International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 01 , January - 2026

Wireless Video Enabled Mobile Robot with PID Control

Shashank S, Dr. H R Ramesh
Department of Electrical Engineering
University of Visvesvaraya College of Engineering
Bengaluru, India

Abstract - **Autonomous mobile robots (AMR) are becoming more common these days because they are useful and have many real-world applications. They are becoming more reliable and practical because they can move around on their own without needing physical or electronic guide. This work presents the development and implementation of a mobile robotic platform utilizing a Proportional-Integral-Derivative (PID) control algorithm for real time motion regulation and trajectory tracking. A camera-based vision system was incorporated to identify and quantify obstacles in the robot's path. The PID controller continuously processes feedback from onboard sensors (IR sensor, Ultrasonic sensor) to minimize the error between the desired and actual states of the robot, such a position, velocity, or orientation. The control loop dynamically adjusts motor actuation to achieve stable and precise movement. Tuning of the K_P, K_i and K_d gains was performed to optimize system responsiveness, reduce steady-state error, and dampen oscillations. Experimental results demonstrate improved path following accuracy, robust disturbance rejection, and consistent performance across varying terrains and operational conditions.**

Keywords - Autonomous mobile robots, trajectory tracking, PID control algorithm, onboard sensor.

1. INTRODUCTION

Autonomous mobile robotics is a critical area of research in control systems and intelligent automation, with applications spanning logistics, defence, surveillance and exploration. The core challenge in autonomous navigation lies in achieving reliable motion control and real time environmental interaction under dynamic and uncertain conditions. Classical control strategies, particularly the Proportional Integral Derivative (PID) controller, remain widely adopted due to their computational efficiency, ease of implementation and proven effectiveness in linear and non-linear systems.

This work presents the design and implementation of a differential- drive mobile robot equipped with precise motion control, reliable environmental perception to navigate and perform cleaning tasks efficiently in dynamic indoor environments. The important function of vision-based processing in this case consists of self-localization. For literature on this approach, the reader is referred to [1], [2], [3] and [4]. The robots employ DC motors for locomotion and an additional DC motor driven rotary brush mechanism for surface cleaning operations, synchronized with the robot's movement. An important adjunct to the problem of navigation is the problem of obstacle avoidance, another well- researched problem in the part [5], [6]. The controller is designed to minimize the error between the reference trajectory and the actual state (position, velocity) by modulating wheel motor based on feedback from inertial and Arduino Uno microcontroller, which serves as the central unit for low level motor control and sensor interfacing. Currently researchers are working on algorithm design for mobile robot trajectory planning [7]-[12]. To augment situational awareness and enable obstacle recognition, the platform incorporates a monocular camera system coupled with computer vision algorithms. The vision module performs real time image acquisition and processing for the detection and localization of obstacles in the robot's field of view. Many trajectory planning methods are available in the literature to determine the route of a moving robot with obstacle collision avoidance [13]-[16].

By integrating classical control theory with visual perception, the proposed system provides a scalable architecture for autonomous navigation in semi structured and unstructured environments. The paper outlines the system design, control methodology, sensor integration and performance evaluation based on experimental trials.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 01 , January - 2026

2. SYSTEM ARCHITECTURE

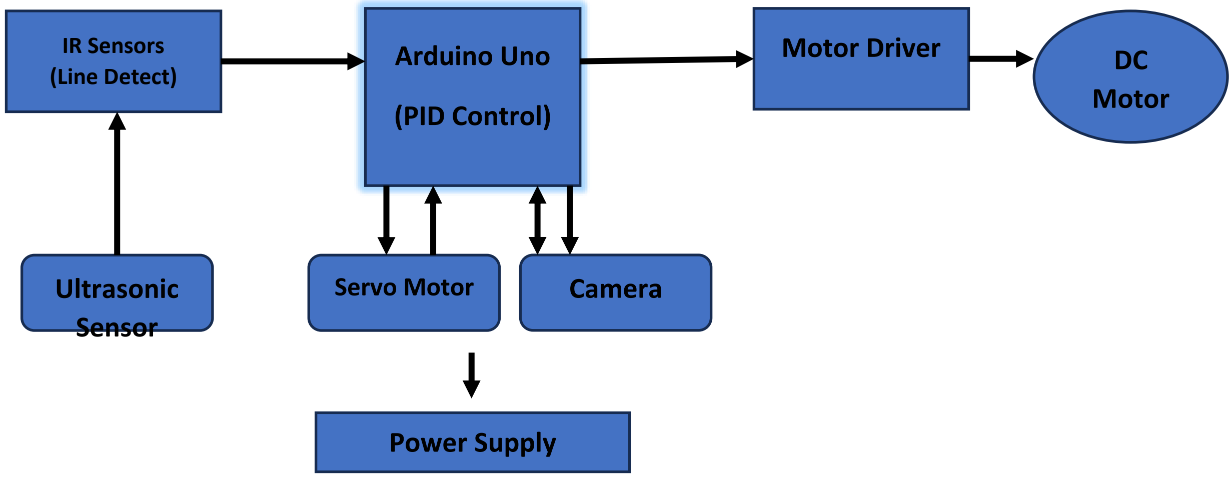

Fig. 1 Block diagram of Autonomous Mobile Robot.

The above Figure 1 represents the block diagram of Autonomous Mobile Robot which included the Arduino Uno microcontroller, motor driver shield, ultrasonic sensor, servo motor, DC motors, IR sensor.

The Arduino Uno is an 8 bit microcontroller that acts as the central processing unit for the robot. It receives input signals from respective sensors, processing them according to embedded control algorithms (like PID) and generates output signals to control motors and servos. The IR sensor array detects the position of robot. This array helps determine the error by using PID algorithm to continuously correct the robot's direction by adjusting the speed of the motors. The motor driver allows bidirectional control of DC motors and can regulate speed. The ultrasonic sensor detects obstacles in front of the robot, while the servo motor rotates the sensor to scan the environment (typically from -45° to +45°). Power supply system supplies regulated power to all components.

This theoretical framework explains how each subsystem contributes to the robot's overall autonomy and functionality. The integration of PID control, environment scanning, and live video makes the robot:

- Adaptive
- Autonomous
- Remotely observable

3. PID Controller

The mathematical model of the plant is appropriately obtained by using both Simulink and Control Design and state-space averaging technique to forecast its response and observe its behaviours in both the time and frequency domains. Control systems are planned and executed in this regard to improve critical dynamic properties of the plant, such as stability, response time, steady-state error, and oscillations that make up the transient and steady-state. Because of its features of being simple to design, easily comprehensible, and very understandable, the Proportional-Integral (PI) feedback compensator structure is a commonly used controller.

The standard continuous time PID controller equation for motor control is

$$C_o(t) = K_P e(t) + K_i \int_0^t e(\tau)d\tau + K_d \frac{de(t)}{dt} \qquad (1)$$

The equation (1) represents PID controller representation. Where $C_o(t)$ is the controller output at time t, e(t) is the error (reference point minus feedback speed) and K_P, K_i, K_d are proportional, integral and derivative gains respectively. The discrete-time equivalent sums the proportional, integral and derivative terms based on the error at each sampling instant.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 01 , January - 2026

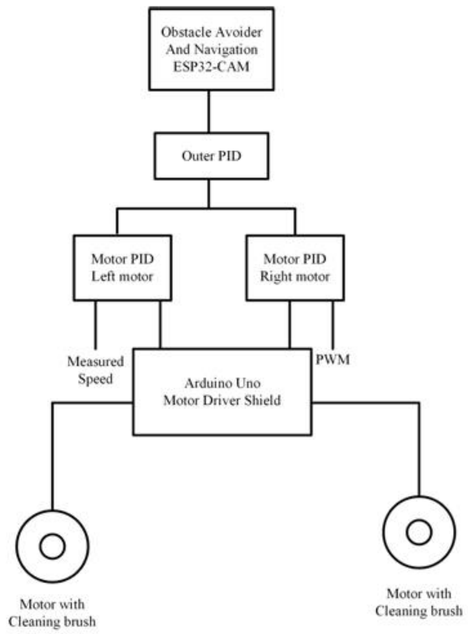

Fig. 2 Block representation of PID Controller to the Autonomous Mobile Robot.

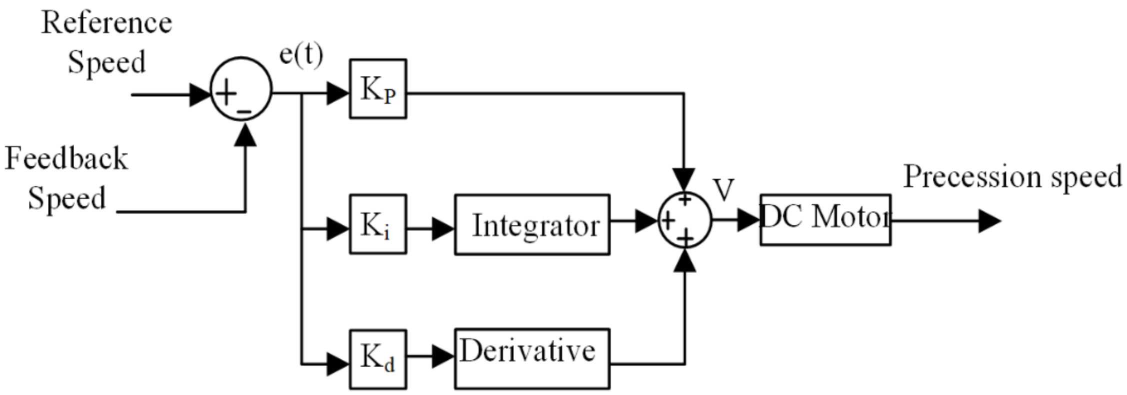

Fig. 3 Block Diagram of PID Controller for DC motor.

The above Figure 2 specifies the PID controller to the Autonomous Mobile Robot in which the PID controlled output is incorporated with the right and left motor to control the rotational speed of the motor. The best known controllers used in industrial control processes are proportional -integral-derivative (PID) controllers because of their simple structure and robust performance in a wide range of operating conditions [17]. The Figure 3 enumerates the block diagram of the PID controller. The error e(t) is improvised by using the linear PID controller and the respective output is the controlled motor speed as per requirements. The PID controller achieve the output using a feedback loop that combines the correction of current error, eliminates persistent error over time and predicts future error. PID controllers are crucial for automating processes by providing consistent and reliable control, reducing the need for constant human intervention.

4. SIMULATION OF MOTOR SPEED CONTROL USING PID CONTROLLER

The PID controller is allowed to control the DC machine speed. The MATLAB Simulation of the motor control speed is designed in Simulink. Here the below Figure 4 specifies the circuit diagram of closed loop to control the speed of the DC machine to 1750 rpm.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 01 , January - 2026

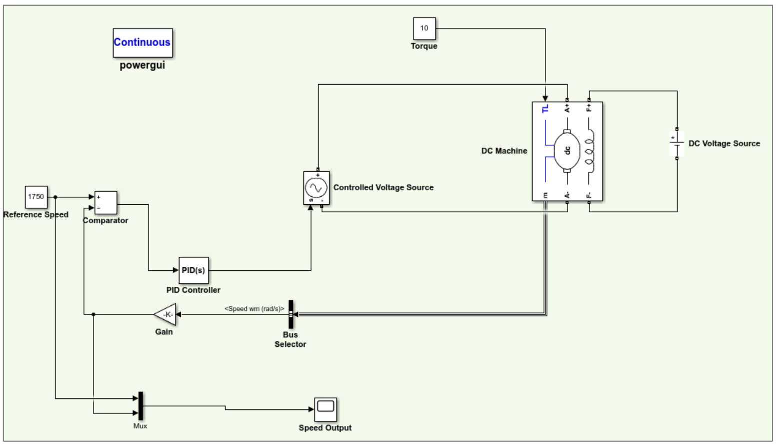

Fig. 4 MATLAB Simulation Circuit of DC machine control using PID controller.

A PID controller is a robust and widely used control technique for regulating the speed of a DC machine. It works by minimizing the error between desired speed and the actual speed by adjusting the motor's input voltage. Proper tuning of the PID parameters ensures that the motor responds quickly and accurately to changes in the desired speed. The tuning of the PID controller to achieve optimal performance like low rise time, minimal overshoot, and fast settling time.

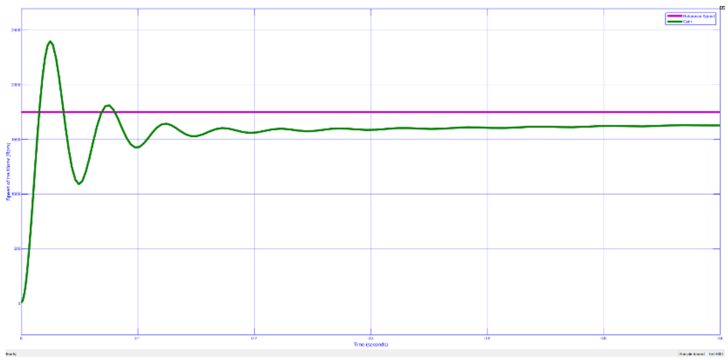

Fig. 5 Output waveform of DC Machine speed without PID tuning.

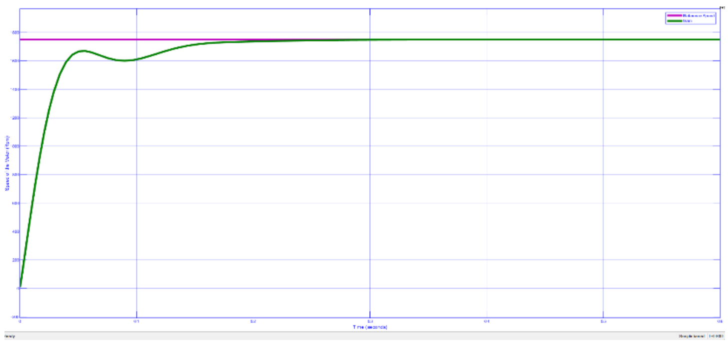

Fig. 6 Output waveform of DC Machine speed with PID tuning.

The above Figure 5 represents the Output DC Machine speed without PID tuning having damping oscillations and it's not reach out to the reference speed. The Figure 6 specifies Output DC Machine with respective PID tuning to reach the reference speed by correcting the error. The below table 1 projects that the rise time, overshoot and settling time of tuned PID controller is less when compare to the without PID.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 01 , January - 2026

Table 1. Comparison of Output response of the DC machine.

DC Machine speed = 1750 rpm, Torque = 10 N-m				
	Rise Time (sec)	Overshoot (%)	Settling Time (sec)	Output DC Machine Rotational Speed (rpm)
Without PID	0.0125	0.37	0.3	1600
With PID	0.01	0.02	0.2	1750

5. HARDWARE IMPLEMENTATION

To implement a PID controller in an automatic robot, hardware components must collect data, process, the PID algorithm and actuate control commands. The optimal hardware choice depends on the robot's performance requirements, such as speed and precision.

Table 2. Hardware Component Specification.

Component	Model
Arduino	UNO
Motor Driver shield	LD293D
ESP32-CAM (camera)	REES52
Servo Motor	SG90
Ultrasonic sensor	HC-SR04
Battery	12/24 VDC
4 x DC motor	100-300 rpm
Chassis, Wheels, switch	

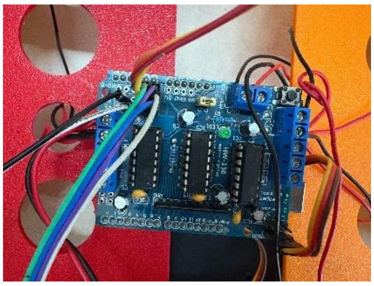

Fig. 7 Arduino Uno.

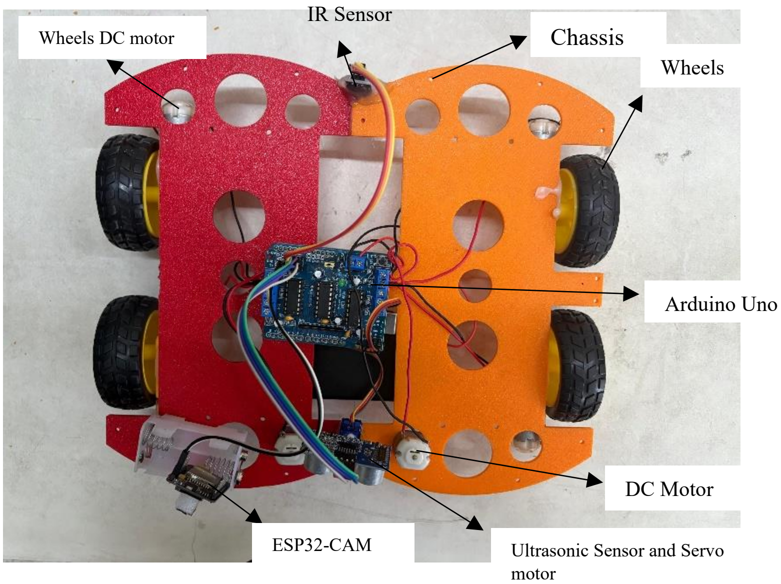

Fig. 8 Hardware Prototype of Autonomous Mobile Robot.

6. CONCLUSION

This mobile robot project incorporating PID control with an Arduino Uno, an IR sensor, an ultrasonic sensor and a camera are the key conclusions center on the successful integration of multi sensing for precise, adaptive navigation. The project demonstrates the benefits of a PID control strategy over simpler methods, while also identifying the practical challenges and offering pathway for future improvements. In this project, we successfully designed and implemented a mobile robot integrated with a PID controller,

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 01 , January - 2026

tuned to optimize movement and responsiveness based on real time sensor inputs. Overall, the system demonstrated the effectiveness of sensor fusion and feedback control in autonomous robotics. Future improvements could include advanced image processing using external processors, wireless communication and adaptive PID tuning for dynamic environments.

Acknowledgements

The authors would like to express their sincere gratitude to the **University of Visvesvaraya College of Engineering (UVCE)** for providing the infrastructure, technical resources, and support necessary for carrying out this research work. The study presented in this paper was made possible through the collaborative efforts and valuable guidance provided by the engineers and research staff at UVCE. The authors also acknowledge the support of the management of UVCE for encouraging research in Control and Instrumentation techniques in autonomous mobile robots.

REFERENCES

[1] A. Kosaka and A. Kak, ªFast vision-guided mobile robot naviga tion using model-based reasoning and prediction of uncertainties,º CVGIPÐImage Understanding, vol. 56, no. 3, pp. 271±329, Nov. 1992.

[2] A. J. Mu˜noz and J. Gonz´alez, ªLocalizing mobile robots with a single camera in structured environments,º in Proc. World Automat. CongressÐRobot. Manufact. Syst., May 1996, pp. 539±544.

[3] K. Sugihara, ªSome location problems for robot navigation using a single camera,º Comput. Vision, Graph. Image Process., vol. 42, no. 1, pp. 112±129, Apr. 1988.

[4] T. Tsubouchi and S. Yuta, ªMap assisted vision system of mobile robots for reckoning in a building environment,º in Proc. IEEE Int. Conf. Robot. Automat., Mar.±Apr. 1987, pp. 1978±1984.

[5] J. Borenstein, ªReal-time obstacle avoidance for fast mobile robots,º IEEETrans. Syst. Man Cybern., vol. 19, pp. 1179±1187, Sept./Oct. 1989.

[6] J. Borenstein and Y. Koren, ªHistogramic in-motion mapping for mobile robot obstacle avoidance,º IEEE Trans. Robot. Automat., vol. 7, pp. 535±539, Aug. 1991.

[7] V. F. Muñoz, A. García-Cerezo, and A. Cruz, A mobile robots trajectory planning approachundermotionrestrictions, Integr. Comput.-Aided Eng., vol. 6, no. 4, pp. 331347, 1999, doi: 10.3233/ica-1999-6406.

[8] Y. Zi Cong and S. G. Ponnambalam, Mobile robot path planning using ant colony optimization, in Proc. IEEE/ASME Int. Conf. Adv. Intell. Mechatronics, Jul. 2009, pp. 851856, doi: 10.1109/AIM.2009.5229903.

[9] O. Hachour, Path planning of autonomous mobile robot, Int. J. Syst. Appl., Eng. Develop., vol. 2, no. 4, pp. 178190, 2008.

[10] C. Sprunk, Planning motion trajectories for mobile robots using splines, Dept. Comput. Sci., Albert-Ludwigs Univ. Freiburg, Freiburg im Breisgau, Germany, Tech. Rep., Oct. 2008. [Online]. Available: http://www2.informatik.unifreiburg.de/~lau/students/Sprunk2008.pdf

[11] D. T. Wooden, Graph-based path planning for mobile robots, Ph.D. dissertation, Dec. 2006, p. 114.

[12] C. W. Warren, Fast path planning using modi ed A* method, in Proc. IEEE Int. Conf. Robot. Automat., vol. 2, May 1993, pp. 662667, doi: 10.1109/ROBOT.1993.291883.

[13] C. ÓDúnlaing and C. K. Yap, A retraction method for planning the motion of a disc, J. Algorithms, vol. 6, no. 1, pp. 104111, Mar. 1985, doi: 10.1016/0196-6774(85)90021-5.

[14] B. Li and Z. Shao, Simultaneous dynamic optimization: A trajectory planning method for nonholonomic car-like robots, Adv. Eng. Softw., vol. 87, pp. 3042, Sep. 2015, doi: 10.1016/j.advengsoft.2015.04.011.

[15] O. Khatib, Real-time obstacle avoidance for manipulators and mobile robots, in Autonomous Robot Vehicles. New York, NY, USA: Springer, 1986, pp. 396404.

[16] J. R. R. Kunigahalli, Visibility graph approach to detailed path planning in CNC concrete placement, in Autonomous Robotics Construction XI. Amsterdam, The Netherlands: Elsevier, 1994, pp. 141147.

[17] Loucif, Fatiha. (2005). DC MOTOR SPEED CONTROL USING PID CONTROLLER.