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Self-Balancing Electronic Skate-Board

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***Abstract*—Powerful microcontrollers are used as parts most intelligent automated system. Integration of field of transportation with these intelligent devices will aid in development of new generation of transportation. With the use of efficient microcontrollers and sensitive sensors has helped a lot in achieving this milestone. These devices play a vital role in today's world, where the conventional means of transport keep depleting the nonrenewable resources and increases the population, taking steps towards the seize of existence of life. This paper implements the self-balancing mechanism onto a skate-board, that can be used as alternate mode of transport for short distance in day-to-day life. This implementation is based on the inverted pendulum concept to counter the disturbance in balance and involves PID controller algorithm for the smooth self-balancing of the system.**

I. INTRODUCTION

In the modern world, every aspect of life is automated through robotics and technology. The field of robotics has dominated the minds of people around the world. Two wheeled balancing robot is a classic engineering prob- lem based on inverted pendulum and is much like trying to balance a broom on the tip of your finger. This challenging robotics, electronics and controls problem is the basis of study for this paper. The basic idea for a two-wheeled dynamically robot is pretty simple: move the actuator in a direction to counter the direction of fall. In practice this requires two feedback sensors: a tilt angle sensor to measure the tilt of the robot with respect to gravity, an accelerometer to calibrate the gyro thus minimizing the drift and use of motors to balance and navigate the system.

The processing of all the raw values of sensors and counter- ing of the direction of fall is implemented with PID controller, which is a feedback controller, in a continuous loop giving the mechanism of balancing. The PID controller output is is used to drive the twin motor-system to achieve the balanced motion. In this paper, the above techniques are applied on to a skate- board to achieve a new generation of transportation, which is more flexible, portable and can be used in any kind of terrain.

II. PROBLEM STATEMENT

Todays conventional means of transports burns very high amount of non-renewable fuels with is unsustainable. It is also not suitable for short distance traveling as the fuel wastage rate is more in such cases. Power consumption in the above means is very high, not ecofriendly and becomes less economical on a long term basis.

When modern day electric driven transports are considered they are driven by motors that are powered in order of 3000W (Segway HT etc.) to 100 kW (in case of electric cars) which is also very huge, but gives low performance. When mobility, flexibility and portability is considered, it is very less due to bulkiness and limited terrain handling capabilities. Designs like Segway[11], hover board, walk car, cant be used only on flat terrains.

III. BLOCK DIAGRAM

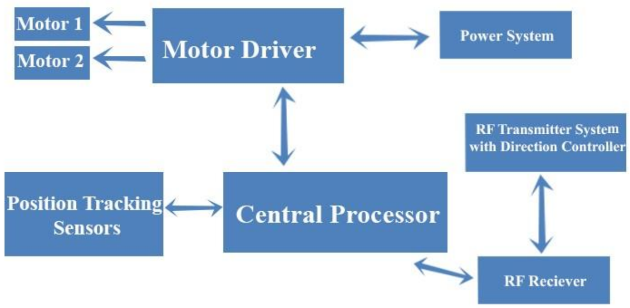

Fig. 1. System Block Diagram

IV. METHODOLOGY

Implementation of the design involves two major aspects; design of physical prototype which is suitable for the use in day to day life and design of softwares that runs the entire system.

A. Hardware Design

Hardware design involves building of a user friendly phys- ical device that can be used in day to day life with ease. This involves various procedures like development of a skate platform, followed by mounting or suitable threaded axle rod on which the wheels are mounted. Placements of all the electrical components is also taken care off.

B. Software Design

Software implementation involves the programing of the entire system. System operation logic can be explained with the help of a simple flow chart.

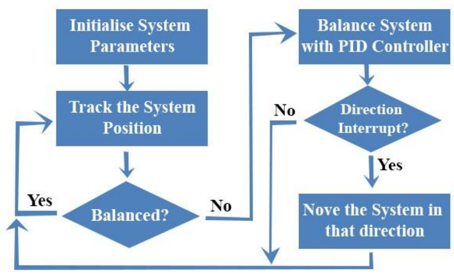

Fig. 2. System Flow Diagram

1) Flow Chart: All the parameters for the code such as MPU, PID co-efficients, baud rate, DMP, FIFO buffer are initialized. The offset reads for the MPU is obtained and then converted to angle values which is used to determine the system position and for balancing. IF the readings of MPU read X and Y values as 0,0 then it indicates that the system is balanced. Else the system tries to balance by rotating the wheels in that respective direction with the help of PID controller[7].

***2) PID Controller**:* A Proportional Integral Derivative controller (PID controller)[4] is a control loop feedback mecha- nism (controller) commonly used in industrial control systems. A PID controller continuously calculates an error value as the difference between a desired set point and a measured process variable. The controller attempts to minimize the error over time by adjustment of a control variable, such as the position of a control valve, a damper, or the power supplied to a heating element, to a new value determined by a weighted sum:

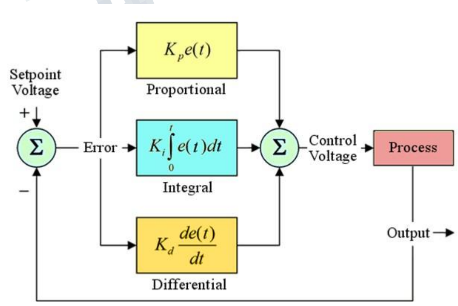

Fig. 3. PID Controller Equation

where KP, KI AND KD, all non-negative, denote the coefficients for the proportional, integral, and derivative gains for tuning respectively. "P" accounts for present values of the error. For example, if the error is large and positive, the control output will also be large and positive. "I" accounts for past values of the error. For example, if the current output is not sufficiently strong, error will accumulate over time, and the controller will respond by applying a stronger action. "D" accounts for possible future values of the error, based on its current rate of change[14].

V. WORKING

When the system is powered on, the system tries returns to the balanced position from its disturbed position, i.e. to a position where X and Y co-ordinates measured from the sensors will read 0,0. Once the raider tilts the board, either front or back, changing the system balance, indicated by new sensor values, the system tries to attain balanced position by applying force in that direction, by moving in that direction (as per the inverted pendulum concept), thus giving the movement of the board in that particular direction.

Joystick controller is used for left and right directional motion. Being analog depending on the joystick output value, speed of the rotation can be controlled. Opto-isolator, which basically consists of and LED on input side and a photo- transistor on the output side and it is used to isolate the reverse current surge from motors, which disrupts the sensor values to suddenly deviate to large values like -127, -127 or 127,127 and thereby damping of jerks is done to give a smooth movement of the skate-board.

VI. RESULTS

This paper was implemented in real time with a prototype and various testes were conducted and observed to match the estimated results.

A. Movement of the Skateboard

The skate which was initially in rest position was switched one, tried to attain the balanced positon and when a tilt was given on either side of the board, the skate-board as observed to move in that particular direction. When there was a direction control signal applied, it was observed to turn in that particular direction and continue is movement, satisfying the expected results.

B. Terrain Handling, Speed and Battery Test

The designed prototype was observed to handle almost any type of terrain with ease and the speed of the device was quite high of around 20km/hr. The battery on full charge gave a usage of around 25-30km on continuous usage and took an hour to recharge it back to 100

C. Stability Analysis

The device was observed to perform smoothly in most of the conditions, because of the use of an opto-isolator along with PID. There were some jerks observed still, which could be solved by using a combination of PID with control algorithms like LQR.

VII. APPLICATIONS

Serves as an eco-friendly and most suitable mode of trans- portation within short range. Opens gateway of innovation for design of self-balanced wheelchairs/vehicles for differently enabled people. This technology can be combined with the brain-wave technology or tongue-sensor technology for de- velopment of vehicles for paralyzed people, leading to ad- vancements in medical electronics field. The design is suitable for surveillance, within the campus, by replacing high power consuming Segway HT etc.,. It alsso Serves as foundation to development of self-balanced and drone vehicles which has limitless applications in day to day life or drones in military.

VIII. CONCLUSION

The design approach used by the above mentioned method-ology is most suitable for the short-distance traveling in and around a campus, which has been implemented as a prototype in real-time. The performance in terms of power and terrain handling is far superior than any of the earlier models. The speed, flexibility and portability of the design is better when compared some of the existing self-balance vehicles. The charging speed of the design is also less, while giving good driving current. In future this design could replace the conventional mode of transport system and put a break to the non-renewable petroleum fuel. This project opens gateways to many more researches that would benefit the differently enabled people to a great extent.

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