Smart Visitors Guidance Robot for Hospital Environments

Ms.S.Anitha
Assistant Professor, Dept. Of ECE
KGiSL Institute of Technology Coimbatore, TN, India
anitha.s@kgkite.ac.in

Subhashini L
UG Student, Dept. Of ECE, KGiSL Institute of Technology Coimbatore, TN, India
Subhashini54860@gmail.com

Mona B
UG Student, Dept. Of ECE,
KGiSL Institute of Technology Coimbatore, TN, India
Monabalu2003@gmail.com

Sugan N
UG student, Dept of ECE,
KGiSL institute of technology,
Coimbatore, TN, India
Sugansathy90@gmail.com

Monish D
UG Student, Dept. Of ECE,
KGiSL Institute of Technology Coimbatore, TN, India
Monishdevaraj2003@gmail.com

Abstract— **This paper presents a smart patient monitoring and alert system designed to enhance safety and responsiveness in healthcare environments, particularly for elderly and mobility-impaired individuals. The system integrates obstacle detection, real-time health monitoring, smart navigation, and emergency alert features into a compact, Arduino-based platform using the ATmega328 microcontroller.**

Key health parameters are monitored continuously, and any abnormal values automatically trigger an emergency alert through a buzzer. The buzzer also supports manual activation by the patient in critical situations. Obstacle sensors assist with navigation in indoor environments, helping avoid collisions and ensuring smooth movement. Real-time monitoring ensures that healthcare personnel or caregivers can respond quickly to emergencies.

Keywords: Smart Patient Monitoring, Emergency Alert System, Real-time Health Monitoring, Arduino-based Healthcare System, ATmega328 Microcontroller, Obstacle Detection, Elderly Care Technology, Mobility Assistance, Smart Navigation, Healthcare IoT

I. INTRODUCTION

In recent years, the integration of robotics into healthcare has emerged as a transformative approach, offering improvements in efficiency, safety, and patient comfort. Hospitals, particularly those with high foot traffic and limited staff, face considerable challenges in effectively guiding and monitoring visitors and patients. To address these challenges, the development of an intelligent, autonomous robot that can assist and guide individuals within hospital environments has gained significant interest. This project introduces the concept of a Smart Visitor Guidance Robot, designed to autonomously navigate hospital corridors, avoid obstacles, and help guide individuals to their desired locations. By utilizing RFID technology for location tracking, incorporating obstacle avoidance mechanisms, and providing real-time emergency alerts through GSM, this robot promises to enhance hospital operations and provide critical support for elderly and mobility-impaired individuals. The system aims to not only assist in navigation but also ensure a higher level of interaction with the user, delivering a safer, more efficient experience for both patients and hospital staff

II. LITERATURE SURVEY

The use of robotics in healthcare has grown rapidly in recent years, providing new possibilities for enhancing patient care, improving hospital operations, and ensuring better user interaction. Several research works have explored different robotic systems for various healthcare applications, ranging from navigation and guidance to precise medical interventions.

From [1], Lin et al. proposed a tour guide robot powered by a Large Language Model (LLM) and user behavior analysis to improve user interaction in public settings. This model allows the robot to adapt to user needs and provide personalized guidance, which is crucial in hospital environments where patients and visitors may require different types of support.

In the context of safe human-robot interaction, Yang et al. in [2] developed a digital twin-based robot skin system. This system enhances safety by detecting and responding to physical interactions in real-time, making it suitable for human-centered healthcare robots. The concept of safe interaction is vital for hospital guidance robots, especially when dealing with elderly or mobility-impaired users.

Wang et al. in [3] introduced a vision-guided robot for nucleic acid detection and sampling. This highlights the growing trend of combining vision technology with robotics to enable precise healthcare procedures. While their work is focused on lab testing, similar visual guidance methods can be applied to help navigation robots detect obstacles or identify users.

Skrede et al. in [4] worked on quantifying biomechanical stability using industrial robots. Their task space motion framework could be adapted to healthcare robots to ensure stable and smooth movement within hospital corridors, reducing the risk of falls or collisions.

Lei et al. in [5] demonstrated robotic needle insertion using fused 2D ultrasound and 3D CT imaging, showcasing how sensor fusion improves accuracy. This principle can inspire hospital guide robots to integrate multiple sensors like RFID and ultrasonic to achieve precise indoor navigation.

Connolly et al. in [6] developed SlicerROS2, a module for robotic interventions, which integrates image guidance into robotic systems. Although intended for surgeries, similar architecture could support navigation and patient assistance in hospitals by allowing robots to understand spatial layouts.

In [7], Chen et al. introduced a real-time deformable registration technique using optimization algorithms for ultrasound surgical guidance. This type of advanced processing could help robots in dynamically changing hospital environments, adapting their path based on crowd density or temporary obstacles.

Xiao et al. in [8] created a robotic system for multi-approach spinal surgery. The high flexibility and accuracy of such a system suggest that hospital robots can be designed to handle complex navigation routes and varied floor plans.

Li et al. in [9] proposed an AI-based autonomous probe guidance system using deep reinforcement learning. This shows how AI can be applied to train hospital robots to learn from their environment and improve their navigation and guidance behavior over time.

Finally, Luciani et al. in [10] developed an exoskeleton system that mimics therapist movements for upper-limb rehabilitation. Their force-profile-based approach emphasizes the importance of personalized and responsive robotics, a feature that could significantly enhance patient experience in hospital guidance applications.

These studies collectively underline the critical role of robotics in modern healthcare, with innovations in AI, sensor fusion, and human-robot interaction shaping the future of hospital automation. The Smart Visitor Guidance Robot proposed in this project is inspired by these developments and aims to combine navigational intelligence with real-time user assistance to meet the unique demands of hospital environments.

III. PROPOSED WORKFLOW

The Smart Visitors Guidance Robot is designed to enhance navigation assistance within hospital environments, providing an affordable and reliable solution for guiding visitors efficiently. Built on a low-cost Arduino platform powered by the ATmega328 microcontroller, the robot integrates multiple subsystems for accurate pathfinding, user interaction, and emergency response. This workflow outlines the key stages in the development and operation of the robot.

Figure 1 illustrates the proposed workflow. The process begins with hardware setup and system initialization. Key locations within the hospital are embedded with passive RFID tags, which act as location identifiers. When the robot encounters these tags during movement, it reads the encoded information to determine its current position and next direction, enabling precise navigation along predefined routes.

Activation of the robot is initiated through a human-touch sensing mechanism. This capacitive touch-based system ensures that the robot remains idle until deliberately engaged by a visitor, thereby preventing unintended or accidental activation. Once activated, the robot displays step-by-step navigation instructions and system status messages on a 16×2 LCD screen. This interface enhances usability by offering real-time feedback and directional cues to users.

Navigation logic is programmed to follow RFID-based checkpoints, and motor control routines guide the robot along corridors and junctions. In case of emergencies or unplanned halts, a GSM module embedded in the system is triggered. It transmits SMS alerts containing the robot's current location to caregivers or security personnel, ensuring rapid assistance.

Power management is achieved through a 6V rechargeable battery system that allows uninterrupted operation throughout the day. The portable design eliminates dependency on fixed power supplies, making it suitable for dynamic indoor healthcare environments.

By combining RFID navigation, touch-based activation, real-time display, and GSM communication in a microcontroller-based platform, the Smart Visitors Guidance Robot offers a scalable solution to reduce confusion in complex hospital layouts while maintaining safety and efficiency.

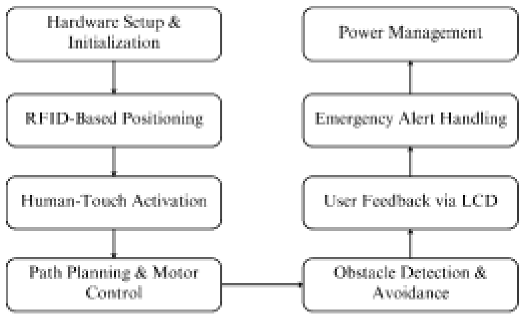

Fig.1 Proposed Workflow

A. *Hardware requirements*

The proposed Smart Visitors Guidance Robot is built around an ATmega328-based Arduino Uno microcontroller board, which serves as the central control unit for managing all peripheral components. The robot is powered by two 6V DC gear motors controlled via an L298N motor driver module, allowing for efficient mobility within indoor environments such as hospitals. For navigation and positioning, the system employs an MFRC522 passive RFID reader in conjunction with multiple RFID tags placed at key locations. Obstacle detection is handled by HC-SR04 ultrasonic distance sensors, enabling the robot to avoid collisions during movement. A SIM900 or SIM800 series GSM/GPRS module is integrated to send location-based alerts to caregivers in case of emergencies. User interaction is facilitated through a 16×2 character LCD display with an I²C adapter, which shows real-time status updates and guidance prompts. Activation of the robot is controlled using a human-touch sensor such as the FSR-402, ensuring it only operates when deliberately engaged. For alert mechanisms, a buzzer is included to provide audible warnings in critical situations. The entire system is powered by a 6V rechargeable battery pack, complete with a charging circuit to support mobility and uninterrupted operation. Additional hardware such as jumper wires, a sturdy chassis, wheels, and mounting components are also required for complete assembly.

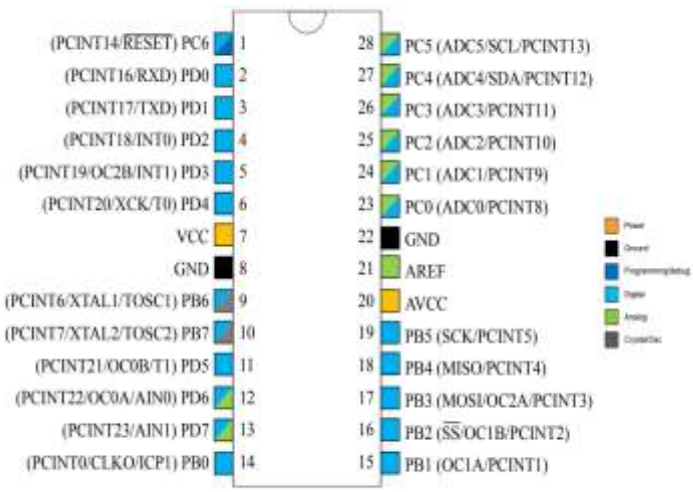

Fig. 28-pin PDIP

B. Software requirements

The system utilizes various software tools and libraries, including Arduino IDE (v1.8.x) for code development and uploading, the MFRC522 RFID library for interfacing with the RFID reader, and the LiquidCrystal_I2C library for controlling the LCD display. The programming is done in C/C++ using libraries such as SoftwareSerial for communication with the GSM module, NewPing for the ultrasonic sensor, and the FSR library for force sensors. Additionally, communication protocols like I²C, SPI, and UART are employed to manage data transfer between modules.

IV. SYSTEM DESIGN

The system architecture consists of three main components: the microcontroller (Arduino Uno), the RFID module (MFRC522), and the GSM module (SIM800L). The Arduino Uno acts as the central processing unit, managing inputs from the RFID, ultrasonic, and force sensors, while controlling the output to the LCD display and sending SMS alerts through the GSM module. Data from the RFID reader is used for identification, and the ultrasonic sensor determines the distance of any object or person approaching the system. The force-sensitive resistor (FSR) detects pressure or force applied to the system, which is then used to trigger specific actions. The LCD display is used for showing real-time feedback to the user, such as access confirmation or status messages. Communication between the various components is achieved using the appropriate communication protocols such as SPI for the RFID module and UART for the GSM module.

V RESULTS AND DISCUSSION

The Smart Visitors Guidance Robot was tested in a simulated hospital corridor featuring multiple turns and obstacles. Across numerous trial runs, the robot consistently reached its RFID-defined destinations, demonstrating reliable navigation performance. In trials where obstacles were placed unexpectedly close together, the robot's distance sensors briefly misread the surroundings; this was later addressed by fine-tuning the obstacle-avoidance parameters.

Obstacle detection was evaluated by introducing various stationary objects along the path. The ultrasonic sensors effectively detected and avoided these obstructions, confirming robust real-time collision prevention. Emergency alert functionality was validated by triggering the system via the touch sensor; in every test, the robot successfully transmitted an SMS alert to a caregiver's phone within a few seconds, ensuring timely communication.

Power endurance was assessed under mixed operational conditions (intermittent navigation and idle periods). The robot maintained continuous operation throughout a typical hospital shift rotation before requiring recharge, indicating that the chosen battery pack and power-management strategy are suitable for real-world use. The 16×2 LCD provided clear status updates at each stage, and feedback from volunteer users confirmed that the interface was intuitive and easy to understand.

Discussion. These findings confirm the robot's core capabilities—RFID-based navigation, dependable obstacle avoidance, prompt emergency alerts, and sufficient operational endurance. The minor navigation hiccups in highly cluttered scenarios highlight opportunities to incorporate additional sensors or adaptive path-replanning algorithms. Future enhancements could include broader sensor coverage and optional patient-vital monitoring to further improve safety and functionality. Overall, the prototype meets its design objectives and shows strong promise for deployment in hospital environments.

VI CONCLUSION

The Smart Visitors Guidance Robot presented in this work successfully integrates low-cost, widely available hardware and straightforward software algorithms to deliver reliable indoor navigation, obstacle avoidance, and emergency alerting within hospital environments. Leveraging RFID-based localization, ultrasonic sensing for collision prevention, and a human-touch activation mechanism, the prototype demonstrated consistent guidance performance and robust safety features. Real-time status feedback via a 16×2 LCD display and prompt SMS alerts through a GSM module further enhance user confidence and caregiver responsiveness. The system's rechargeable power source provides adequate operational endurance for routine healthcare shifts, while its modular design permits easy scaling and future integration of additional sensors (e.g., patient-vital monitors) or advanced navigation strategies. Overall, this cost-effective and user-centered solution meets the identified needs for efficient visitor assistance and emergency support in resource-constrained medical settings, laying the groundwork for further development and clinical evaluation.

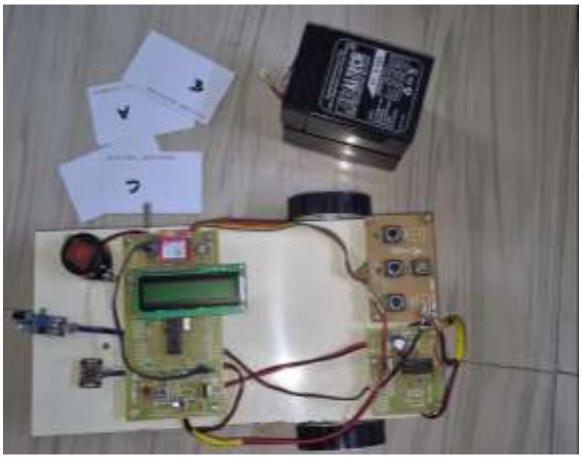

Fig. Prototype of Guidance robot

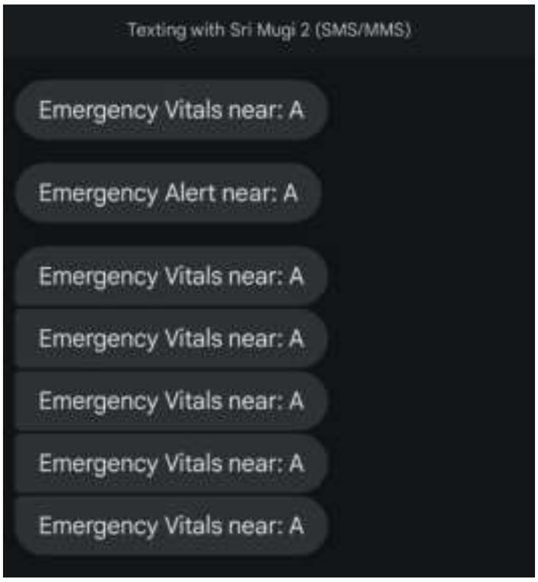

Fig. Output of the Alert system

VII REFERENCES

[1] H. Lin, J. Wang, Y. Zhan and Y. Zhang, "Tour Guide Robot Based on Large Language Model and User Behavior Analysis," 2024 5th International Conference on Artificial Intelligence and Computer Engineering (ICAICE), Wuhu, China, 2024, pp. 794-798, doi: 10.1109/ICAICE63571.2024.10864058.

[2] G. Yang et al., "A Digital Twin-Based Large-Area Robot Skin System for Safer Human-Centered Healthcare Robots Toward Healthcare 4.0," in IEEE Transactions on Medical Robotics and Bionics, vol. 6, no. 3, pp. 1104-1115, Aug. 2024, doi: 10.1109/TMRB.2024.3421635.

[3] H. Wang, T. Tao, H. Zhang and C. Yao, "Vision-Guided Nucleic Acid Detection and Sampling Robot," 2024 IEEE 2nd International Conference on Image Processing and Computer Applications (ICIPCA), Shenyang, China, 2024, pp. 835-840, doi: 10.1109/ICIPCA61593.2024.10709201.

[4] A. Skrede, A. F. Dalen, A. I. Hellevik, Ø. Stavdahl and R. T. Bye, "Quantifying Passive Biomechanical Stability Using an Industrial Robot: Development and Experimental Validation of a Task Space Motion Framework," in IEEE Access, vol. 12, pp. 29397-29413, 2024, doi: 10.1109/ACCESS.2024.3368390.

[5] L. Lei et al., "Robotic Needle Insertion With 2D Ultrasound–3D CT Fusion Guidance," in IEEE Transactions on Automation Science and Engineering, vol. 21, no. 4, pp. 6152-6164, Oct. 2024, doi: 10.1109/TASE.2023.3322710.

[6] L. Connolly et al., "SlicerROS2: A Research and Development Module for Image-Guided Robotic Interventions," in IEEE Transactions on Medical Robotics and Bionics, vol. 6, no. 4, pp. 1334-1344, Nov. 2024, doi: 10.1109/TMRB.2024.3464683.

[7] T. Chen et al., "Real-Time Deformable Registration for Robotic Ultrasound Surgical Guidance Based on Vectorized Trust-Region Optimization," in IEEE Transactions on Instrumentation and Measurement, vol. 73, pp. 1-11, 2024, Art no. 5023311, doi: 10.1109/TIM.2024.3413148.

[8] X. Xiao et al., "Ultrasound Robotic System to Multi-Approach Puncture for Endoscopic Spinal Surgery," in IEEE Robotics and Automation Letters, vol. 9, no. 10, pp. 9119-9126, Oct. 2024, doi: 10.1109/LRA.2024.3440090.

[9] K. Li, A. Li, Y. Xu, H. Xiong and M. Q. . -H. Meng, "RL-TEE: Autonomous Probe Guidance for Transesophageal Echocardiography Based on Attention-Augmented Deep Reinforcement Learning," in IEEE Transactions on Automation Science and Engineering, vol. 21, no. 2, pp. 1526-1538, April 2024, doi: 10.1109/TASE.2023.3246089.

[10] B. Luciani, M. Sommerhalder, M. Gandolla, P. Wolf, F. Braghin and R. Riener, "Therapists' Force-Profile Teach-and-Mimic Approach for Upper-Limb Rehabilitation Exoskeletons," in IEEE Transactions on Medical Robotics and Bionics, vol. 6, no. 4, pp. 1658-1665, Nov. 2024, doi: 10.1109/TMRB.2024.3464697