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Development of Low Cost Solutions towards Automation of a Typical Wheelchair

Imran Ahmed[*,1], Mohammad Aamir Khan[1], Tauqeer Ahmed Khan[1]

[1]Mechanical Engineering Department, The University of Lahore, 1-KM Thokar Niaz baig, Raiwind Road, Lahore, Pakistan
*Corresponding author: Imran Ahmed (email: imran.ahmed@me.uol.edu.pk)

***Abstract*—This paper is about design, development and kinematic analysis of the wheelchair for disabled persons. Design improvements and suspension incorporation are among various ideas that were investigated and incorporated in the design. The proposed Design solution uses two wiper motors and a mechanical power system with timing belts and pulleys. Wheelchair motion is controlled using android application. Android based Smartphone provide a new technique for interaction between machine and human beings. Wheelchair can move in all four directions left, right, forward, backward and stop. A 3D model of the wheelchair was prepared in CREO. Structural analyses are performed on CREO software and final vehicle was simulated in ADAMS to access stability and ride quality. Motion simulation for the wheelchair is observed in Adams Software package in two cases: First one is traction motion and second is steering motion. Wheelchair stability test was also studied in ADAMS. Results obtained from Adams simulation describe the efficiency of proposed wheelchair driving system. The final outcomes were an economical design which was found penetration in Pakistani market**

***Index Terms*— Automation; Low Cost Solutions; Wheel Chair; Dynamic Analysis; Stability Analysis.**

I. INTRODUCTION

We have structured this paper in four sections. In the introduction part literature review of existing design of wheelchair is presented. In the 2nd part design of experimental wheelchair prototype and the design solution for the motion control of the wheelchair is described. Third part presents the kinematics of electric wheelchair by performing wheelchair motion simulation is Adams Software package. In last part dynamic stability analysis of the wheelchair are presented. Physically injured and disables patients with good mental strength try to get through places using manual and conventional wheelchairs. To face this problem an android based automatic wheelchair is used. The available wheelchairs are very expensive so a common person cannot afford. The price for automatic wheelchair is between Rs. 250,000 to Rs. 600,000. [6] The major objective of this project is to design and assemble a very low cost automated wheelchair having a weight upto90kg.The anticipated arrangement of the wheelchair comprises of two wiper motors. These wiper motors are used to drive each rear wheel of the wheelchair and drive train comprising of toothed belts worldly course of action pulleys and distinctive mechanical parts that couples the motors pole to the shaft of driving wheel. Precise Velocity and torsion produced by every wiper motor is control by maintaining the beat measurement. Ordinarily strong state transfers square measure normally is used to switch offer the voltage extremity for the purpose to fluctuate running bearing of PM (permanent magnet) wiper motors [1] [2]. Wheelchair administration module is utilized to change over point information from the humanoid telephone motors control flag. Administration modules square measure microchip based for the most part and has a few flexible values. Control module use input to show whether the motor is reacting legitimately to android application order [7] [8].

II. DESIGN AND CONTROL SYSTEM DEVELOPMENT OF WHEELCHAIR

For this reason, desired solution of the wheelchair design is made in CREO Computer software package [10]. Bolstered wheelchair elements computed parameters is built up the required torque and speed of impetus motors. Two wiper motors are connected to each back wheels of the wheelchair. The electric wheelchair is operated on 12V and draw in near 3A when fully loaded. The majority of riggings territory

unit metal for duplicated durability and furthermore to solidified yield shaft has 9.5mm breadth. It is upheld

by two metal balls. This can be pre-designed for the 90 (degree) shift of movement, anyway this could be changed by reconfiguring the inserted controller [11]. Update seat drive prepare comprising of toothed belts, toothed pulleys and diverse mechanical parts. This is used to couple motors shaft with the shaft of driving wheel of wheelchair. Wheelchair model developed in CREO Software is shown in Figure 1.

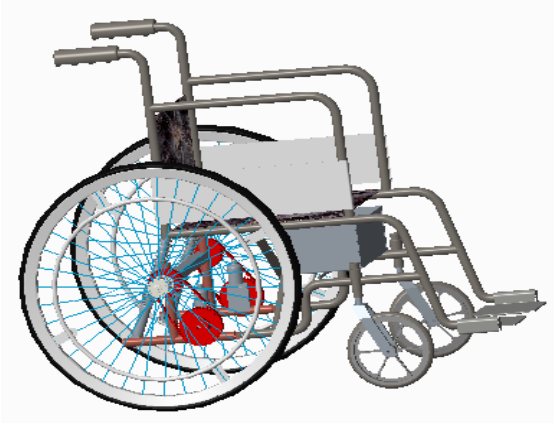

Figure 1 Creo Model of Wheelchair

Model develop in CREO Software is important because we can use it for simulation of wheelchair in Adams Software to study the motion dynamics. This Model is also important for further study in order to do optimization in development to minimize weight and ergonomics. Wheelchair uses the timing bets for motion transmission. Belt transmission system in shown in figure 2.

Figure 2 Wheelchair belt transmission

This experimental model of wheelchair is assembled at Mechanical Engineer Department "The University of Lahore" is shown in Fig. 3 and figure 4. The desired design solution of electric wheelchair use two wiper motors each attached to the rear wheels. Motion is transmitted to the wheels by using timing belts. Belt transmission doubles the motor torque and reduces the angular velocity.

Figure 3 Wheelchair Prototype Front View

Figure 4 Wheelchair Prototype Side View

Control system to be implemented is predicated on L298N H-bridge motor controlling module. H-Bridge's square measure for the most part used in predominant motor speed and course. Relate in Nursing H-Bridge consists of four relays and drive current in either directions. It is controlled with the help of Pulse breadth modulation. Pulse expansiveness Modulation could be an implies that in predominant the time of Associate in nursing electronic pulse breadth. The more drawn out the beats the snappier the wheel can flip and shorter the beats, wheel can flip slowly. Wiper motors can keep going for any longer and be a ton of solid whenever it is control by PWM [13]. Microcontroller used in this project is predicated on Arduino 2560 mega board. It has fifty four input/output pins. It has sixteen simple data sources

and four UARTs equipment serial ports and a sixteen (MHz) oscillator. USB connection also available is this Arduino microcontroller. An impact jack to associate in Nursing ICSP header and reset button. [14] [15], see Figure. 5

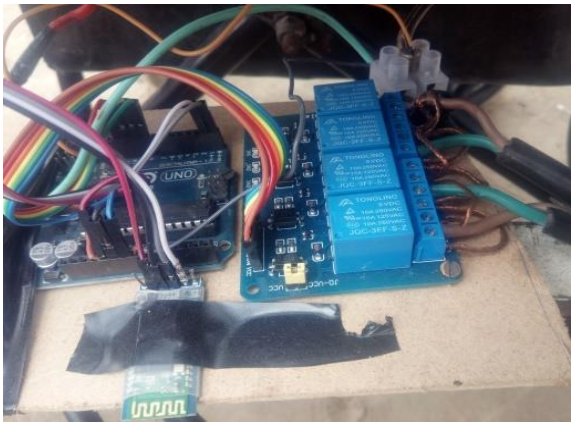

Figure 5 Control System Development of Wheelchair

III. MOTION ANALYSIS OF WHEELCHAIR

Movement examination of wheelchair motion is performed in MSC Adams Software package, for this reason, we have imported the model developed in CREO software into Adams software package database. Through a fitting Adams-created method is broke down what's more on the grounds that the wheelchair movement flight and in this manner the movement parameters. First the parts materials assortments unit illustrated, upon the projects that figures the dormancy properties all things considered. Upon this progression, next the turn joints of the wheel's zone unit delineated. Wheelchair front wheels move independently and are fitted on structure of chair by the help of pivotal outspread heading. Kinematics of the model has been developed in Adams is shown in Figure.6

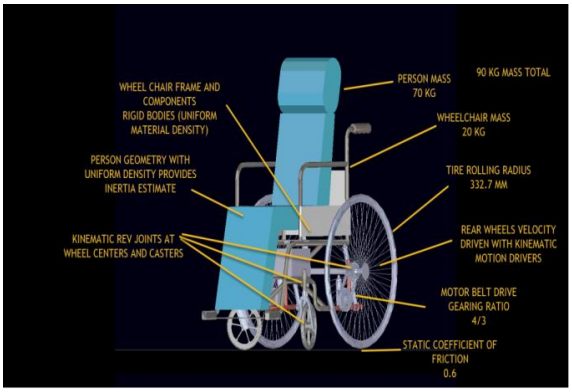

Figure 6 Wheelchair Kinematic Model in ADAMS

The contacts powers between the haggles are typically depicted by the contact mechanism demonstrate that's dictated by mechanical parameters. For example, the firmness, drive type, damping or rubbing coefficients and infiltration profundity. These parameters are characterized by concentrate advance writing [16] [17]. The wheelchair ground contacting parameters are described which are important to specify in order to obtain proper contact between the wheels and the ground. By considering the efficiency and preciseness, impact method is utilized to define wheelchair wheel and ground contact parameters [16] [18].

A. Analysis Parameters

Necessary parameters that are required to perform the motion analysis are studied form the literature and are explain here as: Coefficient of friction between ground and wheels is finalized by studying the literature and is given as
μ=0.4-0.6 this is for old asphalt and concrete type roads.
Stiffness (K) Contacting bodies detail is specified from the literature. The typical values of Poisson ratio and Young modulus for ground are ν = 0.16 and E = 2.2×10^{10}(N/m^2) and for wheel ν = 0.28 and E = 92 7.3 0 (N/m^2).

Force exponent (e) Value of force exponent is e=1.3. [16] [17].

Damping Coefficient. (C).In this case of simulation value of damping coefficient is used C=100 (Ns/m).
Penetration depth. In many cases reasonable value that is used for this purpose is 0.01mm. In our case we have used the value 0.1mm. Because of numerical convergences in MSc Adams software.

Typical values for dynamic friction and static friction are: μ_d = 0.18, μ_s = 0.2. Values of static and dynamic viscous velocity founded in literature are: v_s = 10mm/s, v_d =100mm/s

The Electric wheelchair movement examination has been performed in Adams software. 1st the primary case for straight line movement, the two motors are set to keep running with same speed. For this reproduction both the motors keep running with 41 (rpm), and the wheelchair movement direction has been appeared in Figure 7, the impetus torque being appeared in Figure 8. Wheelchair mass center velocity is shown in figure 9. We can observe that the Wheelchair motion speed is relatively consistent

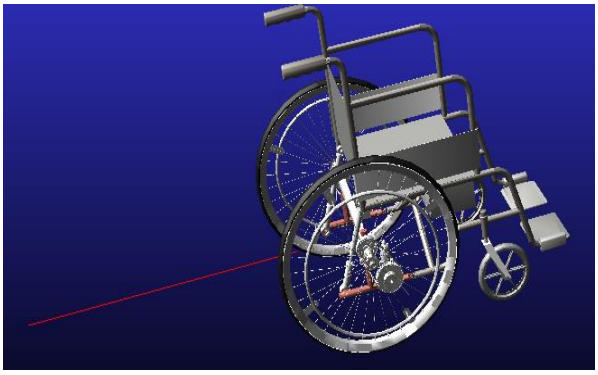

Figure 7 Straight line Motion Trajectory

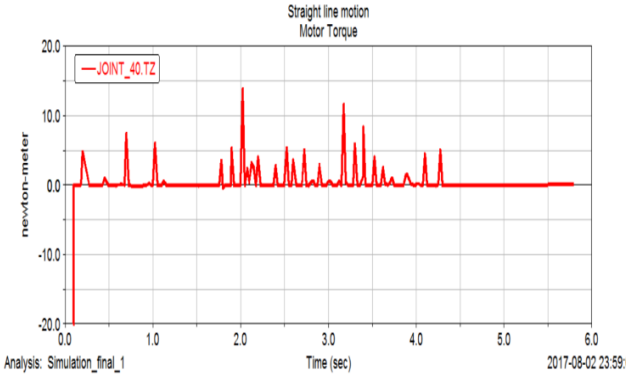

Figure 8 Propulsion Torque for Straight line motion.

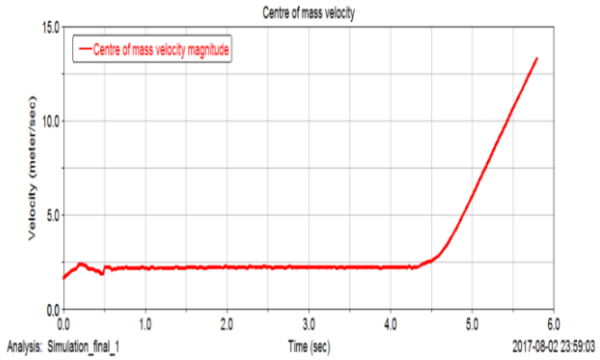

Figure 9 Wheelchair mass center velocity

In 2nd case of motion simulation, right side motor is set to run with 18.15 (rpm) and the left motor runs with 41(rpm). Traced motion trajectory of wheelchair can be observed in figure 10. Right and left motors torque measured in Adams software is given in figure 11 and 12. Wheelchair displacement is shown in figure 13 and mass center velocity in figure 14. We can see clearly that more torque is required for right wheel as compare to the left wheel. The reason is because it will spin at low angular speed.

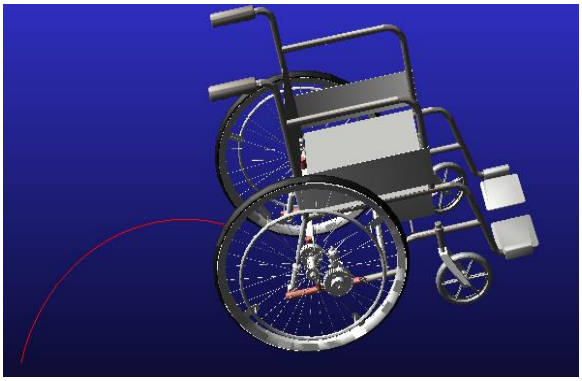

Figure 10 Wheelchair motion trajectory for steering motion

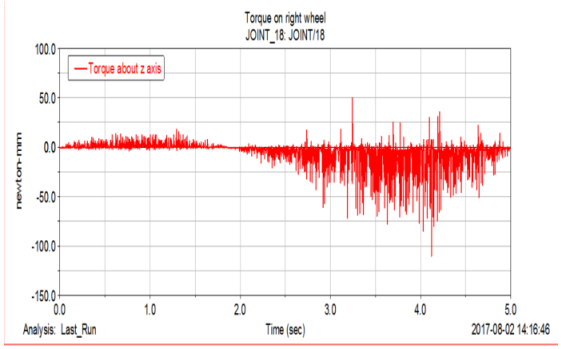

Figure 11 Propulsion torque for right wheel

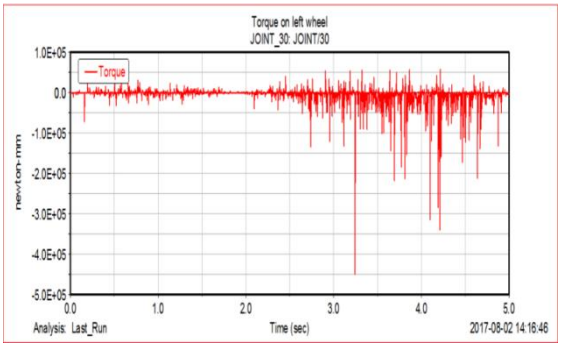

Figure 12 Propulsion torque for left wheel

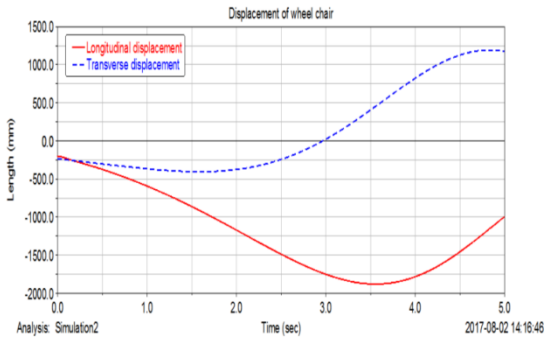

Figure 13 Displacement of wheelchair along longitudinal and transversal axis.

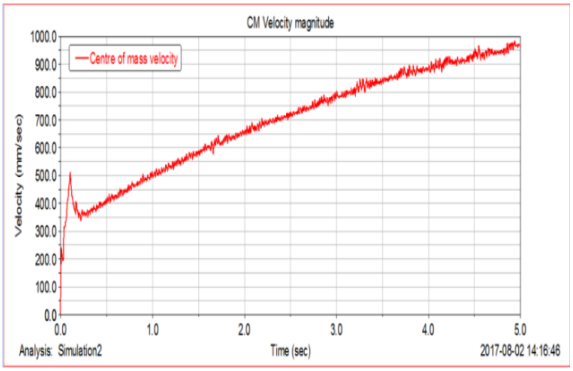

Figure 14 Wheelchair Velocity magnitude.

IV. COST ANALYSIS

This project is aimed to reduce the cost of automated wheelchair and make it available for common people. The total cost of the prototype wheelchair is shown in table 1.

Table 1. Cost Analysis of Wheelchair

Particulars	**Cost (Rupees)**
Wheel chair	4,500
Motors	2,500
Assembling and machining cost	5,000
Pulleys	4,500
Controller System	5,000
Batteries	2,500
Android phone	15,000
Total Cost	39,000

Our project cost 39,000 with a Android phone and market price of the powered wheel chair is 170, 000. [18]

V. CONCLUSIONS

The proposed wheelchair prototype model is successfully designed, implemented and controlled by using an Android application. The new innovative design and expected low cost of the automated wheelchair will make this independent mobility system available to a much broader pool of consumers than the more expensive products with safety and operational deficiencies. In the dynamic analysis on the automated wheelchair we can see that when wheelchair moves on flat type path the values of torque in straight line motion and in steering motion are little low. We can see in the results plots greater value of torque is required when the wheelchair is moving on a bump and pit type surface.

REFERENCES

[1] A. G. Rodriguez, A. G. G. Rodriguez and R. Morales, "Mechanical Synthesis for Easy and Fast Operation in Climbing and Walking Robots, Climbing and Walking Robots" IntechViena, 2010.

[2] R. Gurpude, P. Dhopte, K. Chimote, and A. Bhambulkar, "Design, Synthesis & Simulation of Four Bar Mechanism for Guiding Wheel for Climbing," *International Journal of Computer Technology and Electronics Engineering (IJCTEE)* Vol. 2, Issue 2, April 2012.

[3] A. B. Hassan, "Design and Fabrication of a Motorized Prototype Tricycle for the Disable Persons," *IOSR Journal of Engineering*, Vol. 2(5), pp.1071-1074. May 2012.

[4] G. Ionut Daniel, D. Nicolae, and M. Alexandru, "design and structural analysis of a powered wheelchair transmission" *acta universitatis cibiniensis – technical series.* vol. Lxvii 2015.

[5] A. Sutradhar, M. S. H. Sunny, M. Mandal, R. Ahmed, "design and construction of an automatic electric wheelchair," presented at 3rd international conference on electrical information and communication technology (eict) khulna, bangladesh, 7-9 Dec. 2017.

[6] G. S. Modak, M. M. Bhoomkar, "Evolution of a Stair-Climbing Power Wheelchair," *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, pp. 36-41, 2009.

[7] H. Salmin, H. Rakibul, P. Kumar Kundu, B.M. F. J. Shuvo, "Design and Implementation of an Electric Wheelchair to economize it with respect to Bangladesh," *International Journal of Multidisciplinary Sciences and Eng*. 2014.

[8] B. James, D.S. Reswick, "Automatic transmission for electric wheelchairs," *Journal of Rehabilitation Research and Development* Vol. 22 No. 3. June, 2012.

[9] PTC Creo 4.0. Research Software, 2016.

[10] Motor controlling manual, Palolo Simple Motor Controller User's Guide, 2001–2014.

[11] P. Wellman, V. Krovi, V. Kumar, and W. Harwin, "Design of a Wheelchair with Legs for People with Motor Disabilities," *IEEE Transactions on Rehabilitative Eng*. Vol. 3, pp.343-353, 1995.

[12] Tesla Robotics and Electronics "Arduino Modules - L298N Dual H-Bridge Motor Controller"

[13] Dr. Subhi, R. M. Zeebaree, and H. M. Yasin, "Arduino Based Remote Controlling for Home: Power Saving, Security and Protection," 2013.

[14] R.F. Edlich, K.P. Nelson, M.L. Foley, R.M. Buschbacher, W.B. Long and E.K. Ma, "Technological advances in powered wheelchairs," J. Long. Term. Eff. Med. Implants, vol. 14, pp.107.130, 2004.

[15] D. Kong, J.M. Meagher, C. Xu, X. Wu, Y. Wu, "Nonlinear Contact Analysis of Gear Teeth for Malfunction Diagnostics," presented at 5th Conference and Exposition on Structural Dynamics, 2008.

[16] MSC Adams reference manual. ISI research software, 2013

[17] K. Vernekar, and H. Kumar, "Computational and Experimental Approach for Fault Detection of Gears" *Columbia International Publishing Journal of Vibration Analysis, Measurement, and Control* Vol. 2 No. 1 pp. 16-29. 2014.

[18] V. Kaundal, R. Singh, "Low Cost Robotic Wheel Chair for Disabled People in Developing Countries" presented at Conference on Advances in Communication and Control Systems. *(CAC2S 2013)*. 2013.