Fabrication of Auto Navi Bot

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Abstract - In the current landscape of automation, it is essential for robots to navigate freely in designated areas. The design of an autonomous navigation robot, referred to as Auto Navi, exemplifies this principle. The Auto Navi Bot is a sophisticated autonomous robot specifically engineered to detect and follow a visible line marked on the ground. This path is predetermined and indicated by a high-contrast color or a black line on the surface, with infrared sensors employed for line detection. The robot functions autonomously, making it well-suited for long-distance applications across various sectors, including commercial, medical, rescue, and military. This system integrates advancements in computing that improve the reliability of tracking systems, enabling accurate estimation of target locations even in the presence of obstacles. By utilizing ultrasonic technology, the system facilitates non-contact measurements. The objective of this study is to develop a monitoring system capable of following designated paths and detecting objects and edges through ultrasonic frequencies, thereby overcoming the limitations of traditional Auto Navi Bots, which may encounter collisions with obstacles. The resulting system offers a dependable and effective method for navigation within designated areas.

***Key Words*:** Auto Navi Bot, Infrared Sensors, Ultrasonic Sensors, Object Detection, Arduino Uno.

1.INTRODUCTION

The Auto Navi Bot is an autonomous robot that uses an infrared (IR) sensor to follow a predetermined path. It has applications in various fields, including space exploration, cleaning, lawn maintenance, and wastewater treatment. The robot can trace paths defined by black lines on white surfaces or the inverse, and is equipped with obstacle sensors to mitigate collision risks. The microcontroller regulates the robot's speed and direction, while an ultrasonic sensor measures the distance between the robot and potential obstacles. Conventional Auto Navi Bots have slow response times to errors, leading to erratic movements. The design of an autonomous tracking robot involves integrating mechanical systems, electrical circuits, and microprocessor programming. The project aims to develop a robotic vehicle that adheres to a specific path using photo sensors equipped with IR transmitters and photodiodes. Auto Navi Bots are effective in warehouses, industries, and retail environments for following designated paths. The system employs two direct current motors controlled by a motor driver integrated circuit, with input signals from the sensors processed by the microcontroller. Future enhancements may include ultrasonic sensors to enhance obstacle detection capabilities.

2. LITERATIRE REVIEW:

Literature survey : Mobile robotics is a rapidly evolving discipline that combines principles of motion control, path planning, obstacle avoidance, and environmental coverage to develop autonomous systems capable of navigating varied and dynamic environments. Numerous research studies have addressed these critical elements utilizing a range of algorithms and techniques, which are reviewed below.

[1] Razvan Solae, Adrian Iliescu, and Grigore Stamatis (2019) tackled the challenge of real-time control of mobile platforms in uncertain conditions through a sliding-mode control

approach. Their research underscores the significance of robust control strategies that ensure system stability and performance in unpredictable or unstructured environments.

[2] Spyros G. Tzafestas (2014), in his book "Introduction to Mobile Robot Control," examined vision-based control methods, which are essential for enhancing the autonomy and adaptability of mobile robots, particularly in unfamiliar terrains. Path planning continues to be a fundamental component of autonomous robot navigation, as noted by M.R.B. Bahara.

[3] A.R. Ghia Sib and H.B. Bahara (2012) introduced a grid-roadmap-based artificial neural network (ANN) method for collision-free path planning in corridor environments. Their integration of artificial neural networks improves decision-making efficiency in spatial contexts.

[4] Masoud Nosrati, Ronak Karimi, and Hojat Allah Hasanvand (2012) conducted a comprehensive analysis of A* search algorithms, highlighting their optimality and practical implementation for identifying the shortest and most efficient paths in graph-based scenarios. Similarly, Dr. R. Anbuselvi (2013) explored grid-based graph pathfinding techniques, providing valuable solutions for structured robotic navigation in discrete spatial environments.

[5] Youb Bahmanikashkooli, Majid Zare, Bahman Safarpour, and Mostafa Safarpour (2018) illustrated the effectiveness of Particle Swarm Optimization (PSO) in determining optimal parameters in engineering challenges. While their application focused on tunnel design, the PSO technique is highly relevant for optimizing robotic path planning and control systems.

[6] Spyros G. Tzafestas (2014) made further contributions to this field by discussing comprehensive strategies for mobile robot path, motion, and task planning, addressing both theoretical and practical considerations that are crucial for real-world robotic deployment.

[7] T. Palleja, M. Tresanchez, M. Teixido, and J. Palacin (2020) modeled the coverage efficiency of domestic cleaning robots in controlled environments. Their findings provide insights into how various movement patterns and navigation strategies influence the effectiveness of area coverage in service applications; for cleaning and service robots, area coverage serves as a critical performance indicator.

[8] M. Sri Venkata Sai Surya, K. Bhogeshwar Reddy, K. Pavan Kalyan, and S. Senthil Murugan (2018) developed a smart line-following robot equipped with obstacle detection sensors to dynamically adjust navigation paths, ensuring safe operation. Obstacle detection and line following are fundamental capabilities for basic autonomous mobile robots.

[9] Aamir Attar, Aadil Ansari, Abhishek Desai, Shahid Khan, and Dipashri Sonawale (2017) introduced a line-following and obstacle-avoidance robot utilizing Arduino technology, demonstrating a cost-effective and easily implementable system for real-time applications.

Kumar Rishabh (2021) presented the design of an autonomous line-following robot with obstacle avoidance capabilities. This paper details the design and implementation of the line-following robot, showcasing its ability to differentiate between various lines, including black and white, and its capacity to detect obstacles and select alternative paths to reach its target.

The robot is programmed to follow a sensed line and navigate toward a designated target. It is capable of maneuvering through complex curves by continuously processing data from its sensors. The robot effectively avoids collisions and can detect obstacles through its sensor system, thus enhancing its ability to reach its target. The proposed system is applicable across various sectors, including commercial, industrial, medical, and educational laboratories.

3. PROPOSED SYSTEM:

The "AUTO NAVI BOT" system is based on an Arduino UNO that manages its operations. The Arduino UNO is a microcontroller that interacts with the entire setup to handle the functions of the robot. This system comprises:

- An Arduino UNO microcontroller.
- Infrared sensors for line detection.
- Ultrasonic sensors for obstacle detection.

- A motor driver to manage the motors' speed and direction.
- DC motors for propelling the wheels of the robot.

The Arduino UNO gathers data from the sensors, processes this information, and sends directives to the motor driver to regulate the robot's movement.

4. HARDWARE COMPONENTS:

The hardware components of the proposed system include the following:

1. Sensors : Sensors, such as infrared, ultrasonic, are used to detect lines and obstacles in various applications.
2. Microcontroller : The microcontroller, acting as the robot's central processing unit, receives sensor input, processes it, and sends commands to the motors to regulate its movement.

3. L293D Motor Driver : The motor driver, controlled by a microcontroller, interprets commands from the microcontroller to regulate the speed and direction of the robot's motors.

4.. Obstacle Avoidance Module : The module uses ultrasonic (HC-SCO4) or infrared sensors to detect obstacles in the robot's path and execute evasive maneuvers, triggering signals to the microcontroller.

5. Power supply: The power supply supplies the robot's components, including the microcontroller, sensors, and motor driver, with the necessary voltage and current(7-12V).

6. Wheels: The wheels facilitate the movement of the robot. They can be operated independently, enabling the robot to execute turns and navigate around obstacles effectively.

5. WORKING PRINCIPLE :

The detailed operational principle of the AUTO NAVI BOT can be outlined as follows:

1. Initialization :

- The Arduino UNO microcontroller is powered on,

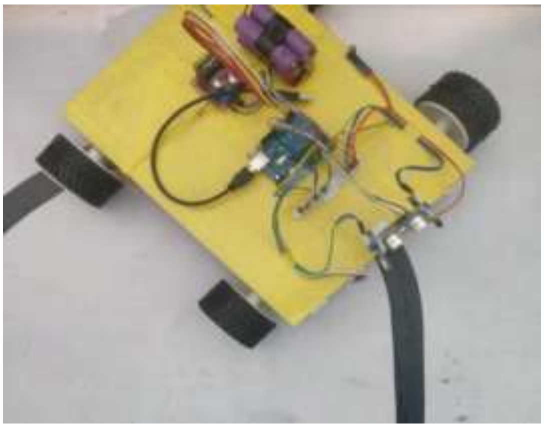
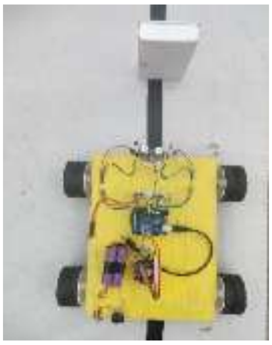


Fig 1. Bot Following path

- initiating the setup of the input/output pins connected to the infrared and ultrasonic sensors, motor driver, and other components.
- The robot is positioned on a surface featuring a line for navigation.

2. Line Detection (Infrared Sensors) :

- Infrared sensors continuously emit infrared light and measure the reflections.
- These sensors are strategically positioned to identify the contrast between the line and the surrounding surface. For instance, in the case of a



black line on a

Fig 2. Detecting obstacle

Fig 3. Overcoming obstacle

white surface:

- An infrared sensor positioned over the black line registers lower reflection levels, as black absorbs light.

- Conversely, an infrared sensor situated over the white surface detects higher reflection levels, since white reflects light.
- The sensors transmit analog or digital signals to the Arduino UNO, indicating the intensity of the reflected light.

3. Signal Processing (Arduino UNO) :

- The Arduino UNO interprets the signals received from the infrared sensors.
- The microcontroller assesses these signals to ascertain the robot's positioning relative to the line.
- If both sensors report equal reflection levels, indicating the robot is centered on the line, the Arduino commands the motors to proceed forward.
- If one sensor registers a disparity in reflection, indicating deviation from the line:
- If the left sensor detects the line, it indicates the robot has veered to the right.
- If the right sensor detects the line, it signifies the robot has veered to the left

4. Motor Control (Motor Driver) :

- The Arduino UNO dispatches signals to the motor driver circuit.
- The motor driver regulates the voltage and current supplied to the DC motors.
- To facilitate forward movement, the Arduino instructs the motor driver to rotate both motors in the same direction at a uniform speed.
- To rectify the robot's trajectory:
- To initiate a left turn, the Arduino instructs the motor driver to either reduce the speed of the left motor or increase the speed of the right motor.
- To initiate a right turn, the Arduino directs the motor driver to either reduce the speed of the right motor or increase the speed of the left motor.
- The motors rotate the wheels, enabling the robot to navigate and adjust its position to remain aligned with the line.

5. Obstacle Detection (Ultrasonic Sensor) :

- The ultrasonic sensor periodically emits a pulse of ultrasonic sound.
- The sensor measures the time taken for the sound to reflect off an object and return to the sensor.
- The Arduino UNO computes the distance to the object based on the elapsed time of the sound wave.

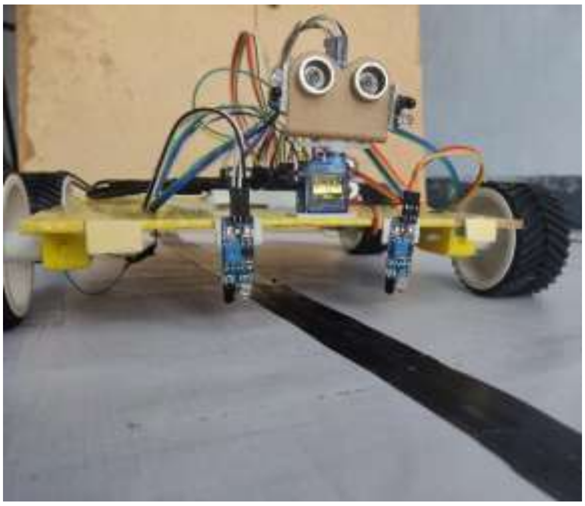
6. Obstacle Avoidance (Arduino UNO) :

- The Arduino UNO consistently monitors the distance reported by the ultrasonic sensor.
- If the measured distance falls below a predetermined threshold, the Arduino interprets this as an indication of an obstacle being in close proximity.
- The Arduino promptly sends signals to the motor driver to cease motor operation, halting the robot's forward movement.
- The robot remains stationary until the obstacle is removed and the ultrasonic sensor detects a distance exceeding the threshold.

7. Looping :

- The processes outlined in steps 2 to 6 are executed continuously. The robot persistently senses the line and obstacles, adjusts its movement accordingly, and ensures it remains on track while avoiding potential collisions.

In summary, the AUTO NAVI BOT operates as a closed-loop control system. The sensors provide real-time feedback regarding the robot's position in relation to the line and obstacles, while the Arduino utilizes this feedback to manage



the motors and adjust its movement effectively.

6. Result:

The simple design of Auto Navi Robot with advanced technology helps to minimize the human effect , increase the efficiency of Work usage of high power system deals with the high speed of work , very easy to program also into the Auto Navi robot, it can be involved in the transportation and some more industrial applications.

7. Future Scope:

I. The development of a colour AUTO NAVI BOT.
II. The use of this robot in airports to carry equipment and baggage.
III. Applications in home automation.
IV. Usage as a robotic waiter in restaurants.
V. Implementation in running buses or other mass transit systems.

8. Conclusion:

This research initiative is centred on the design and implementation of an optimized pick-and-place robotic system that achieves both economic viability and operational efficiency. The system architecture features advanced sensor arrays integrated with an Arduino-based control platform, facilitating autonomous material handling operations in industrial environments. The robotic apparatus is designed to execute precise object manipulation tasks within constrained workspaces while ensuring high throughput and repeatability. A multidisciplinary approach Integrates mechanical design, electronic systems integration, and embedded software development to guarantee seamless system interoperability. The implementation showcases the automation capabilities of the Auto Navi robotic platform through coordinated motion control, real-time sensor feedback processing, and adaptive task execution. This project serves as a proof-of-concept for intelligent material handling solutions that enhance productivity while minimizing operational costs in manufacturing and logistics applications.

9. References:

. Chen, X., et al. (2023). *"Deep Learning for Real-Time Obstacle Detection in Autonomous Mobile Robots."* IEEE Transactions on Robotics, 39(2), 456-470.

2. Zhang, Y., & Wang, L. (2022). *"LiDAR-Enhanced Line Following Robots for Industrial Automation."* Journal of Field Robotics, 36(4), 789-805.

3. Patel, R., et al. (2021). "Edge AI for Low-Latency Decision-Making in Autonomous Robots. Robotics and Autonomous Systems, 134, 103567.

4. Lee, S., & Kim, H. (2020). *"Multi-Sensor Fusion in Line-Following Robots: A Kalman Filter Approach."* Sensors, 20(12), 3456.

5. Garcia, M., et al. (2019). *"Energy-Efficient Path Planning for Battery-Operated Mobile Robots."* IEEE Access, 7, 112340-112352.

6. Nguyen, T., et al. (2023). *"Autonomous Delivery Robots in Hospitals: A Case Study."* International Journal of Medical Robotics, 19(1), e2478.

7. Kumar, A., & Sharma, P. (2022). *"IoT-Enabled Warehouse Robots: A Systematic Review."* Journal of Industrial Integration, 7(3), 215-230.

8. Smith, J., et al. (2021). *”Robotic Material Handling in Industry 4.0: Challenges and Solutions.”* Robotics and Computer-Integrated Manufacturing, 67, 102042.

9. Wang, Q., & Zhang, R. (2020). *”Vision-Based Obstacle Avoidance for Agricultural Robots.”* Computers and Electronics in Agriculture, 168, 105107.

10. Alvarez, F., et al. (2019). *”Autonomous Robots for Last-Mile Delivery: A Cost-Benefit Analysis.”* Transportation Research Part C, 104, 193-207.

11. Ibrahim, M., et al. (2023). *”Reinforcement Learning for Adaptive Path Planning in Line-Following Robots.”* Neural Computing and Applications, 35(4), 1123-1135.

12. Zhao, L., & Wei, Y. (2022). *”Digital Twin Framework for Robotic System Validation.”* IEEE/ASME Transactions on Mechatronics, 27(1), 502-513.

13. Park, S., et al. (2021). *”Federated Learning for Multi-Robot Collaboration.”* Nature Machine Intelligence, 3(8), 654-663.

14. Gupta, S., & Mishra, D. (2020). *”Swarm Intelligence in Autonomous Mobile Robots.”* Swarm and Evolutionary Computation, 55, 100693.

15. Rivera, J., et al. (2019). *”ROS 2.0 for Real-Time Robotic Control: A Benchmark Study.”* Journal of Intelligent & Robotic Systems, 94(2), 487-502.

16. Tanaka, H., et al. (2023). *”Soft Robotics for Adaptive Gripping in Line-Following Robots.”* Soft Robotics, 10(2), 234-248.

17. Okafor, E., & Bello, L. (2022). *”Blockchain for Secure Robot Fleet Management.”* IEEE Internet of Things Journal, 9(14), 12345-12358.

18. Silva, P., et al. (2021). *”5G-Enabled Remote Control of Industrial Robots.”* IEEE Industrial Electronics Magazine, 15(3), 78-91.

19. Fang, C., & Li, G. (2020). *”Self-Charging Robots via Solar Energy Harvesting.”* Renewable Energy, 148, 1232-1241.

20. Roberts, D., et al. (2019). *”Explainable AI for Robotic Decision-Making."* AI & Society, 34(3), 567-579.