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A Review on Various Methods for Self Balancing

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Abstract - Bicycle Physical Dynamics have been studied by Scientists, Engineers and Mathematicians. Self Stability Balancing existence on controlling a moving Bicycle has not been extensively researched or achieved satisfactorily. For Transportation and recreation Bicycles have been a popular form over a century. This Paper, will Focused on various methods and algorithms to Self Balance Bicycle with various disturbances applied on it. Our findings will be related to any application involving the control of a two wheeled aligned vehicle. One such application could be a ”learning bike” that would offer supportive control for an inexperienced bicycle rider. Paper is based on development of self balancing two wheel bicycle by using various mechanisms and control algorithms for stability purpose. This Techniques will assist the future development of stability controllers for bicycles and will estimate the feasibility of a “learning bike” with regards to cost and safety issues.

Keyword - *Gyroscopic effect, Accelerometer, Self Stability concept, Wheeled Robot.*

1. Introduction

Bicycle can automatically balance itself by recovering from sideways disturbance at forward moving speed it also have bigger self stable speed range. We focused on historical observations and details about bicycle self stability from bicycle existence. For transportation, Bicycle is more popular form of recreation over a century. In past it have been extensively research by scientists, mathematicians and engineers alike. By using faster and smaller modern computers and reliable sensors made possible the effective and cheap control of dynamic systems.one best application is “learning bike”.some people suggest stability as self-stability and other the relieve with which a rider can maintain balance, either in hand on or in hand off bicycling where the rider influences steering only by bending of wheel. This Paper contents ability of assisted-stability bicycle to decrease the amount of supportive control as the rider becomes more skilled.

The dynamic environment with no direct feedback, output feedback controllers is given that successfully stabilize seesaw, bongoboard, and curved floor models using only global robot information along with optimization to derive robust output feedback controllers and compared their performance with similarly derived robust LQR controllers.[1] Various sensing technologies have been designed for automatic steering control by using the point of measurement of the vehicle lateral displacement by developing driver’s steering mechanism to a real-world challenging application.[2] The control of the posture of the robot is the most challenging issue in this design while achieving simultaneous stabilization of the central body, which can exhibit undamped oscillations due to the lack of friction.

It also discusses controllability and delivers an original control design for an MWP-class robot moving on an inclined plane.[3] For a spacecraft-mounted robotic arm, control-moment gyroscopes (CMGs) are proposed as actuators to reduce reaction forces and torques on the spacecraft base. for a CMG robotic system, kinematics and dynamics are established and numerical simulations are performed for a general CMG system with an added payload by using same power as used in robotic system.[4] For surface identification, a tactile probe designed in a context of all-terrain low-velocity mobile robotics. A small metallic rod called tactile probe with a single-axis accelerometer attached near its tip based on analyzing acceleration patterns.[5]

For the two-wheeled self-balancing autonomous robot, uniqueness of the inverted pendulum system has drawn interest from many researches and achieving its aims to balance a two-wheeled autonomous robot based on the inverted pendulum are considered by the capacity to balance on its two wheels and spin on the spot, many researches have been focused on it in recent decades [8], [6].This paper is successfully overcoming the current researches, As the robot is mechanically unstable, it is necessary to keep the system in equilibrium.[6] To measure the posture information Low cost MEMS accelerometer and gyro are selected. With a robust sliding mode controllers and novel data fusion method are adopted as controllers of two different motion modes in construction of a low cost coaxial self-balancing robot using MEMS sensors [7], [8]. In this paper, the servo state feedback control used in Balancing robot system Accelerometer as sensors to measure angle changes and then sends signals to the Servo motor for the stability.[8]

2. Related Work

2.1 Overview of the Literature

The survival of self-stability was distinguished many times since the dawn of the bicycle. However today, self-stability being widely exposed with a technical interest in bicycle handling. There are various general categories of research that pertain of this paper like research on dynamic model of the bicycle, self stability control approach, benefits, current research and experiment performed earlier.

2.2 Common Beliefs

The most explicit common beliefs concerning bicycle self stability are:

1) 1. Front wheel gyroscope:- The front wheel must have forward-rolling with gyroscopic precessional which causes when the bend over rate of falling to one side steering toward that side. We will call this the ‘gyroscopic’ or ‘gyro’ effect.
2) 2. Path for coupling preference to steering:- The front wheel must have positive path, so that falling to one side allow at least in the popular observation ground contact forces to effect steering to that side.
3) 3. Path for centering:- The front wheel must have positive path so that the wheel self align behind the steering axis.

2.3 What is New in this Review

Author [1] has derived Dynamic Balancing System for balancing that successfully stabilize seesaw, bongoboard, and curved floor models in unstable environment with output feedback controllers using only global robot information and with no direct feedback of the dynamic environment. For successfully stabilizing the models, the direct feedback of environment information is not essential considered in this paper. This paper also offered an optimization to derive robust output feedback controllers and compared their presentation with similarly original robust LQR controllers. The robust output feedback controllers have equivalent robustness to disturbances and considerably better robustness to modeling uncertainties, When compared with the robust LQR controllers with full state feedback.

Author [2] has designed an automatic steering controller for revenue service by discovering that driver’s steering rate is comparative to a specific vehicle angle error that provide high-gain corrections in vehicle dynamics and speeds. Driver’s steering mechanism is the first adaptation to a real-world challenging application which is transformed into an equivalent lookdown controller and exposed that drivers in result achieve a PID control with speed-dependent look-ahead distances and feedback gains. Implementation of simple linear steering rate control law, which is used to calculated desired steering angle instead of determine how fast the steering angle changes are needed based on the target angle error and move the hand wheel to enlarge or decrease the steering angle.

Author [3] work reported here delivers an original control design for an MWP-class robot affecting on an inclined plane and also discusses controllability. The control of the posture of the robot is the most challenging issue in this design while achieving simultaneous stabilization of the central body, due to the lack of friction undamped oscillations can exhibit. It is hence shown that deep close by into the internal dynamics of the system in combination with proper collection of its generalized coordinates and the system amount produced functions are critical in the creation of effective feedback controllers for non holonomic systems with underlying unstable zero-dynamics.

Author [4], For a control-moment gyroscopes (CMGs) robotic system, kinematics and dynamics are recognized also with the numerical simulations are perform for a general CMG system. For a spacecraft-mounted robotic arm, control-moment gyroscopes (CMGs) are planned as actuators to reduce reaction forces and torques on the spacecraft base with an added payload added payload's effects are examination on otherwise reactionless CMG systems motivates the assessment of probable operations concepts to diminish base reactions and power consumption. It show that base reactions can be significantly reduced, while using the same amount of power which is similar to that of robotic system driven by conventional joint motors with CMG actuation.

Author [5] describes a technique for surface identification using tactile probe designed in a context of all-terrain low-velocity mobile robotics. In this paper, with a single-axis accelerometer attached near tactile's tip probe is made of a small metallic rod. Surface identification is rooted in analyzing acceleration patterns induced at the tip of this automatically robust tactile probe, while it is passively dragged along a plane.

Author [6] has successfully describes the kinematics model on two wheeled self-balancing autonomous mobile robot on the inverted pendulum model. It analysis can be divided into two body and wheels. The velocity decompositions of robot wheel and body are analyzed respectively and by this method the left and right wheel kinematic model is recognized. The model is correct by ADAMS simulation analysis and validation.

Author [7] explained a low cost coaxial self-balancing robot with two wheels of which are placed coaxially for turning with zero-radius. For obtaining precise posture information, the shortcomings of low cost MEMS accelerometer and gyro which are selected as sensors can be overcome by this data fusion method even with oscillation and impact and also they are selected as sensors.To process the sensor data of accelerometer and gyro, a data fusion method is adopted and the drawback of accelerometer or gyro can be avoided individually simply by using data fusion method. The dynamical simulation using MATLAB Simulink and ADAMS and the physical experiments show that the sliding mode controllers are efficient and have good presentation.

Author [8] In this paper, Author uses the servo state feedback control for the self balancing robot. Using ADXL3xx accelerometer as sensors in Balancing robot system to control by measuring angle and angle changes and then sends signals to the Servo motor for robot can balance the stability respectively.

3. Proposed Method

Proposed system is mostly a wireless inhibited two wheel bicycle with inherent ability to balance itself while driving at scrupulous speed. To get this with machine knowledge stage and embedded system we are proposing the system. This proposed system expected to make a bicycle boot, powered by an electric motor, which could balance by itself and move along a various path. The main aim was to make the cycle balance on its individual by controlling its handle. Teaching a bicycle motivating is long time process and goes through structure information base for limitation decision making while balancing robots.

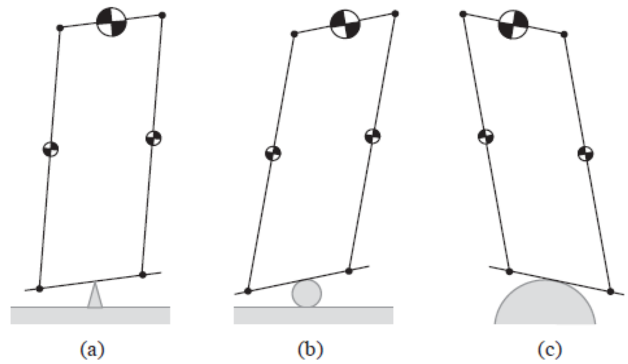

Fig. 1 Balancing in different dynamics, Unstable Environment

3.1 Balancing Proposed Technique

The robustness of the robust output feedback controllers presence and results that explain their robustness and gives stabilizing the nonlinear dynamics of bongoboard, seesaw, and curved floor models. Output feedback controllers used that successfully stabilize seesaw, bongoboard, and curved floor models using only global robot information and also with no direct feedback of the dynamic environment. Our main aim was to observe the relationships (i.e., differential equations) that explain the behaviour dynamics of drivers' steering with vehicle positions and angles, steering angle at hand wheel, vehicle speed, and yaw rate. Drivers are intense on the angle error between where the vehicle's direction and where they would like the vehicle to go.

Based on the locations where the steering rate starts to match the target angle errors, transition point is calculated here. The magnetic sensing technology is adopted by the automatic steering system in which magnetic field strength of magnetic markers installed under the roadway and the lane position is determined with speed controlled by the driver. For providing adequate stability margin to sustain higher gains, Control synthesis indicates that this driving mechanism has desirable zero locations with vehicle speed and time varying. The wheels having geometric centers of mass which coincide with the geometric centers of the spheres.

The wheels are denoted bodies 1 and 2, while the central body is body 3, This objective must be achieved for controllability simultaneously with the stabilization of the central body, in order to avoid unstable zero-dynamics. For achieving simultaneous stabilization of the central body challenging issue is the control of the posture of the robot which can exhibit undamped oscillations due to the lack of friction. Tactile probe used for identifying various surface properties which is cannot be possible directly by optical sensors. The posture information of the robot can also be controls by two DC motors through two motor drivers to provide self-balancing and locomotion. Robotics having mainly 3 sections mechanical systems, control systems and sensing systems and for autonomous self balancing robot robot is composed of a chassis carrying two dc servo motors which is used to balance a two-wheeled autonomous robot based on the inverted pendulum model.

Velocity decomposition is used control left and right wheel kinematic model and then self-balancing robot's body is calculated laid the foundation for self-control. The task of the servo state feedback control is to stabilize the self balancing robot. Since an integral is added to tract the output of the system without steady-state error. This requires the mobile robot platform can get the path tracking in its movement, and be able to guess its own position, direction, speed, acceleration, and then to determine a driving wheel torque according to the desired moving speed.

Fig. 2 Bicycle Balancing Technique

The inverted pendulum is in equilibrium state is the basic means of word balance which its location is like standing straight 90 degrees. For balancing the system it keeps falling off, away from the vertical axis by using a gyro chip to provide the angle location of the inverted pendulum or robot base and input into the microcontroller, which the program in itself is a balancing method. The major aim of the microcontroller is to combine the wheel encoder, accelerometer sensors and gyroscope to guess the approach of the stage and then to use this in order to drive the feedback wheel in the direction to maintain an standing and balanced position.

The essential idea for a two-wheeled dynamically balancing robot is appealing straight forward: By Moving actuator in the direction of fall in a direction to counter.A tilt or angle sensor used to measure the tilt of the robot with respect to an accelerometer to calibrate the gyro thus minimizing the drift and gravity this are the two requires feedback sensors. These are 1) the tilt angle and 2) its first derivative, the angle velocity are the two conditions are used to balance the robot. These two measurements are summed and fedback to the actuator which produces the counter torque necessary to balance the robot.

3.1.1Gyroscopic Effects

Gyroscopes can be a next "killer" application for the MEMS industry in the coming years mostly used in applications such as vehicle stability control, navigation assist, roll over detection are only used in high-end cars, where cost is not a major factor. 3D input devices, virtual reality, platform stability, robotics, camcorder stabilization, and more are some of the examples of consumer applications. For innovative design and development low-cost and high-performance gyroscopes based on the latest MEMS technologies are discussed. [7] A gyroscope that uses the principles of angular momentum is a device to maintain a prescribed orientation. It having wheel mounted on an axis when it rotation, it can turn freely in any direction it resists any change in the orientation of its spin axis. By comparision from earlier research gyroscopic effect is best used for Stability and controlling steering wheels. In gyroscope, If a torque is applied to the spin axis, it will turn in the direction of the torque, but as a replacement it move in a direction perpendicular to it known as precession. It is approximately universally accepted that gyroscopic effects due to the spin angular momentum of the front wheel are important for bicycle self-stability. In an effort to determine the authors' intentions, we look at their stability calculations and arguments. [4]

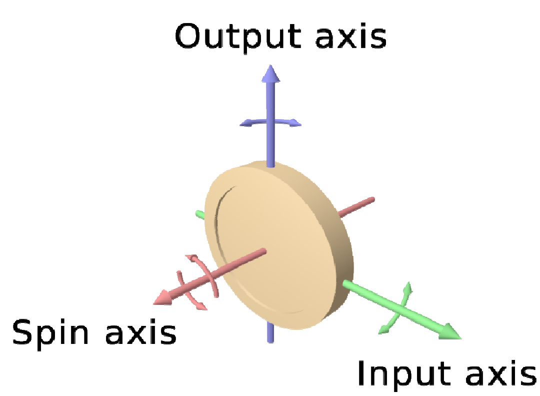

Fig . 3 Gyroscopic Flywheel

3.1.2 Positive Trail

A similar action of path/trail is less simple. To begin with, dissimilar gyroscopic behaviour, the essential mechanics of casters was never a popular concept for the general public. Also, trail is credited with two rather independent effects, one combination leaning to steering, and the other causing self-position of the steering. The thought that trail in a bicycle has a wheel-aligning role alike to that in a non-leaning cart.

3.1.3 Steer Axis Tilt

Steer-axis tilt and Trail are linked. If the form of the fork is set, rising the steer axis tilt also increases the path. With the steer axis tilted so as to fetch the handle bars close to the rider, The path would be too huge except it were compact by bending the fork forward, thus placing the wheel center ahead of the steering axis. We focused with proper steer axis tilt for a fixed trail, not for a fixed fork shape. Our understanding is that tilt of the steer axis was only rarely linked to self stability. An Accelerometer for state detection of the bicycle whether it is moving or stable or in a position of tilt i.e falling angle.[7] An electromechanical device accelerometer is used to to get the travelling motion and also measure acceleration forces like gravity force that is static in nature which pulling at your feet. Forces can also be dynamic which is generally produced by simply moving or vibrating the accelerometer and it is also maintain stability when bicycle is in turning motion.[8]

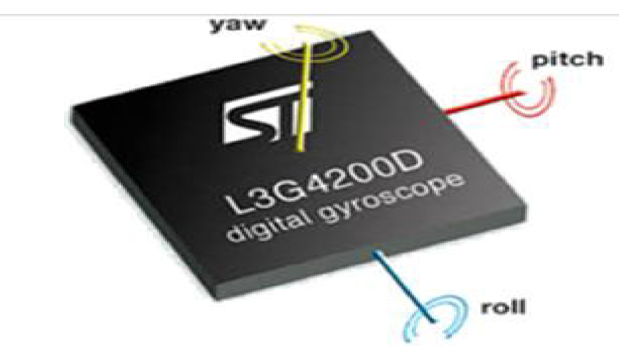

Fig. 4 Accelerometer

3.2 Control Approach

The Controllability for self balancing can be carried by various equations and methods like Linear equation of motion , Lagrange's function etc. Because of the multiple degrees of freedom, it is not easy to model the dynamics using classical Newton's force analysis of the robot. So, the Lagrange's function method is applied to dynamics modeling to keep away from complicated force analysis. The Lagrange's function is as follows:

$$L = E - V \tag{1}$$

Where E is the kinetic co-energy and
V is the potential energy.

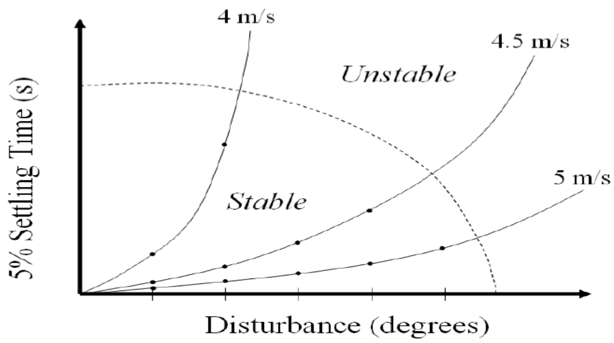

Fig. 5 Stability Plot

Critical design issue is came into light by investigation of these dynamic models. Stability is controlled either by commanding a steering torque or by commanding an absolute position (i.e. steer-angle) which creates many design implications on our bicycle, such as whether we need only mount a DC motor directly or a more complicated servo motor. Controllability can be achieve by considering torque to be the control variable. Applying a steering torque on bicycle would be a natural means of control with various dynamics and kinematics on bicycle. By considering the equations of motion may be manipulated to learn the property of either a steer-torque controller or a steer-angle controller to achieve a torque based on the roll angle of the bicycle via a steering torque is a sound approach for our stability controller.

5. Conclusion

As balancing two wheeled vehicles were always challenging task for controllability even for normal human being. In this paper, we could see the self-balancing techniques based on by maintaining the center of gravity ,done by controlling falling angle Balancing two wheeled vehicle needs lot practise and it is proper balanced between maintaining centres of gravity in motion by the way of developing different methods we are trying to provide self balancing ability to two wheeled vehicles by using various effects or with ground reaction forces on it with different possibilities and difficulties for stability in different path. This will let the researcher develop automated guided vehicle from two wheeler vehicle which could save not spaced for transportation. Also by solving problem with flexibility formation in various environments as well as guaranteeing the string stability which is generated by combination of various effects with collision avoidance of the robot in the formation.

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