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# Implementation of a Two-Wheel Self - Balancing Robot Based on Inverted Pendulum Concept Using Node MCU

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**ABSTRACT:** This paper presents a two-wheel self-balancing (TWSB) robot implementation using node MCU. To demonstrate balancing an unstable robotic platform on two wheels,acceleration is provided to the wheels according to its inclination from the vertical axis. Balancing is a big challenge in TWSB robot, so inverted pendulum concept is used for balancing the robot always at 90̊ (degree) body position. This Robot balances itself by using two wheels, in which it moves with high speed when compared to four-wheel robot. By using the sets of results obtained from the sensors, we can solve the problem of the inverted pendulum and therefore the robot can be kept in the upright position without falling down.

**KEYWORDS**:An unstable robotic platform on two wheels, inverted pendulum concept is used for balancing, with high speed when compared to four wheel.

## I. INTRODUCTION

This world's almost robotics fields are most developing around the world.Such a machine why using for this generation.The humans can't finish a difficult works all,robots are completed the difficult works during easily. The dream of a humantobe creating such a machine that replicates them in every aspect of daily environmentlifeactivities. Such a machine that reflects their thoughts, expressions, attitude and perform the daily life activities. Improvement in this field for a last couple of decades has changed dreams into reality. With the use of efficient microcontrollers and sensitive sensors has helped a more in achieving this machine. Now robots can be seen in our daily life environment. Robots are worked on production field in factories, appeared as intelligent machines to do a specific and difficult task or used as commercial products.

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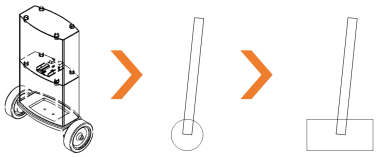

**Fig 1. Balancing of TWSB robot**

Two wheelSelf Balancing (TWSB) robotics also a development in the robotics field. This TWSB robot is actually based on the concept of Inverted pendulum theory. This type of robot has gained fame, interest and support among researchers and engineers because it utilizes such a control system that is used to stabilize an unstable system using efficient microcontrollers and sensors. Two-wheeled balancing robots can be used in lot of applications with different lines such as agricultural fields of intelligent gardener, an automatic trolley in hospitals, shopping malls, hotels, airports, healthcare applications or an intelligent robot to guide for blind or disable people. These types of robots can produce the expected result work in non-uniform surfaces due to their balanced control system. Self-Balancing Robot the aim of our project is to design and implement a TWSB robot that would bring many attributes and aspects of robots in it. A suitable microcontroller for stabilizing the robot is implemented. Two type of sensors be used to provide tilt information and encoders with motors are used to measure wheel's rotation.A statement ofbeforehand that a self-balancing robot is based on inverted pendulum concept theory. AInverted Pendulum is anthesaurus unstable system. Force must be properly applied to keep the system intact. To achieve this, proper control theory is required. An inverted pendulum theory is a pendulum which has itscentre mass above its pivot point

## II. TWO WHEEL SELF-BALANCING ROBOT

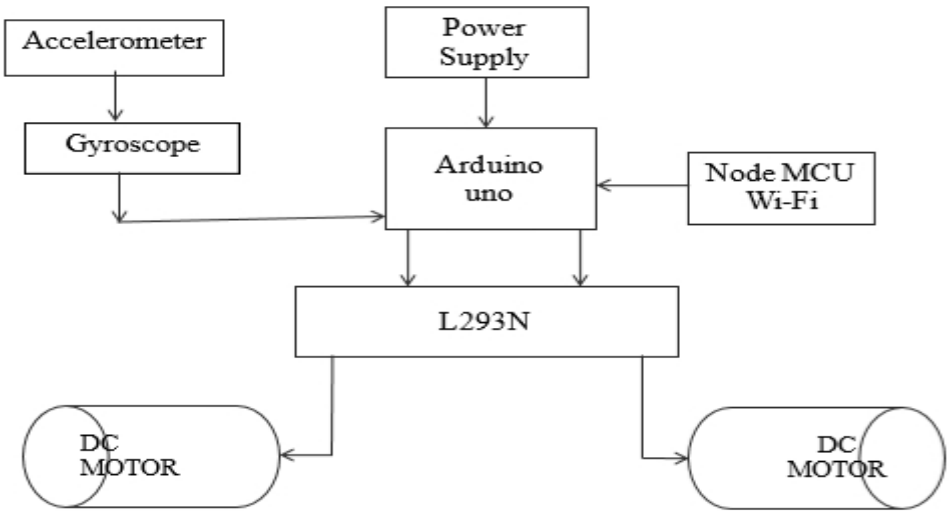


**Fig:2 Block Diagram of proposed system**

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A two combination of gyroscope and accelerometer is require to sense angle position and direction axis of the robot and input into the microcontroller, which implements the balancing procedure to Self-Balancing Robot stabilize the robot. The microcontroller will then provide a type of feedback signal to the H-bridge circuit to turn the motor clockwise or anticlockwise. If tilt is in forward direction, wheels are moved in forward direction and vice versa, thus balancing the robot. Motors can encoded are used to measure the wheel's rotation. After frequency to voltage converter is used to transform frequency of motor into voltage for react. The D flip-flop circuit is also used to measure the direction of wheels either clockwise or anti-clockwise. The outputs of the both D-flip flop and H-bridge circuits are fed to microcontroller for processing and computing.

## III.INVERTED PENDULUM

A rearranged pendulum is a pendulum that idea is focus of mass over its turn point. It is shaky and without extra help will fall over. It tends to be suspended steadily in this reversed position by utilizing a control framework to screen the edge of the shaft and move the rotate point on a level plane back under the focal point of mass when it begins to fall once again, keeping it adjusted. The rearranged pendulum is a great issue in elements and control hypothesis and is utilized as a benchmark for testing control systems.

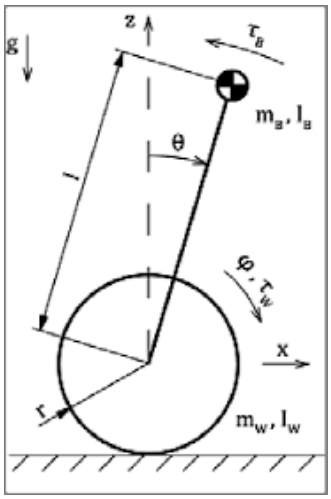


**fig:3 Inverted pendulum**

Usually executed with the turn point mounted on a truck that can move on a level plane leveled out of an electronic servo framework as appeared in the photograph; this is known as a truck and shaft apparatus. Most applications limit the pendulum to 1 level of opportunity by fastening the post to a hub of revolution. Though a typical pendulum is steady when hanging downwards, a rearranged pendulum is inalienably precarious, and must be effectively adjusted so as to stay upstanding.

## IV. SYSTEM DESCRIPTION OF TWSB ROBOT

The rotational axis between two wheels driven by two same motors is on the same horizon for TWSBR. The center of gravity is on the body which can rotate freely around the rotational axis. The body will incline to fall forward or backward without any external force. The right-angle coordinate of TWSBR is built as follows: the central point of the rotational axis between two wheels is selected as an original point. The forward direction of the body is the positive direction of X-axis,

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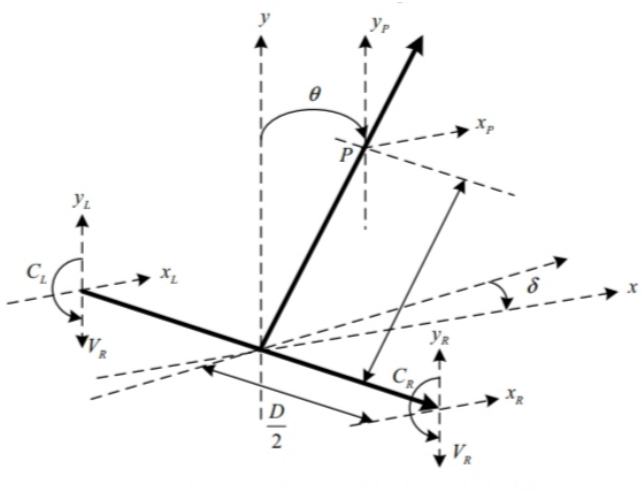


**Fig:4 Coordinate axis of TWSB robot system**

which is vertical against ground. Upward is the positive direction of Y-axis, and the direction of rotational axis between two wheels is as positive direction of Z-axis, satisfied the right-hand principle. The coordinate of TWSBR is shown, where three free degrees are go-ahead along X-axis, rotating around Y-axis and turning round Z-axis.

## V. SELF BALANCING CONTROL SYSTEM

### A. Q-Learning

Fortification learning is a sort of AI that decides the activity inside a particular situation so as to amplify a reward. One of the qualities of fortification learning is that the specialist can just get a reward subsequent to playing out the activity, and hence should keep on collaborating with the earth so as to decide the ideal approach through experimentation. Figure. demonstrates the operator condition communication in support learning. The "operator" and "the earth" are the two fundamental components inside support learning. The student that is in charge of basic leadership is characterized as the "specialist", though all that it collaborates with is alluded to as "nature". The learning procedure includes nature displaying the present circumstance or state to the operator, to which the specialist will choose an appropriate activity. The earth will at that point react with the new state and a reward esteem dependent on the move made.

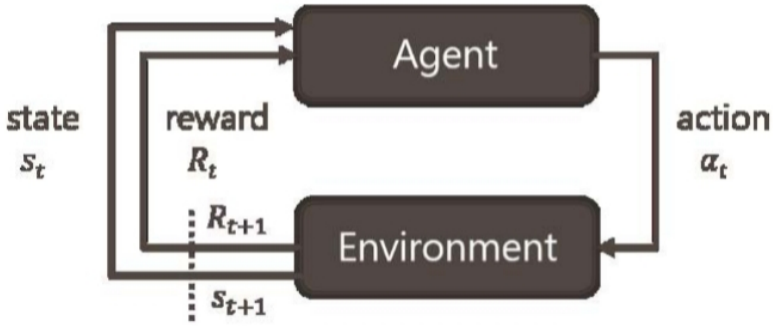


**Fig:5 Reinforcement Learning Structure**

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This activity esteem is then used to decide the long haul viability of the approach. The refreshing strategy utilizes the limit of the accompanying activity incentive to refresh the past esteem work utilizing the accompanying equation:

$$Q(s_t, a_t) = (1-\alpha)Q(s_t, a_t) + \alpha[R_t + \gamma\, maxQ(s_{t+1}, a_{t+1}')]$$

**B.Two wheeled and self-balancing robot principle**

The two-wheeled adjusting robot to spoke to as a basic upset pendulum. Where high is l and quality is m; it is put on the wheel which can move around, on the off chance that we need to make the robot like a settled altered pendulum in the vertical position through the control, there are just two different ways: First is alter the course of gravity, and the second is expanding the extra worry to make the reestablishing power and dislodging the other way. The straightforward technique is a second way, since make a course of gravity need any intricate device to utilize. Fig. 1 demonstrates the power in two haggled adjusting robot. The wheel at the base of the modified pendulum is controlled to influence it to do the quickened movement.

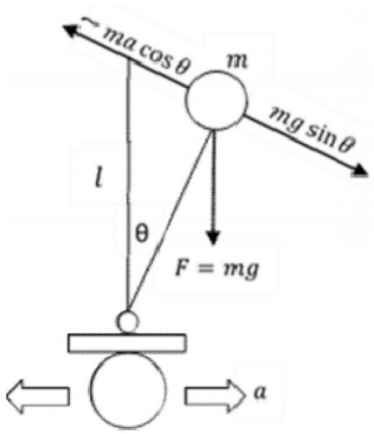


**Fig:6Two wheel self-balancing robot motion analysis**

BasedontheFig.1and focused in the inverted pendulum, that can show the additional force (inertia force); the direction of this force is opposite to the acceleration of the wheel, and the size is in proportion to it. The restoring force which the inverted pendulum receives is:

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$$F = m\ g\ \sin\theta\ ma \approx mg\ \theta - mk_1\ \theta \qquad (1)$$

Suspicions equation expresses that the increasing speed is corresponding to the avoidance control haggle proportion of k1, in the event that k1 > g (gravitational quickening), at that point the course inverse to the power to balance out the development. To balance out the pendulum the other way in a vertical position it might conceivable, additionally need help drive that is corresponding to the diversion sped damping with the heading inverse. In this manner Equation (1) can be changed into:

$$F = mg\ \theta\ ma - mk_1\ \theta - mk_2\ \theta \qquad (2)$$

Therefore, the control algorithm of the wheel acceleration of the two-wheeled self-balancing robotis[1]:

$$a = k_1\ \theta - k_2\theta \qquad (3)$$

At that point the position edge θ, speed, and precise velocityΔθ are utilized as the reference, fuzzy yield from fuzzy rationale thinking at that point enhanced with PID controller utilizing auto tuning parameter

## VI. CONCLUSION

Thus the we are going to develop a self-Balancing Robot in which Inverted Pendulum Concept is deployed and by using various sensors the Robot performance and speed will be high.

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