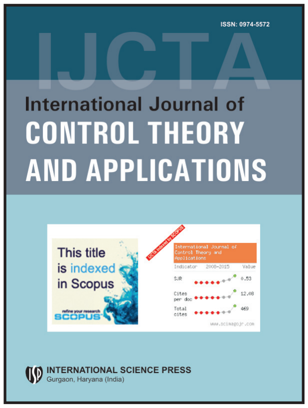

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Curvature Based 2 Wheels Self Supporting Robot Based on the Particle Swarm Optimization Algorithm

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Abstract: The balance of Double wheel self supporting robot is maintained by following the inverted pendulum concept. The PWM technique is adapted for controlling the DC motors which are connected to the robot wheels. In the existing robot models tilt sensor is used which makes them to move in a straight line only. Even with the connecting encoder tilt sensor does not reduced the error. The proposed method uses both Gyroscope and Accelerometer which are used to detect tilt angle & acceleration. As a result of this our robot will be able to move in curvilinear path. Any error from this sensor is overcome by coupling a kalman filter. By Using IOT and adopting port forwarding method multiple robots can be controlled. The application areas of this kind of robots are moving wheel chair, explosive detection and disposing and short range vehicles. Steady control and remit the overshoot amount were controlled by using particle swarm algorithm for based on LQR control model and also theoretically discussed.

Keywords: Dual wheeled self balancing robot (DWSBR), pulse width modulation (PWM), Inverted pendulum (IP), partial integral derivative (PID), Random competition clustering (RCC), Internet of things (IOT).

Robot Controller Board (RCB), Inverted pendulum (IP), Port forwarding on router (PFR), Internet protocol (IP), Microcontroller (MC), Probabilistic finite automata (PFA), Two wheeled mobile robot (TWMR).

1. INTRODUCTION

The two wheeled balancing robot belongs to an angular motion, multivariate & unstable essential motion control system. Robot is using different control theories & control approaches, finally gets more practical after math's theoretical significance. Device construction and design is simple, with constant movement, more efficiency and ability to adapt to different environmental conditions. Device has been used in wide applications like human traveling in domestic area and for security in government places. This paper proposes a dual wheel swarm robot which is a self balancing one. Figure 1 shows the self balancing wheel movement during its running time. The dual wheels are connected to two 440 RPM motor which is controlled by PWM signal generated from the controller board. For the self equilibrium of robot a dual – axis gyroscope and an accelerometer are used. For confining of motor the kalman filter data is used as feedback for the PID controller for self supporting the robot. Earlier only PD controllers were used which did not produce efficient results. Now we are using fuzzy logic PD controller which has a better control over the robot balancing and movement. This is done by utilizing the values obtained from the sensors as a feedback and providing exact values to the controller board. An information goes to internet through virtual port which means a virtual path sending a data to an another IP address from an another system.

When we need information from internet a request is made by us to the web then it will response with the help of router. The router only knows from which system the request was made. If one gives request to a port for forwarding, the request does not reach directly internet, but it reach router then after getting repose from request. It consists of many ports depending upon application of desired categories.

The condition of Equilibrium model of the two wheeled self supporting robot

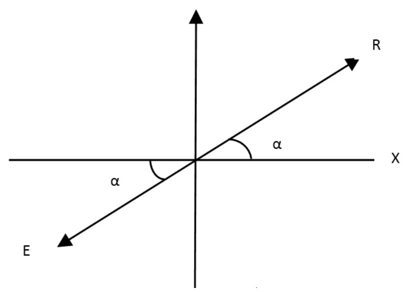

Figure 1: Equilibrium model graph of robot
E = Equilibrant, R = Resultant

Resultant force of the force system is R with direction α with Horizontal. The particle may starts moving in the direction of reultant force. If we apply an additional force like some resultant force on the same line of action but in opposite direction. The particle will be arrested or the particle is said to be in equilibrium. Equilibrant (E), is equal to the resultant force (R) in magnitude and direction, colinear but opposite in nature condition of force system resultant is zero.

2. LITERATURE REVIEW

In control engineering the pendulum inversion is a major problem. Bulter and Bright use this inverted pendulum principle for a robot design [1]. This paper deals with the effect of different weights on the step response for the balancing robot and manufacture a system for all environment. This system designed based on the adaptive control techniques and the four states of the varying weight characteristics. A paper by Brentari et. al., [2] presents as an affordable cost inverted pendulum balancing robot, because robot was made by less cost electronic components and motor used. Wheel pitch angle of inner and outer loops side is adjusting by speed and velocity of movement of that time. Here occurs displacement error. It is controlling maximum pitch angle can be adjusted by the three saturation based control laws. It is selling minimum cost only compare than others. A fast motion control technique of inverted pendulum robots is used by Hatakeyama and A. Shimada [3]. It is self-control system to simulate and controller design for many pendulums has been a challenge for long. . Hatakeyama and A. Shimada had insisted opposite the basic. Balance was broking during the moving time. Controller was designing by using zero dynamics. It derived by partial feedback linearization. Main aim of this controller controlled tilt angle of it. Here introduce nonlinear control methods by finding curve and including revolving motion.

In Li's paper a two wheeled auto balancing vehicle is designed using the kalman filter and angle fusion [4]. Accelerometer (ADXL335), control chip(STM32) and gyroscope are used as attitude sensing system. Along with this a digital PID control algorithm is used to adjust the PWM output which in turn controls the motor speed to change the motion state of the vehicle. From this analysis the working of attitude sensor, kalman filter algorithm and PID control algorithm are studied. It is observed that during the movement process and gyroscope drift the accelerometer output is not stable. So in order to make up for the shortcomings of each other there is a need a point of fusion which is found out using kalman filter.

Robot unstable condition was determine by using a novel control method, during movement time wheels unbalance is going to control automatically is proposed by L cui et. al., [5]. It is controlled by using two types they are svc approach for high level and partial derivative controller for low level to control motor velocity.

The paper by Kwon, Kim and Yu proposes a new Tilting methods equilibrium robot which examined stability [6]. By the addition of tilting mechanism this robot can also generate roll and vertical motion along with other conventional two wheeled inverted pendulum mechanism. Advantage of body separation tilting over the single body tilting in power consumption is found out from the static force analysis. In the dynamic modeling, using Kane's method the non linear equation of motion is derived and the tilting equilibrium platform is imagined as a dimensional inverted pendulum moving with bottom. Using a velocity and other parameters' control loop the tilt angle reference is generated naturally with based on centrifugal force variation which follows a circular motion path.

The objective of the paper by Vicmudo et. al., is to plan the path for swarm robots proceed on genetic algorithm [7]. Position of pre-defined object will be determined by the Swarm robots and uncircuitous way to reach the desired object without any problems will be generated by genetic algorithm. The simulation results prove that the proposed algorithm is capable of planning a safe collision free paths and the optimum path will be obtained while using more population. The paper by Sexena proposes a control strategy to find the optimal path to an object using swarm robots [8]. The entire system is based on master slave concept and wireless communication is the basic concept for swarm robots coordination. Based on the phenomena of light that always travels in a straight line the shortest path for the object is found out.

Goss et. al., present low argentine find shortest path between points or food source and nest[9]. Argentine ant has only limited individual capacity for orientation, yet by interacting with each other via their trail pheromar, minimum path way are going to select between food and nest. This uses monte-corlo simulation methods to arrive at the shortest path. Ants were founded minimum path way and interactions among ants. Masking in both the experiments are carried out under red light (dark) to ants were insensitive and the outputs are similar to that obtained in presence of light.

In their paper Schedler et. al., discuss the decision communication between swarm robots [10]. The method uses self organized decision making where each robot makes its own decision for the work and sends the decision to other robots. Similarly all robots communicate with each other and share the decision of one and other, after analyzing all the decisions by manto-carlo method through positive feedback simulation technique. By this the decision making speed of the robot increases with increase in operating speed. Due to this the execution of the work by the robot increases.

Non linear nature of the system and its instability were controlled by fuzzy control model for two wheeled self balancing robot. Wu, W.Zhang,Y.Qin,Y.Liu,X.Zang and J.Liu were discussed practically and given more information about Fuzzy control model.[11,12] We are going to design structure for two wheeled robot, it is difficult to balance itself because weight. To overcome its effeteness and correctness of system by using LQR method. The system structure model was establishing by using LQR controller. Its more complex to conclusive weighted matrix R and Q [13,14,15] Its Problem, pendulum stability was not controlled. System is getting Good control effect for applied genetic algorithm to LQR controller of the inverted pendulum system [16]

3. METHODOLOGY

From Figure 4, it can be seen that the proposed system consists of two 440 RPM DC motors, two wheels, 3-axis accelerometer, gyroscope, controller board, chassis and bar. Two wheels were operated by DC motors. These two wheels are interconnected by using bar. The MMA7341L 3-axis accelerometer is used to measure the acceleration in a predefined axis. Robot tilt angle was not only measured and also corrected by using tilt sensor line(3 axis accelerometer) accelerometer is fixing top of the robot. It is used to measure static accelerations with respect to earth gravity force. It is angle range for 90 degree and also hold the tilt angle values Robot wheels revole is measuring for gyrosensors and also whih it is rotating fast. Gyrosensors not only is measuring wheel rotation and also how much wheel rotating for moving time of robot fast. Gyroscope measured fastly and accuracy of wheel rotation compares then accelerometer. The robot chassis is made up of plastic. Two 440 RPM motors are used and for balancing the robot the accelerometer and a dual-axis gyroscope is used. To control two motors PID controller is implemented .The Kalman filter is used for fusion of data of accelerometer and gyroscopes. For controlling of motor the Kalman filter data is kept as feedback for the PID controller of the self supporting robot. By keeping the baud rate to maximum of 115200bps the problem of Kalman filter multi data transmission during the same iteration is solved. The robot has been tested under different environmental conditions. Using the two wheeled balancing robot, two algorithms are compared. The two algorithms are the proportional derivative controller and servo state feedback controller. Figure 4 is the screenshot for two wheel balancing robot controlled by system keyboard through internet. It is interconnected between internet and robot hardware components.

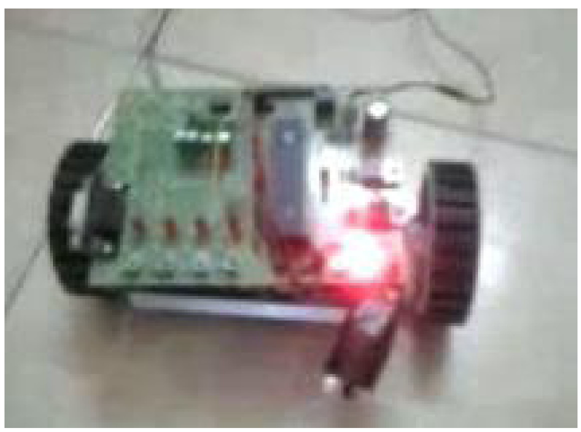

Figure 2: Dual wheeled robot with controller

$$R = \sqrt{\left(\sum H\right)^2 + \left(\sum V\right)^2}$$

$\sum H$ and $\sum V$ are to be Zero for equilibrium condition.

$\sum H$ is algebraic sum of Horizantal forces

$\sum H = 0$ indicates that (← sum of left hand side = sum of right hand side →)

$\sum V$ is algebraic sum of Vertical forces

$\sum V = 0$ indicates that (↓ sum of upward force = sum of downward force ↓)

condition of quilibirium action and reaction are equal colinear, but acting opposite direction.

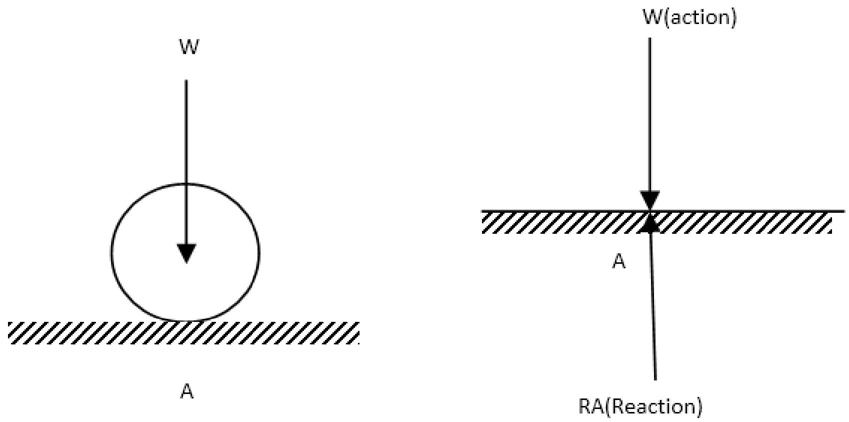

Figure 3: Condition of equilibrium, action and reaction are equal

Impulse-momentum equation it is also derived from the Newton's second law when a large force acts for a short period of time those forces is called an impulse force. It is denoted by the simple I.

$$\mathrm{I} = \int_{t1}^{t2} \mathrm{F}\,dt \text{ ; linear impulse = Force} \times \text{time}$$

It was falled by moving curved path, so avoid this problem ,here introduce angular motion impulse force

$$\mathrm{I} = \int_{t1}^{t2} \mathrm{M}\,dt$$

Impulse momentum equation is also derived from the Newton's second law,

$$\mathrm{F} = ma$$

$$= m \,.\, \frac{dv}{dt}$$

$$\mathrm{F}\ dt = m\ dv$$

$$\int \mathrm{F}\,dt = \int m\,dv$$

Let the intial velocity of the body is "L1" and it changes to final velocity "V" after a time interval from $t1$ to $t2$.

$$\int_{t1}^{t2} \mathrm{F}\,dt = \int m\,dv$$

$$\int_{t1}^{t2} \mathrm{F}\,dt = m\ v_u^v = m(v-u) = mv - mu$$

M$(v - u)$ is called change of momentum

$$\text{Impulse} = m(v-u)$$

$$\text{Impulse} = \frac{w}{g}\ (v-u)$$

In Figure 1 Equilibrium model graph of robot wheeling. The self-balancing robot was designed and built by using the pic- microcontroller, dc motors, IR sensor and some basic electronic components to get the job done. Microcontroller is used to digitally control engine systems. It has capacity to regain functionality when its hold on for an event such as a button press or other obstruct.

It contains a processor core, memory, and programmable input/output peripherals. The IR sensor is used to measure the distance between the floor and the sensor. Here we have two sensors one at front and one at back, when both sensors have same distance value the dc motor will be in balance position. To rotate the motor in forward direction back sensor should have lesser value compare to front sensor. Similarly, when we want to rotate the motor backward direction front sensor should have lesser value compare to back sensor. When the motor rotates in forward direction the system will be moving at front. Likewise, when the motor rotates in backward direction the system will be moving at back side. Normally motors are operating clock 72 MHZ. so, motor speed is

$$V = ((f)/(\text{fre} + 1)(T + 1)).$$

fre = prescalar value, which is set by TIM_prescalar

T = Count cycle, which is set by TIM period.

f = default timer clock freq.

Above mentioned program is used to control the robot wheels. These robot wheels are controlled by Sensors and accelerometer of feedback signal using Kalman filter.

4. CONCLUSION

The self balancing and movement control of dual wheeled swarm robot by using inverted pendulum concept is successfully carried out. All the obstacles which were present in the moving path were successfully avoided by the usage of camera which was installed in the robot. All the dynamic activities of this robots including the curved path movement were perfectly controlled by the gyroscope and accelerometer.

REFFERENCES

[1] L. J. Butler and P. G. Bright, “Feedback Control of a Self-balancing Materials Handling Robot,” No. December, pp. 17–20, 2008.

[2] M. Brentari, A. Zambotti, L. Zaccarian, P. Bosetti, and F. Biral, “Position and speed control of a low-cost two-wheeled , self-balancing inverted pendulum vehicle,” No. bodies 2, pp. 347–352, 2015.

[3] N. Hatakeyama and A. Shimada, “Movement Control using Zero Dynamics of Two-wheeled Inverted Pendulum Robot,” pp. 38–43, 2008.

[4] S. Li, Application, “Design and Realization of Two-wheeled Auto-balancing Vehicle,” pp. 36–38, 2015.

[5] L. Cui, Y. Ou, J. Xin, D. Dai, and X. Gao, “Control of a Two-Wheeled Self-Balancing Robot with Support Vector Regression Method.”.

[6] S. Kwon, S. Kim, and J. Yu, “Tilting-Type Balancing Mobile Robot Platform for Enhancing Lateral Stability,” Vol. 20, No. 3, pp. 1470–1481, 2015.

[7] M.P. Vicmudo, E.P. Dadios, and R.R.P. Vicerra, “Path Planning of Underwater Swarm Robots using Genetic Algorithm,” No. November 2013, pp. 14–18, 2014.

[8] A. Saxena, “Collective Collaboration for Optimal Path,” pp. 309–312, 2014.

[9] S. Goss, S. Aron, J.L. Deneubourg and J.M. pasteds. “Self-organized shortcuts in the argentine Ant” may 9 september 11, 1989. Pages: 579-581.

[10] Alexander scheidler, Arne brutschy, Eliseo ferrante, and Marco dorigo, fellow, IEEE “The K-Unanimity rule for self-organized Decision-Making in Swarms of Robots” future issue of the journal 2015 IEEE, pages:2168-2267.

[11] J. WU and W. Zhang, “Design of fuzzy logic controller for two-wheeled self-balancing robot” in proceeding of the 6th international forum on strategic technology (IFOST’11), PP.1266-1270, August 2011.

[12] Y. Qin, Y. Liu, X. Zang, and J. Liu, “balance control of two-wheeled self balancing mobile robot based on TS fuzzy model in proceeding of the 6th international forum on strategic technology (IFOST’11), PP.406-409, August 2011.

[13] X. Ruan, J. Liu, H. Di, and X. Li, Design and LQ control of a two wheeled self balancing robot”, in proceedings of the 27th Chinese control conference (CCC’08), PP. 275-279, July 2008.

[14] J. zhao and X. Ruan, “The LQR control and design of dual-wheel upright self-balancing robot”, in proceedings of the 7th world congress on intelligent control and automation(WCICA.08), PP.4859, June 2008.

[15] L. Qiang, K.K. Wang, and G.S. Wang, “Research of LQR controller based on two-wheeled self-balancing robot” in proceedings of the Chinese control and decision conference (CCDC’09), pp. 2343-2348, June 2009.

[16] Y. Li, C. Yue, and M. Wang, “The inverted pendulum system based on genetic algorithm of multi-stage control research”, journal of north china University of technology, PP. 19-24, 2009.