Design and Development of Segway Human Transporter

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Abstract— Designing and Development Of Segway Human Transporter covers the modeling and design of a co-axial, two wheeled scooter to provide a method of human transport. The aim of the project was to design and build a device that behaves in a similar manner to that of the Segway Human Transporter, "the first and only self-balancing vehicle to be commercially available". The design of Segway Human Transporter draws upon the advantages and disadvantages of the previous designs in an attempt to create a robust, easy to use device. Components for the device were selected after extensive research had occurred and design was implemented using the characteristics of these components.

Key words: Designing and Development of Segway Human Transporter, Handlebar, Chassis

I. INTRODUCTION

Automation in industries and domestic life had a great influence on its standard of living. Due to this, automotive had also developed now and then. The aim is development of the specifications of the original Segway Human Transporter (HT) project is outlined in this chapter. The development of suitable goals and specifications were crucial to theproject's success as they guided both the design and aims of the project team.

As part of the requirements of the project a number of goals were established to measure the success of the project. The primary goals were defined as the goals the group hoped to achieve as a minimum for success. The main Objectives of the project are:

- To develop an accurate and robust mathematical model of the system.
- To make it useful for handicapped persons, senior citizens and domestic transportation etc.
- Market price of segway is above 4 lakh; hence our main objective is to reduce its cost between Rs.20000 to Rs.25000.
- By reducing its cost we can make it affordable to normal peoples so they can buy it & use it for short distance transportation.
- Convert the mathematical model into a state space plant.
- Implement closed loop steering and balancing.
- Design and build a physical prototype.
- Create virtual reality model.

II. LITERATURE REVIEW

1) Dein Shaw and S. H. Chan in This, A Man Powered SAGWAY Is Proposed.

The basic concept of the human powered SAGWAY is a hybrid electric bicycle, which combines the human power and electric power together.

There are three driving modes of present design:

- Mixing the man power and electric power mode
- All electric power mode
- All man power mode.
- A transmission mechanism to combine human power and electric power is designed.

2) Dr. Rongfang (Rachel) Liu & Rohini ParthasarathyAuthors of this paper try to explain how segway may be incorporated into the transportation infrastructure.

An average traveller may lose 36 hours a year or $ 600 per capita. If a small percentage of people choose to ride Segway it will help relieve the congested urban roads. Environmental benefits can be gained over a period of time if electrically driven Segway HT substitutes a small percentage automobiles. After examining the Segway technology the authors believe that dedicated non-

3) Nor Maniha Abdul Ghani, Faradila Naim, Tan Piow Yon. This project focuses on the development of a line follower algorithm for a Two Wheels Balancing Robot. As a result of combination between line follower program and internal self balancing algorithms, we are able to develop a dynamically stabilized balancing robot with line follower function.

4) Marco Antonio Meraz, Andrés Yánez. Carlos Jiménez. Raúl Pichardo. This article is based on the equation of motion and balancing.A self balancing system analysis is presented which utilizes freely moving balancing bodies (balls) rotating in unison with a rotor to be balanced.

The rotation of unbalanced rotor produces vibration and introduces additional dynamic loads to obtain the balancing, ω greater than the first natural frequency.

5) M.Thompson, J.Beula Julietta MaryThe purpose of the paper is to design and fabricate a fail-safe Segway Personal Transporter (PT).This seaway was designed to overcome the cost of the actual segway and to provide zero pollution within the campus.This seaway doesn't use the gyro unit which keeps the segway Sin the flat position instead this is achieved by the supporting wheels which we will be seeing in detail.

6) Houtman P. Siregar & Yuri G. MartynenkoThis article is devoted to the stabilization of the segway model in the form of mechanical model. The mechanism is driven by electromotor which rotates the wheels of the segway. Stabilization of region of attraction of the pendulum vertical position is controlled by manipulating the voltage and the elastic coefficient of the coiling spring.s A new means of transportation, which is called as Segway Human Transporter, is designed as a monocycle seating one person.

III. METHODOLOGY AND DESIGNING

A. Handlebar:

The handlebar provides support for steer-by-leaning. The rider should feel some resistance when tilting the handlebar.

A dead-man's grip is also implemented in the handlebar so that the power to the vehicle is cut when the rider falls off.

B. Chassis:

The top surface of the chassis has been covered with grip tape to reduce the risk of slipping accidents, and a thin anodized aluminium profile has been added to the edge for esthetical reasons. The top also has a centre console with a lid, which provides access to the main circuit breaker of the system as well as the charging plug. The hinges for this lid will be designed and cut by laser from a piece of plastic to allow for opening angles larger than 90 degrees while not having a visible hinge on the top of the lid. as the charging plug.

C. Base Plate:

The base plate was an integral part of the overall detailed design. It served as a protective bash guard as well as a basis for the mounting of various different pieces of hardware.

D. Wheels:

Advantage of using the 20 inch bicycle wheels is the possible speeds they would allow the scooter to reach. The vehicle could obtain speeds of up to 20 kilometres per hour if the selected motor achieved the maximum revolutions per minute.

E. Driving Motor:

The rated current of *MY1016* has a specification of rated 19 A under 24V, rated speed 2750 RPM and maximum output power 350 W. Because of the motor's low resistance (1Ω armature resistance), it will has a huge inrush current (up to 120A) at the moment when the motor switches from fully off to on or alters direction.

F. Accelerometer Circuit for Balancing:

Acceleration is a physical characteristic of a system. The measurement of acceleration is used as an input into balancing of control systems.

The control systems use the measured acceleration to correct for changing dynamic conditions by auto adjusting the tilt of cart.

IV. DESIGNING CALCULATION AND KINEMATICS ANALYSIS

The mathematical model that was constructed by our team included many assumptions and simplifications which greatly reduce the quality and robustness of the control system. One such simplification was modelling the person and handlebars as one mass. Another problem with the design, related to the centre of gravity of the vehicle which finished above the axle, giving the rider a sense of an unstable vehicle and also led to increased requirements of the motors to maintain stability when stationary.

By balancing these forces and torques, the following equations of motions were derived.

- Assume friction with the ground is significant enough that there is no wheel slip:

$$H_{TR} = -\tau_R/R \ \& \ H_{TL} = -\tau_L/R$$

- With moments of inertia defined as:

$$J_{P\theta}=M_P(L/2)^2$$
$$J_{R\varphi}=1/2M_RR^2$$
$$J_{L\varphi}=1/2M_LR^2$$

- Motor Torque Calculation For maximum load applied=150kg
- Load on one wheel=75kg
  Wheel radius=0.508m
  μ=0.5

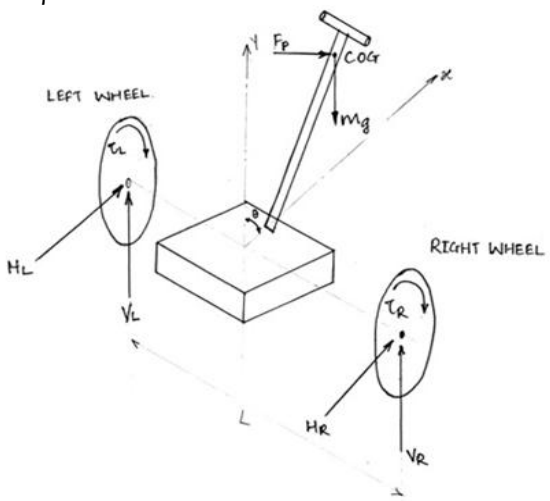

Fig. 1:

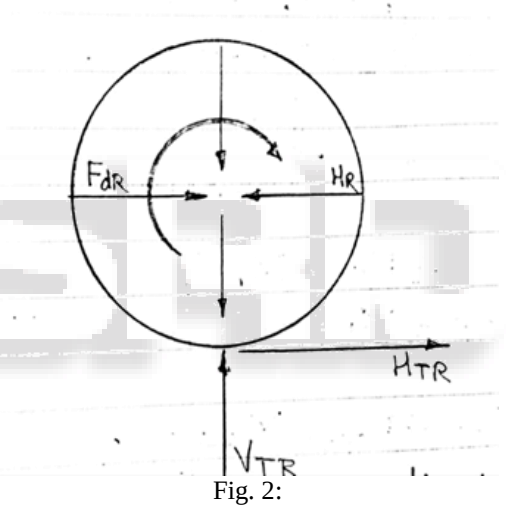

Fig. 2:

- Horizontal motion provided by rotation of the wheels with HTL and HTR as defined previously and therefore:

$$\ddot{x}_R = R\ddot{\varphi}_R = R/JR\varphi(\tau_R - H_{TR}R)$$
$$\ddot{x}_L = R\ddot{\varphi}_L = R/JL\varphi(\tau_L - H_{TL}R)$$

- For one wheel
  Reaction Force N=735.75N
  Friction Force F_r=μN=367.875N
  Motor Torque required=$R_{wheel} \times F_r$ =186.88 N-m
- Standing Platform Designing
  Area of platform =A=0.3072
  E=210Gpa = 2.1×10¬11 N/m
  F= 150×9.81=1471.5N
  L=0.68m
- Deflection=FL/AE
  =(1471.5×0.68)/(0.3072×2.1×1011)
  =1.55×10-8 m

V. CAD MODEL

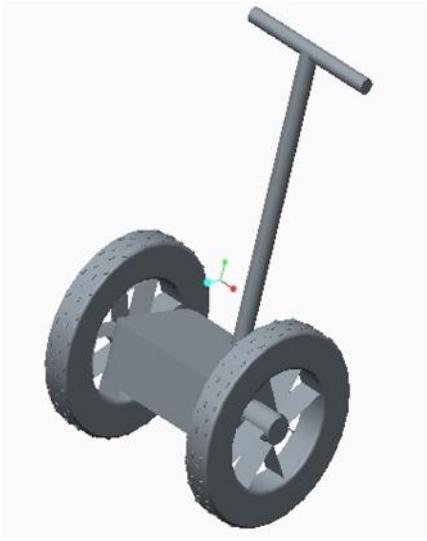

Fig. 3: CAD Model

VI. CONCLUSION

The purpose of designing segway a human transporter has been done successfully .The design consist of accelerating sensors in place of gyroscope. Which reduces its cost and made it easy to be within the reach of common people.

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