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Design and fabrication of Self Balancing Robot

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Abstract: *This project will undertake the construction and implementation of a two-wheeled robot that is capable of balancing itself. The structural, mechanical, and electronic components of the robot will be assembled in a manner that produces an inherently unstable platform that is highly susceptible to tipping in one axis. The wheels of the robot are capable of independent rotation in two directions, each driven by a servo motor. Information about the angle of the device relative to the ground (i.e. tilt) will be obtained from sensors on the device. The precise type of sensor that will be used is yet to be specified. The tilt sensor may be an accelerometer, gyroscopic sensor, or IR sensor (to measure distance to the ground). Information from the sensors will be fed back to the Z8, which will process the feedback using a crude proportional, integral, derivative (PID) algorithm to generate compensating position control signals to the servo motors in order to balance the device.*

Key words: *Self balancing, Robot, 3D CAD, Human transportation*

1. INTRODUCTION

Self-balancing robots have been a topic of interest of many researchers, students and hobbyists worldwide. In essence, it is an inverted pendulum on wheels, a derivative of the inverted pendulum on a cart. Unlike traditional robots, which are in a constant state of equilibrium, the robot is a naturally unstable system [1]. Its design is more complex, as it needs to be actively controlled to maintain its upright position, however, it benefits from being able to turn on the spot. The primary practical application of a self-balancing robot is human transportation, which was popularized by the release of the segway PT (Personal Transporter) [2]. It is used in many industries such as inside factory floors or for tourism in the park. It is more attractive compared to four or three wheeled vehicles as they can take sharp turns and navigate in tighter spaces [3].

2. LITERATURE REVIEW

2.1. According to "Mr. Ralph Hollis "(2008) and his research associates believe that robots in the future will play a vital role in the daily lives of humans. He believes that in order for robots to be productive in our daily lives, some key problems need to be solved first. One the important problem he states in his article about mobile self balancing robots is the overall structure of the robot itself [4].

2.2.According to" SFIT"(2009)Researchers at the Industrial Electronics Laboratory at the Swiss Federal Institute of Technology have built a scaled down prototype of a Digital Signal Processor controlled two–wheeled vehicle based on the inverted pendulum with weights attached to the system to simulate a human driver [5].

2.3. According to" Dean Kamen"(2007) A similar and commercially available system, 'SEGWAY HT' has been invented by Dean Kamen, who holds more than 150 U.S. and foreign patents related to medical devices, climate control systems, and helicopter design. The 'SEGWAY HT' is able to balance a human standing on its platform while the user traverses the terrain with it [6].

2.4. According to "David Anderson "(2010)The uniqueness of these **systems** has drawn interest from robot enthusiasts. For example, a two-wheeled balancing robot similar to JOE built by David .P Anderson, this robot uses a commercially available

inertial sensor and position information from motor encoder to balance the system [7].

2.5. According to "Steven Hassenplug" has successfully constructed a balancing robot called Leg way using the LEGO Mind **storms** robotics kit. Two Electro-Optical Proximity Detector (EOPD) sensors is used to provide the tilt angle of the robot to the controller which is programmed in a C/C++ like programming language specifically for LEGO Mind storms [8].

2.6. According to "Louis Brennan" an Irish-Australian inventor, was one of the first to patent a gyroscopic stabilizing vehicle. In 1903, Brennan patented a gyroscopically balanced **monorail** system that he designed for military use; he successfully demonstrated the apparatus in 1909.By mounting one or more gyrostats (a modified gyroscope) along the body, the monorail balanced itself when its equilibrium was disturbed [9].

2.7. According to "L MARCHAL CRESPO"(2001)There is increasing interest **in** using robotic devices to help provide rehabilitation therapy following neurologic injuries such as stroke. The goal of robotic therapy control algorithms is to control robotic devices designed for rehabilitation exercise, so that the selected exercises to be performed and spinal cord injury [10].

2.8. According to "Chih-Han Yu"(2005) He showed that such a framework allows **several** different modular robotic systems to achieve self-adaptation tasks scably and robustly. examples tasks include module-formed table and bridge that adapt to constantly-perturbed environment, a 3D relief display that renders sophisticated objects, and a tetrahedral robot that performs adaptive locomotion[11].

2.9. According to "Koichi Nishiwaki"(2011) The adaptation strategy uses the actual center of mass motion and the contact status to the ground for changing the stepping length, the step cycle, and the landing edge. A compensation method for the effect of the multi body system is also presented, so that these discussions can be made applicable to the actual humanoid system[12].

2.10.According to "K MOKONOPI" (2006) A two wheeled balancing robot consists of a robot chassis and two wheels. As its name suggests, it has the ability of maintaining an upright "balanced" position which is referred to as its stability. It is unique compared to multi-wheeled or track robots because of this ability. It also has the capacity to turn on the spot making it far easier to man power. This makes the two wheeled balancing robot an ideal candidate for working in confined areas or in transportation applications[13].

2.11. According to "MP MILLER"(2008) The two wheel balancing robot is a very popular project in the fields of robotics and control engineering. Therefore is a lot of work that has been done and more work is still been done on balancing a two wheeled robot. The following section is a literature review on this particular topic. A literature review is part of a research project where a researcher researches on similar work to his or hers. This very important part of the research helps the researcher to find out how other researchers have tackled the problem he/she is attempting to solve. It gives insight on how to go about solving the problem at hand and provides information on available technologies and tools for solving the problem [14].

3. RESEARCH METHODOLOGY

To fulfill the purpose the following method will be used: Derive dynamical equations based on theory of the inverted pendulum Form transfer functions for the angle deviation, ψ and position, x • Find a controller that can control these two conditions • Set up requirements for the demonstrator • Design a demonstrator that fulfils these requirements, investigate the boundaries of the control signal Chosen error sources will be investigated: • Design a three dimensional model in CAD - Computer Aided Design that is as identical as possible to the physical demonstrator to acquire correct parameters needed for the simulated model. Investigate the accuracy of the sensor that delivers the angular data With an accurate model of the system and a functioning demonstrator this provides a platform for experiments in a simulated environment. The simulated model in comparison to the demonstrator will be validated by implementation of a PID-controller in both in order to compare impulse responses. [15].

4. ADVANTAGES, DISADVANTAGES AND APPLICATIONS

4.1. ADVANTAGES

4.1.1 Localizes the errors and facilitates in quick detection with minimum efforts.
4.1.2 reduces time travelling for foot distance.
4.1.3 zero emission machine.
4.1.4 requires less space for riding and parking

4.2. DISADVANTAGES

4.2.1 costly due to use of PID CONTROLLER
4.2.2 only skilled & trained person can operate

4.2 APPLICATIONS

4.3.1 used in rocket propulsion as inverted pendulum
4.3.2 used as vehicles by human

5. EXPECTED OUTCOMES

We came into this project expecting to build a two-wheeled robot that would balance itself with the help of an IMU. It took a good amount of work, and we encountered significant challenges, but we met our expectations and achieved our goal. After building the chassis, designing and testing the circuits, writing the software, and tuning the PID coefficients, we were able to successfully balance the robot on the two wheels, and even carry a load. But it is still not perfect - the few issues detailed above, including the minor wobble, the asymmetrical motor speeds, and the lack of encoders are small problems that can be fixed in a future update.

The key to completing this project was careful advance planning of every step we needed to make, and every material we need to buy. We spent what at first seemed like an excessive amount of time planning, but it all paid off in the end, because we were able to more effectively manage our time, and were more prepared for the problems we would encounter.[16]

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