of the Motion of the Robot and torque output that is given for the required motion. The 3-DOF is restricted with the model and all the 8 Servo motor are controlled and the coordination between the Active and passive legs are monitored.

7.REFERENCES :

[l] Kralj A, Bajd T. Functional Electrical Stimulation: Standing and Walking after Spinal Cord Injury, CKC Press Inc., Boca Raton, Florida, 1989.

[2] Bajd T, Kralj A, Karhik T, Savrin K, Obreza P. Significance of FES-assisted plantafflexion during walking of incomplete SCI subjects, Gait&Posture, Vol. 2, pp. 5-10, 1994.

[3] Bajd T, Kralj A, hfran M. Unstable states in four-point walking, J. Biomed. Eng., Vol. 15, pp. 59-162,
1993.

[4] McGeer T. Passive dynamic walking, Int. J. Robot. Res.,[SI Bajd T, Kralj A, Kartnik T. Unstable tates in four-legged locomotion, *In Proceedings of IEEE/RSJ/GI Int. Conf.*

[5] Winter DA. Biomechanics of Human Movement, John Wiley & Sons, New York, 1979.

[6] iefran M, Bajd T, Kralj A. Analysis of paraplegic subjects walking patterns through parallel structure kinematic model,*The Third Int. Conf. on Advances in Robot Kinematics,Ferrara, Italy*, pp. 224-229, 992.

[7] Kumar V, Waldron KJ. Force distribution in walking vehicles, ASME Journal of Mechanical Design, Vol. 112, pp. 90-99, 1990. Vol 9, pp. 62-82, 1990. pp. 1019-1025, 1994. 307.

[8] T. Kenjo, A. Sugawara, Stepping Motors and Their Microprocessor Controls, 2nd Edition, Oxford University Press, Oxford, 2003.

[9] P. Acarnley, Stepping Motors - A guide to theory and practice, 4th Edition, The Institution of lectrical
Engineers, London, 2002

[10] http://www.mathworks.com - Guide for Image Acquisition.

[11].Microcontroller architecture and Organisation,Mazidi 2nd Edition.

[12].G.Liu, S.Xie, L.Yu, S.Li, D.Chu ,"A Guiding Principle to Optimize Crutch ",*Proceedings of the 2008 IEEE*
International Conference on Robotics and Biomemitics Bangkok, Thailand,2009

(* I- M.Tech Mechatronics, SMBS, VIT University, Vellore, Tamil Nadu ,India)

(# Under the guidance ,Divisional Leader , Robotics Lab, SMBS, VIT University, Vellore , Tamil Nadu,India)