Middle-East Journal of Scientific Research 25 (4): 827-831, 2017
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2017.827.831

Two Wheels Self Supporting Balancing Swarm Robots Was Balanced and Controlled by Using Inverted Pendulum and IOT

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Abstract: This paper proposes that many robots to be operated simultaneously with balance. The Two wheels self supporting balancing Robots are balanced by using inverted pendulum principle. It is stabilized by microcontroller. Tilt error are being suppressed by sensors and wheel rotation is being measured by encoders with DC motors. Main aim of the paper is that many robots are to be operated through Internet by using port forwarding model, which communicate by simulating router with IOT. Swarm robots are used in defense for boarder security. Gyroscope and Accelerometer are used to measure tilt angle and acceleration of robot. These signals are corrupted with noise. Gyroscope drift is removed by accelerometer through the kalman filter. Each robot is can bale to control itself by using decisions making algorithms. These robots are operated by human for manual or operated automatically with respect to controlling program.

Key words: Dual wheeled self balancing robot (DWSBR) · Internet protocol l (IP) · Inverted pendulum (IP) · Microcontroller (MC) · Probabilistic finite automata (PFA) · Two wheeled mobile robot (TWMR)

INTRODUCTION

The researchers' minds have been dominated by the Area of robotics since past twenty years. Robots were found by human to be adopted for doing daily activities of humans. It was dreaming of humans to control the robots' gestures, postures and the day to day activities of human life. Researchers' dreams are realized now, as human actions are converted into information and stored in robot. They are then simulated for reality. This milestone is achieved by the help of latest sensitive sensors and efficient controllers. It is employed on production line in factories, where specific task is carried out by some intelligent machine during commercial production. Now we are going to discuss about field of 2 wheel robot. These can be balanced by using sensors and accelerometer. It can be used in different places such as hospitals, hotels, companies and in social service. The DWSB robot is balanced using inverted pendulum theory. It is generally very difficult to achieve balance of robot. This problem is reduced by applying external force using sensors and accelerometer. Feedback signal is given to microcontroller for motor rotation. From the Figure. 1 shows the balancing movement using inverted pendulum concept.

Normally balancing is complicated for any system, when all the system is not in stable condition. It moves in forward and backward directions. Here DWSB robot is implemented by connecting two wheels with motors. It is very difficult to balance both wheels simultaneously. So to solve these problem sensors are used to make robot to be kept in 90 degree upright position always. The robot wheel is attached to motor. DC motors get power from controller board. To reduce this problem accelerometer and gyroscope are used. These are used to sense the tilt angle position and the distance travelled in horizontal plane. This information is given as feedback to controller. Finally DWSB robot is balanced and controlled. Figures 2 and 3 show how Robot position is balanced. introduction of the manuscript is supposed to explain the nature of the problem, previous work, purpose and the contribution of the manuscript. The contents of each section may be provided to understand easily about the manuscript.

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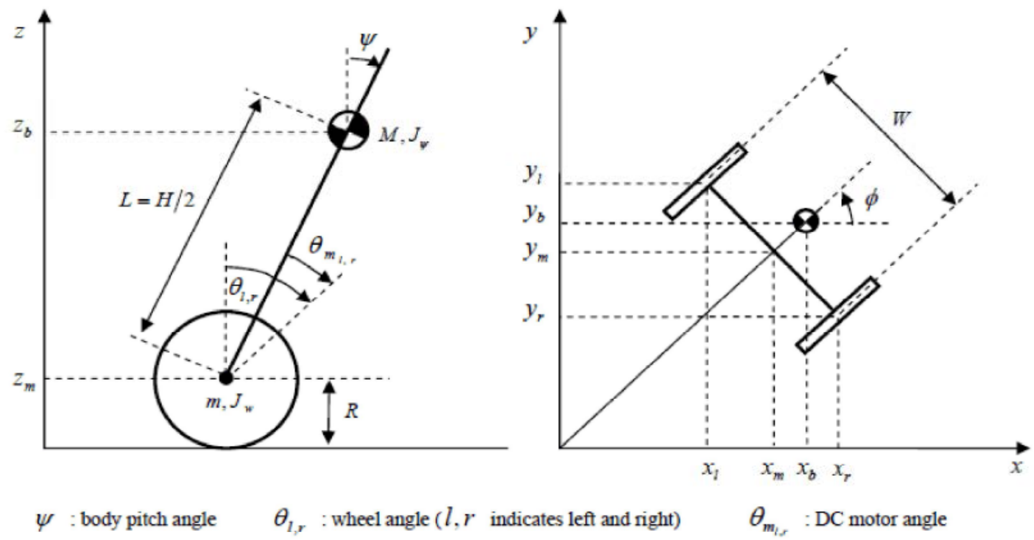

Fig. 1: Inverted Pendulum concept

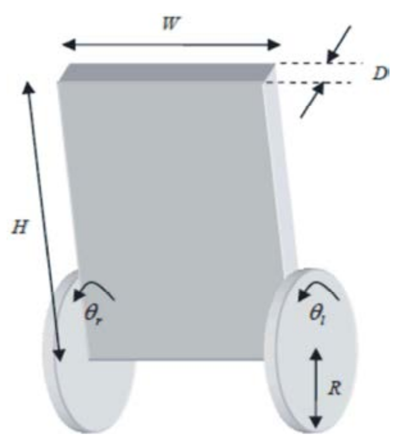

Fig. 2: Dual wheeled inverted pendulum balance

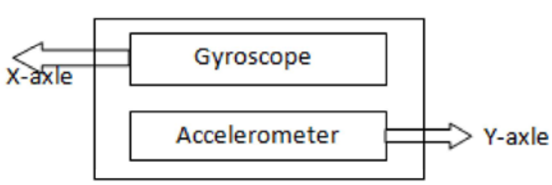

Fig. 3: Combination of Accelerometer and Gyroscope

Literature Review: Allouche *et al* explain the stabilization of TWMR during the time of step crossing [1]. TWMR stabilization was controlled by LMIs and it was derived from normal Lyapunov. Here two different approaches were applied to control robot like state space representation and mechanical modeling with time varying inertia. Finally it was controlled by TS based controller.

Azizan *et al*, in their paper show that the segway robot is controlled by human rider with steering bar using fuzzy model [2]. Linear system was controlled by TS fuzzy model and nonlinearities control the robot using state space representation and mechanical modeling with time varying inertia. TWMR has combination of mechanical systems and is controlled by TS controlled direct controller. But linear and nonlinear gains were verified by LMI model system. User viewpoint only provides interface between human body and vehicle.

In the paper by Borne *et al* the group of robots is combined and the work of large structures is completed [3]. A large structure was divided into many small structures and also many small robots were fixed at regular intervals. Each robot data communicated from locally fused relative pose by using camera and laser. It gives some advantage of cost, size and scalability.

Dwyer *et al.* explain the operation made by miniaturized robot which uses Transanal Endoscopic Microsurgery (TEM) that utilizes a natural orifice approach rather than open approach [4]. TEM based robot consists of Endomicroscopy and Ultrasound, which provides high resolution images on surface level and depth resolved information at macroscopic level. Robot is allowed three dimensional reconstructions by endoscopic view from ultrasound data.

The paper by Ren and Ruan informs about the TWSB mobile robot performance by using Skinners operant conditioning of movement balance skills like a animal or human being and self organization by improving gradually

[5]. Simulation has verified disturbance or non disturbance conditions. Robustness, self learning and self balanced control were by Skinners operation based on neural network.

Jia - Ziong explains the control by adaptive Kalman filter and also two sensors [6]. When normal Kalman filter was used, it faced a lot of problems. To overcome these problems, there two sensors are connected. They are Gyro and Accelerometer sensors. Their signals are given to an adaptive Kalman filter, where errors are corrected and robot has achieved stable position, better performance with the least cost.

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In their paper, Jing *et al* notify that micro robot was working based on wireless communication [7]. It was made by magnetic thin film with 2 operating modes of magnetostrictive principle, as operated push/ Pull mode in moving orthogonal direction. It is not only small size and also thin thickness. It was tested by different environments condition like dry and with fluid.

In their paper Johannsmeier and Haddadin proposed Human and robot interaction planning to complete the task, which is used to industrial assembly section [8]. It consists of two layers. They are making decision even with unpredictable events and also explicitly plan for them. Not only is human agent but robot also is considered as agent. They have made hybrid task allocation of industrial assembly process.

In their paper Mcmahon and Plaku explained that underwater vehicles were controlled by sampling based motion planning with constraint based solvers within limited range of area [9]. Even though any obstacles and varying ocean time were made between robots and target, it was able to reach target specific time period using navigation road map.

A swarm robot was operated by topological maps in unknown environments condition [10]. It clearly gave information and guided navigation path for Resource constrained robots. It has been simulated for Real and Virtual situations. This paper mainly says about navigation path for robots, which was communicated among them for different environments.

Ruan and Zhao, in their paper, say that dual wheel robot is controlled by PWM signal, sensors/wheel and feedback controller [11]. Obstacles on path have been detected by sensors, which were balanced for any uneven terrain. System simulation result proved by using LQR algorithm. Left and right turns were easily possible under system commands.

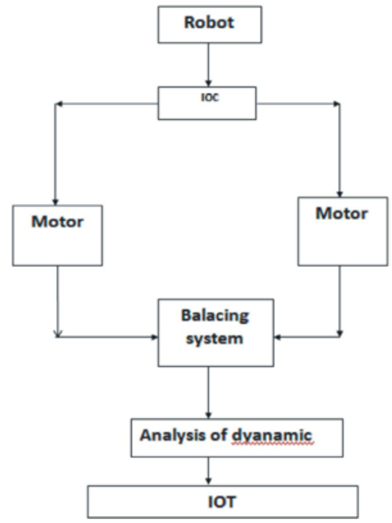

Fig. 4: Methodology chart Fig.5 Dual wheeled robot with controller

Valencia *et al* proposed a balancing system for TWSB robot controlled by Accelerometer and Gyro pair of sensors [12]. These are used to detect tilt angle and Noise signals of low and high frequency. PID was getting feedback signal from sensors, which was received by wireless communication in Bluetooth mode.

The authors have explained robot was controlled by inverted pendulum theory [13]. TWSBR was moved for few meters only. To overcomes these problems, port forwarding router concept through the internet is used. The method of configuring the IP address of IOT is also explained.

From the available literature reviewed as above, it is seen that the dual wheel robot is designed to move from one place to another place by using shortest path algorithms. Here robots are controlled by using swarm robot concepts. These robots are operated anywhere by humans except underwater. Each robot works based on port forwarding router concepts. Port forwarding concepts is clearly explained in paper [13].

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

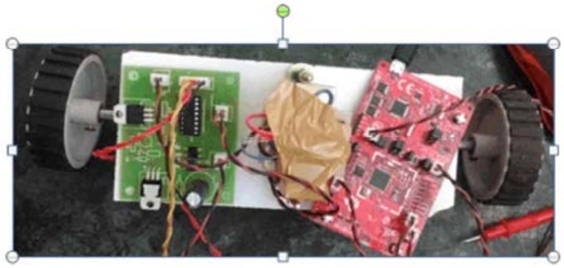

Fig. 5: Dual wheeled robot with controller

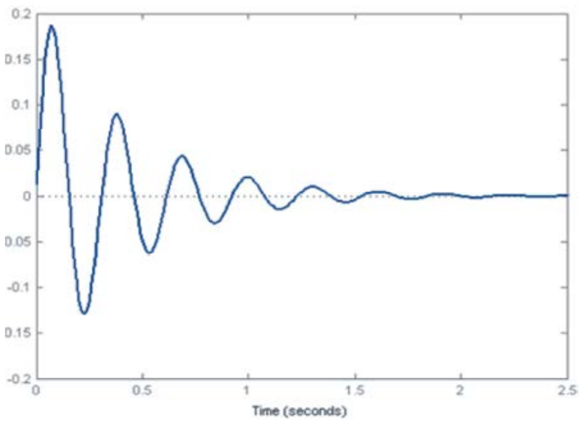

Fig. 6: Accelerometer response

measure the acceleration in a predefined axis. The MMA7341L 3-axis accelerometer mounted on the robot is chosen because it can be used as a tilt sensor. When configured as a tilt sensor the accelerometer can measure static accelerations. The MMA7341L 3-axis accelerometer uses earth's downward gravity force as its reference. So the sensor has a range in degrees of ±90o. An advantage of using the MMA7341L 3-axis accelerometer as a tilt sensor is that it can hold on to its output angle value. The digital IDG500 Dual 500 deg / sec gyroscope can only provide a measure of angular change. Angular change or rate refers to how fast an object is rotating in radians per second. The output of the gyroscope can be considered to be the derivative of the measured output angle from the accelerometer.

The gyroscope tends to have a faster reaction to change as compared to an accelerometer. A very unique feature of the gyroscope is that it has a rest average value also referred to as a bias. 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.

The Controller board consists of onboard charger, motor board, memory devices, sensors, switches, input output pins and microprocessor. The Robot read/write is controlled by input / output pins for controller board, which are having digital and analog pins for TKD0 to TKD5.Switches, are operated by ultrasound sensors. Each pin is operating maximum of 40 mA and 5V. The pins are soldered for connecting external devices. The board has an extra 512kbit EEPROM.

Based on the instruction robot is controlled by human. Multiple robots are also configured using port forwarding concept. Each robot is having unique IP address. These IP address is derived from protocol. It is observed from Figure 6 that an accelerometer gives the following output graph when measured at 90 degree when servo motor is moving in counter clockwise direction. On Y-axis we have taken angle and on X-axis we have taken time. After performing testing process on accelerometer with the help of servo motor we get value of 430 on Y-axis. Y-axis value increases to 105 from original value for sensor in counter clockwise direction and vice versa. But only one change for clockwise direction on Y-axis value 170, so its value decrease. Self balancing is achieved for the robot.

Timer 1 of STM32 with a default clock frequency of 72 MHz has to undertake clock pre-scalar operation. The speed calculation formula of stepper motor is

$$V= ((f)/(fre+1)(T+1)).$$

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.

CONCLUSION

With the experimental setup the robot is controlled by inverted pendulum concepts. These Robots were viewed using cameras. The gyroscope provides a measure of instantaneous angular change but it produces a significant drift when gyroscope is operating. The accelerometer provides an absolute measure of acceleration, but the output signal is often corrupted with noise. These problems are overcome by using Kalman filter and also gyroscope drift was eliminated by accelerometer. Swarm robots are operated worldwide through Internet. The robot is tested to run continuously. Still the performance of the robot has to be evaluated by running, in the different surfaces. It has given better performance and also moved in a curved path without falling.

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