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A Review Paper on Transporter Using Dynamic Balancing of Inverted Pendulum

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Abstract -*In this paper, literature collection work has been done and also the principle of inverted pendulum is described. Transporter is to be fabricated either using Aluminum or Mild Steel. The transporter consists of a combination of a series of sensors, a control system and a motor system. Working principle of the transporter is based on the reviewed literatures. The transporter uses accelerometer gyroscope sensor, microcontroller and switches for its operation. The basic design of the transporter will be such that different module can be attached or detached depending on the application. In the upcoming phase prosthetic module can be designed so that it is helpful for person with disability in legs. The transporter is an absolutely eco-friendly vehicle.*

***Key Words*:Inverted Pendulum, PID controller, Accelerometer ,Gyroscope, Prosthetic module.**

1.INTRODUCTION

1.1 Pendulum

Pendulum is a weight suspended from a pivot so that it can swing freely. When a pendulum is displaced sideways from its resting (equilibrium position) it is subject to a restoring force due to gravity that will accelerate it back toward the equilibrium position.

1.2 Inverted Pendulum

Inverted pendulum has been the subject of numerous studies in automatic control since the 1940's. In recent years, researching in self-balancing vehicles, which typically consist of two wheels in coaxial and standing platform. Works related to inverted pendulum are drawing more attention from both research institutions and public sectors. Among these kind of vehicles, the most familiar one is Segway. Due to the surging consciousness on global pollution and energy-shortage crises, automobiles and motorcycles are no longer the best way of transportation. In order to fit the daily requirement and improve problems. Exploring new way of energy utilization, developing lighter vehicles and innovation of mobile carriers are providing new platforms to the new trends.

An inverted pendulum is a pendulum that has its center of mass above its pivot point.

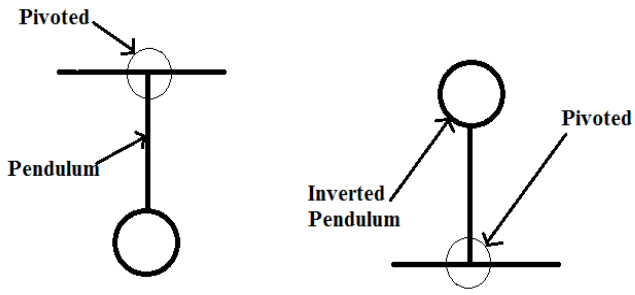

Fig -1: Pendulum and Inverted Pendulum

An inverted pendulum is inherently unstable and must be actively balanced in order to remain upright; this can be done by applying a torque at the pivot point. A simple demonstration of a moving pivot point in a feedback system is achieved by balancing an upturned broomstick on the end of one's finger.

Force must be properly applied to keep the system intact. To achieve this, proper control theory is required. The inverted pendulum is essential in evaluating and comparison of various control theories.

The highly unstable nature of the plant enables an impressive demonstration of the capabilities of feedback systems. The inverted pendulum is also considered assimplified representation of rockets flying into space.

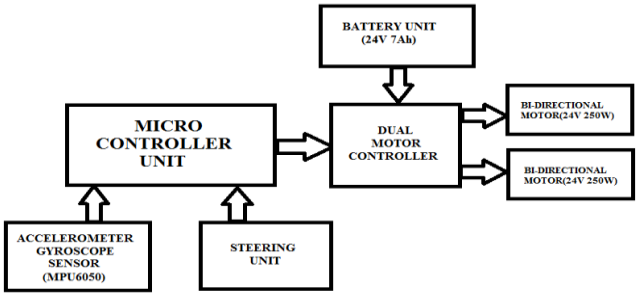

Fig -2: Circuit Block Diagram of the Transporter

1.3 PID Controller

Conventional PID control is developed by calculating and then outputting a corrective action that can adjust the motion of cart accordingly. The structure of PID Controller is taken as:

$u = KP\ e + KI \int e\ dt + KD\ (de/dt)$

Where:-

u is PID output control action,

e is the error i.e. difference between set point input and actual output

$e = y_{ref} - y_{actual}$,

KP, KI, KD are the proportional, integral and derivative gains respectively.

We can see that the output of pendulum angle controller and the cart position controller are of opposite signs. The selection of PID controller parameters (KP, KI, KD) is important as incorrect selection of these parameters can make controlled process input unstable. The control parameters are adjusted to optimum values for the desired response. This is called Tuning of the control loop.

2. OBJECTIVE

- To design and construct a fully functional two wheeled balancing vehicle which can be used as a means of transportation for a single person.
- design of the transporter will be such that different module can be attached or detached depending on the application
- Transporter which we are going to develop is light in weight & very much energy efficient and last but not the least its cost is comparatively less than a conventional standup transporter namely Segway.

3. COMPONENTS

3.1 Microcontroller (Arduino Uno R3)

The Arduino Uno R3 is a microcontroller board based on the ATmega328 .It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It has sets of digital and analog I/O pins that can interface to various expansion boards and other circuits. It provides an integrated development environment(IDE) based on a programming language named Processing, which also supports the languages C and C++.

3.2 Accelerometer Gyroscope sensor (MPU6050)

Accelerometer Gyroscope sensor (MPU6050)which is a serious little piece of motion processing tech by combining a MEMS 3-axis gyroscope and a 3-axis accelerometer on the same silicon die together with an onboard Digital Motion Processor capable of processing complex 9-axis Motion Fusion algorithms

3.3 Dual Motor Controller (Sabertooth 2X12Ah)

The Sabertooth 2X12 is one of the most versatile, efficient and easy to use dual motor drivers on the market.It can supply two DC brushed motors with up to 12A each. Peak currents of 25A are achievable for a few seconds.

3.4 Power Supply

The power supply for the transporter isgiven by connecting two 12 v 7Ah DC power sources in series.

3.5 Bi-directional motors x2 (24v 250w)

This DC motor is capable of rotation in either the clockwise or counter clockwise direction by just reversing the battery polarity to the motor and can be speed controlled.

4. PREVIOUS WORK CARRIED

Researches and Development of an Efficient Electric Personal Mover for City Commuters-World Electric Vehicle Journal Vol. 4 - ISSN 2032-6653 - ©2010WEVA

In this paper they develop a two-wheel-driven self-balancing vehicle named Tiny, based on inverted pendulum control technique, which can carry one person and travels at a maximum speed of 20km/h. They use two BLDC motors as their prime mover. A gravity sensor and a gyro are mounted to obtain values of tilt and tilt rate, the signals from the two sensors are combined with Kalman Filter to indicate the tilt angle of the vehicle, also there is a PD to control the steering unit.The implementation of the Kalman filter, hardware, software, was discussed and Matlab simulations were conducted to verify, and the mathematical model of the vehicle was also presented.

Stabilization of Motion of the Segway-Houtman P. Siregar, Yuri G. Martynenko,-Journal of Emerging Trends in Computing and Information Sciences

This article is concerned with stabilization of the Segway model in the form of a mechanical model. The model consists of a wheel with two-link inverted pendulum which are attached to the mechanism by a hinge. Connections between the links are tied by a elastic coiling spring. The setup is driven by an electromotor which rotates the wheels of the Segway. The vertical position here, is controlled by manipulating the voltage and the elastic coefficient of the coiling spring. The maximal area of attraction of upright position was obtained. The properties of the domains of attraction and controllability of the two-link pendulum at the wheel was researched and it was shown that with increasing stiffness, controllability domain of the two link elastic pendulum increases.

Designing the Self –Balancing Platform-International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 9, September 2015

Preliminary discussion on a two wheeled transport system, which also included history of Segway, inverted pendulum was conducted. The basic structure of the program algorithm was discussed and hardware requirements such as accelerometer and gyroscope sensors which measure the angle and angular rate of the body, Arduino Mega 2560 microcontroller were mentioned. Here they use Kalman filter for sensor fusion during combination of gyroscope and inclinometer. A personal transporter with the more efficient use of energy and for commuting over shortest distance was designed and realized.

A Comparison of Controllers for Balancing Two Wheeled Inverted Pendulum Robot-International Journal of Mechanical & Mechatronics Engineering IJMME-IJENS Vol:14 No:0

The paper presented an experimental comparison between model based controller and non-model based controllers in balancing the TWIP mobile robot. A Fuzzy Logic Controller (FLC) which is a non-model based controller, a Linear Quadratic Controller (LQR) which is a model-based controller, and the conventional controller Proportional Integral Derivative (PID) were implemented and compared on a real time TWIP mobile robot. The FLC controller performance has given superior result as compared to LQR and PID in terms of speed response but had consumed higher energy.

DynamicModeling and Control of a Two Wheeled Robotic Vehicle With a Virtual Payload-K. M. Goher, M. O. Tokhiand N. H. Siddique

In this paper work they dwell into the control of a TWRM (Two wheeled robotic machine) with a load placed at different locations along its intermediate body, also they develop and deploy two control techniques namely proportional-derivative (PD) control and fuzzy logic (FL) control.

They also apply an external disturbance force to the rod which contains the intermediate body, to test the robustness of the controllers. Also comparative simulations of both control algorithms are analyzed.

5.METHODOLOGY

- The transporter is fabricated either using Aluminum or Mild Steel and PVC.
- The dimensions of the transporter is such that it is convenient for a single person to ride. Provision is also made for changing the modules.
- Al and MS used for structure. PVC boards are used for platform.
- Vertical support is provided for the rider to change the tilt angle. The accelerometer gyroscope sensor is used whichwill give information to keep an angle of zero degrees with vertical at all times. This information is theinput to the microprocessor which then runs the PID controller algorithm and directs the motor controller to distribute the necessary power from the battery to the motors.
- Switch is provided for tilt objectives. Turning is obtained by the difference between the speeds of the wheels.
- Calculations on motors, structures, torque requirement and speed are performed.
- Trials are run to adjust the error value of the PID controller till a stable outcome is obtained.

6. CONCLUSION

From the previous work it is seen that several different types of vehicles based on inverted pendulum were carried out. Also instead of using a complex fuzzy logic controller a simple yet effective PID controller is used. An innovative modular design is used such that different modules for different applications can be switched. Light weight, cost effective and environment friendly transporter is built.

REFERENCES

[1] Cao Sijia, Huang Yagang, Zhang Youtong, Zhao Dong, Liu Ke " Researches and Development of an Efficient Electric Personal Mover for City Commuters"-*World Electric Vehicle Journal Vol. 4 - ISSN 2032-6653 - © 2010 WEVA*

[2] Houtman P. Siregar, Yuri G. Martynenko,-"Stabilization of Motion of the Segway" *Journal of Emerging Trends in Computing and Information Sciences.*

[3] Prof.YogeshRisodkar,Mr.GaneshShirsath, Ms.MonaliHolkar, Mr.MayurAmle"Designing the Self – Balancing Platform"-International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 9, September 2010.

[4] "A Comparison of Controllers for Balancing Two Wheeled Inverted Pendulum Robot"- International Journal of Mechanical & Mechatronics Engineering IJMME-IJENS Vol:14

[5] K. M. Goher, M. O. Tokhiand N. H. Siddique Dynamic Modelingand Control of a TwoWheeled Robotic Vehicle With a Virtual Payload

[6] Nehal Ahmad, Jawwad A.K. Lodhi, Nafees P. Khan-" Development of Electric Personal Transporter Based on Lean to Steer Mechanism" *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*

[7] Chung Neng Huang –"The Development of Self-Balancing Controller for One-Wheeled Vehicles" Graduate Institute of Mechatronic System Engineering, National University of Tainan, Taiwan, China Published Online April 2010 (http://www.SciRP.org/journal/eng)

[8] M. Burkert, T. Groll, T. Lai, T. McCoy and D. Smith, 2004, -"Segway Design Project||, Project Report", *Grand Valley State University The Padnos School of Engineering, USA.*

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