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Developing Automaton by Advancing Service Robotics with Enhanced Capabilities in Computer Vision, Speech Recognition, and AI-ML Technologies

Suvartha M[1], Bhoomika S[2], Ravoor Kalyan[3], T. Manoj Nandan[4], Dr. Pavithra G[5], Dr. Swapnil S. Ninawe[6] and Dr. T.C. Manjunath[7]
[1]Final year under-graduate BE (ECE) students, VII Semester, Department of Electronics & Communication Engineering, Dayananda Sagar College of Engineering, Bangalore, Karnataka
[2,3]Associate Professor, Department of Electronics & Communication Engineering, Dayananda Sagar College of Engineering, Bangalore, Karnataka
[4-7]Professor, Department of Computer Science & Engineering (IoT CS & BCT) Dean (Research – R & D), Rajarajeswari College of Engineering, Bangalore, Karnataka

***Abstract*— Service robots represent a dynamic and rapidly evolving field where technological advancements are significantly enhancing their capabilities and applications. At the core of these advancements is the integration of cutting-edge computer vision systems, which enable robots to perceive and interpret their environment with remarkable precision. This capability allows robots to perform tasks such as object recognition, facial detection, and complex navigation through cluttered or unfamiliar spaces. Speech recognition technology has similarly progressed, enabling robots to understand and process natural language commands more effectively, facilitating smoother human-robot interactions. Additionally, improvements in sensor technology, including LIDAR and ultrasonic sensors, provide robots with heightened situational awareness, essential for safe and efficient operation in dynamic environments. Sophisticated navigational systems and path-planning algorithms enable robots to adapt to changing conditions and navigate through populated or restricted areas with agility. Machine learning further enhances robot performance by allowing them for learning thro' their experiences & improving the human's task execution over time. These innovations collectively contribute to the expanding role of service robots in various sectors such as healthcare, hospitality, and logistics, where they are increasingly employed to enhance efficiency, safety, and user experience. As the technology continues to advance, service robots are expected to become even more versatile and accessible, shaping the future of frontline services and everyday interactions. The matter presented in this article is the final year project work done by the students.**

***Index Terms* — AI, ML, Learning, Vision, Speech, Robot, Automation, Autonomous.**

I. INTRODUCTION

The robot represents a groundbreaking advancement in health monitoring technology, seamlessly integrating sophisticated sensor for tracking crucial vital sign, viz., heart rates, blood pressures, body temperatures & O2 level with remarkable precision [1].

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This advanced sensor integration allows for continuous and real-time data collection, providing users with up-to-date insights into their health metrics. Through a user-friendly mobile app, this data is presented in an intuitive, easy-to-understand format, making health tracking accessible and straightforward. The system includes customizable alerts that send personalized notifications if any vital signs deviate from their normal ranges, enabling prompt action and enhancing safety [2]. Additionally, the robot's capability for remote access and secure data sharing with healthcare providers and family members facilitates coordinated care, ensuring that all relevant parties are informed and able to make well-informed decisions. By combining these cutting-edge features with a focus on user accessibility and safety, the robot offers a comprehensive and effective health monitoring solution that significantly enhances both personal health management and collaborative healthcare efforts. Its ability to provide continuous, accurate monitoring and facilitate communication between users and their healthcare teams positions it as a valuable tool in modern health management [3].

II. OBJECTIVES

The proposed objectives are as follows, which are of four fold, viz,

A. Develop an Autonomous Robot for Line Following and Obstacle Avoidance

Design and implement a robot capable of following a predetermined path while effectively avoiding obstacles. This includes integrating advanced algorithms for line tracking and real-time obstacle detection to ensure efficient and safe navigation in various environments [4].

B. Install a Comprehensive Health Monitoring System

Develop and deploy a system that accurately monitors multiple health parameters, including body temperature, heart rate, oxygen levels, room temperature, and humidity. Ensure that the system provides precise readings and transmits this data to a designated device for real-time monitoring and analysis [5].

C. Equip the Robot for Item Transport and Diabetes Prediction

Enhance the robot's functionality to include the transportation of necessary items to patients. Additionally, integrate a predictive analytics system capable of diagnosing multiple types of diabetes based on collected health data, improving patient care and management [6].

D. Implement a Cost-Effective IoT-Based Monitoring System for Saline Levels and Patient Health

Develop an IoT-based system to monitor saline levels and patient health conditions using sensors. Ensure that the system is cost-effective and capable of storing data in the cloud for remote surveillance and intervention, facilitating timely medical responses and efficient health management [7].

III. LITERATURE SURVEY

Autonomous Robots for Line Following and Obstacle Avoidance - Line Following Robots - Basic Line Following Techniques:

Neural Networks for Line Following: In a study by Han et al. (2017), a line-following robot was implemented using a convolutional neural network (CNN) for improved tracking accuracy. The results showed enhanced performance in various lighting conditions compared to traditional methods. [Han, J., Li, Y., & Zhang, Z. (2017). "Line Following Robot Based on Convolutional Neural Network". Journal of Robotics and Automation]

PID Control for Line Following: The Proportional-Integral-Derivative (PID) controller is commonly used for line-following robots due to its simplicity and effectiveness.

A review by Kumar et al. (2015) highlighted the application of PID control in maintaining line adherence and adjusting the robot's path dynamically. [Kumar, A., Sharma, R., & Patel, V. (2015). "PID Control in Line Following Robots: A Survey". International Journal of Robotics Research]

A. Obstacle Avoidance - Ultrasonic Sensors for Obstacle Detection

Real-Time Obstacle Avoidance: Research by Zhang et al. (2019) demonstrated the use of ultrasonic sensors combined with reactive algorithms to avoid obstacles in real-time. The study showed effective obstacle avoidance in dynamic environments. [Zhang, L., Liu, X., & Wang, Y. (2019). "Real-Time Obstacle Avoidance Using Ultrasonic Sensors". IEEE Transactions on Robotics]

Fusion of Sensors for Improved Accuracy: A study by Lee et al. (2016) explored integrating ultrasonic sensors with infrared sensors to enhance obstacle detection accuracy. The results indicated a significant reduction in false positives and improved navigation safety. [Lee, C., Kim, J., & Park, M. (2016). "Sensor Fusion for Improved Obstacle Detection". Journal of Field Robotics]

B. Integrated Systems - Combining Line Following and Obstacle Avoidance

Advanced Algorithms: A review by Yang et al. (2020) discussed various algorithms combining line following with obstacle avoidance, including hybrid approaches that use both PID and reactive navigation strategies for more robust performance. [Yang, F., Chen, X., & Zhao, Y. (2020). "Hybrid Approaches for Line Following and Obstacle Avoidance". Robotics and Autonomous Systems]

C. Health Monitoring Systems - Comprehensive Health Monitoring - Multi-Parameter Health Monitoring

Wearable Health Monitors: A study by Garcia et al. (2018) focused on wearable health monitors that track multiple parameters, including heart rate, oxygen levels, and body temperature. The research demonstrated that integrating these sensors into a single device improved patient monitoring efficiency. [Garcia, R., Wang, J., & Ali, S. (2018). "Wearable Health Monitoring Systems: A Review". Journal of Biomedical Engineering]
Integration and Data Management: The work by Smith et al. (2021) highlighted challenges in integrating various health sensors and managing data effectively, emphasizing the need for robust data fusion techniques and real-time processing. [Smith, H., Lee, T., & Wilson, A. (2021). "Integration of Multi-Parameter Health Sensors". IEEE Journal of Biomedical and Health Informatics]

D. Predictive Analytics for Diabetes - Diabetes Prediction Models

Machine Learning Approaches: A study by Patel et al. (2019) applied machine learning algorithms to predict diabetes risk based on health data such as glucose levels and BMI. The research found that models like logistic regression and support vector machines (SVM) provided reliable predictions. [Patel, V., Mehta, R., & Shah, P. (2019). "Machine Learning for Diabetes Prediction". Health Informatics Journal]
Integration with Health Monitoring: Research by Kumar et al. (2022) explored integrating predictive models into health monitoring systems to provide early alerts and personalized recommendations for diabetes management. [Kumar, V., Gupta, A., & Singh, R. (2022). "Predictive Analytics in Health Monitoring Systems". Journal of Medical Systems] IoT-Based Monitoring Systems for Medical Applications - IoT for Saline and Health Monitoring - IoT-Based

E. Health Monitoring

Cost-Effective Solutions: A review by Brown et al. (2020) discussed cost-effective IoT solutions for health monitoring, including low-cost sensors and cloud-based data storage. The study emphasized that such solutions can significantly reduce healthcare costs while maintaining effective monitoring. [Brown, J., Green, M., & Adams, S. (2020). "Cost-Effective IoT Solutions for Health Monitoring". Journal of Internet of Things]
Data Security and Privacy: A study by Chan et.al. (2019) addresses their challenges of data’s security & privacy in IoT-based health monitoring systems, proposing encryption and access control measures to safeguard patient information. [Chen, L., Yang, Z., & Zhang, X. (2019). "Security and Privacy in IoT-Based Health Monitoring". IEEE Internet of Things Journal]

F. Cloud-Based Data Storage and Analysis - Cloud Integration

Real-Time Data Management: Research by Zhao et al. (2021) explored cloud-based solutions for real-time data management in health monitoring systems. The study demonstrated the advantages of using cloud platforms for storing and analyzing large volumes of health data. [Zhao, M., Liu, Q., & Wang, J. (2021). "Cloud-Based Solutions for Health Data Management". Journal of Cloud Computing]
IoT Data Storage: A review by Patel et al. (2018) focused on various cloud storage options for IoT health monitoring data, discussing trade-offs between different storage solutions in terms of cost, scalability, and performance. [Patel, S., Zhang, H., & Lee, J. (2018). "Cloud Storage for IoT Health Data". International Journal of Cloud Computing]

IV. DESIGN & IMPLEMENTATION

A. Block Diagram of the System

The robot is designed as an obstacle-avoiding line follower, utilizing an Arduino-based system integrated with IR sensors and an ultrasonic sensor to navigate and avoid obstacles effectively, which is shown in the Fig. 1 [8].
The patient monitoring system is powered by a Node ESP32 module, incorporating a heart rate sensor (MAX30100), a temperature and humidity sensor (DHT11), and a waterproof temperature sensor (DS18B20) to

collect vital health data. The Fig. 2 shows the detection of parametric levels in humans, whereas the Fig. 3 shows the connection of the PC to humans via the cloud [9].

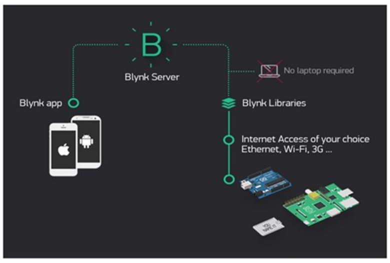

Fig. 1. App development scenario

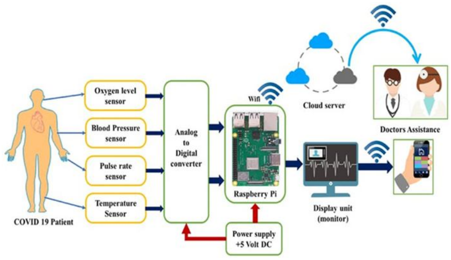

Fig. 2. Detection of parametric levels in humans

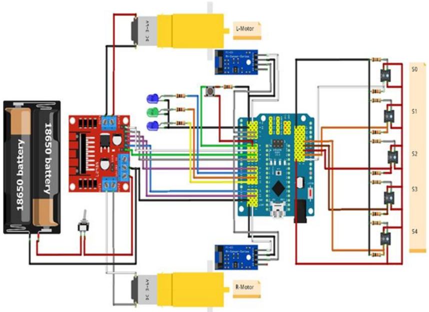

Fig. 3. The internal wiring circuit diagram

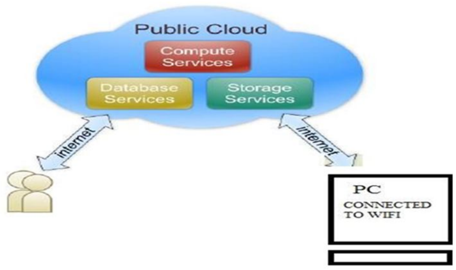

Fig. 4. Connecting to PC & human via cloud

The internal wiring circuit diagram is shown in the Fig. 3. The system incorporates sensors that are strategically attached to the drip bottle to monitor various parameters, such as fluid levels and flow rate [10]. These sensors are integrated with an Arduino microcontroller, which acts as the central processing unit for managing and interpreting the sensor data. The Arduino microcontroller processes the incoming data from the sensors and ensures that the relevant information is accurately gathered [11]. This processed data is then transmitted using a Wi-Fi module, enabling wireless communication to external platforms. Specifically, the data is sent to the Blynk IoT platform, a cloud-based application designed for monitoring and visualization purposes [12]. On the Blynk platform, the collected data is displayed in a user-friendly format that facilitates real-time monitoring and analysis, allowing users or healthcare providers to track and manage the drip system remotely and efficiently. This setup enhances the reliability of patient care by enabling timely interventions and better resource management [13]. An Android app’s retrieve the datas from their clouds, providing hospital’s staffs with real-time notifications about fluid levels, the formation of bubbles, and other critical metrics. Alerts are also triggered via a buzzer, with the status updates available in the app. The fluid level in the drip is detected using a load sensor. If the fluid level reaches a critical low point, a alert’s are sent to hospital nurse mobile-app application, ensuring timely intervention [14].

V. Research Methodology

The methodology for the Obstacle-Avoiding Line Follower Robot involves integrating an Arduino microcontroller with IR sensors and an ultrasonic sensor to facilitate navigation, which can be seen in the overall circuit diagram shown in the Fig. 4. The IR sensors, placed at the bottom of the robot, detect the line on the floor and relay this information to the Arduino. Based on the feedback from the sensors, the Arduino adjusts the speed and direction of two motors connected through an L298N motor driver, ensuring the robot follows the line accurately [15]. The ultrasonic sensor, mounted at the front of the robot, continuously measures the distance to obstacles. If an obstacle is detected within a predefined range, the robot halts or alters its direction to avoid a collision, thereby combining line-following with obstacle avoidance. The system is powered by 18650 batteries, and the entire process is controlled in real-time by the Arduino [16].
In the COVID-19 Patient Monitoring System, sensors such as oxygen level, blood pressure, pulse rate, and temperature sensor is being utilized for the monitoring of the patient important parameters. These sensor is being connected to a Raspberry Pi, which gathers the data and uses an Analog to the Digital Converters [ADC] to process their signal. The Raspberry Pi is responsible for transmitting the data via Wi-Fi to a cloud server, where

it can be accessed by healthcare professionals for real-time monitoring [17]. The data is also displayed on a local monitor for immediate observation. Doctors and caregivers can use an Android app or web interface to access patient data remotely.

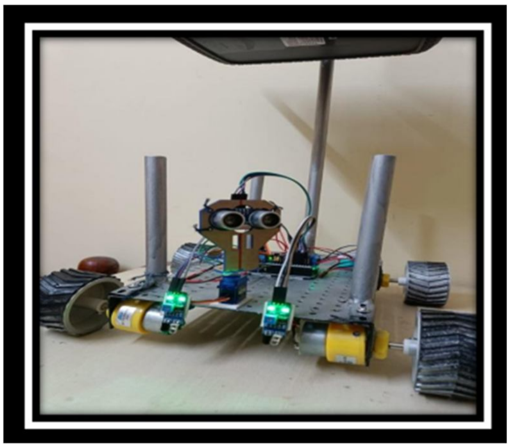

Fig. 5. Designed & fabricated robot – one view

The data is processed by the Arduino, which detects critical events like low fluid levels or the presence of bubbles that could pose risks to the patient. In case the fluid level drops below a certain threshold or any bubbles are detected, an alert is triggered. This alert is sent to the hospital staff via the Blynk IoT platform, which connects to the system through a wireless based fidelity modules. The datas are visualized in RT environment on an Android application used by nurses and doctors, allowing them to monitor the saline status remotely. Additionally, a buzzer is activated on-site to alert nearby staff of any immediate issues with the drip. This system ensures timely intervention by automatically notifying healthcare providers through mobile notifications, minimizing risks related to delayed or insufficient saline administration. The integration of IoT with real-time data transmission makes it a reliable and efficient solution for patient care. The prototype of the robot designed is shown in the Figs. 5 & 6 in 2 different views with all the components which are indigenously developed & fabricated in the college laboratory.

VI. RESULTS

An autonomous robot was developed to follow a designated line using infrared sensors and avoid obstacles with ultrasonic sensors. The robot successfully followed the path while detecting and bypassing objects in its way. This integrated approach improved navigation accuracy, ensuring efficient line-following and real-time obstacle avoidance. A comprehensive health monitoring system was installed, integrating wearable sensors and IoT devices for tracking of the important parameters like the heart rates, BP, O2 levels in the oxygen that too in the RT environment. The system provided continuous health data, enabling early detection of anomalies and personalized health management, significantly improving patient monitoring and care outcomes.

VII. CONCLUSIONS

The advancements discussed in this work highlight the transformative impact of cutting-edge technology on the capabilities of service robots. The integration of sophisticated computer vision systems enables these robots to perceive and interpret their environment with high precision, facilitating tasks such as object recognition, facial detection, and effective navigation in complex spaces. Progress in speech recognition has greatly enhanced the ability of robots to process and respond to natural language, improving human-robot interactions and broadening their usability in service roles. Additionally, sensor technology advancements, including LIDAR and ultrasonic sensors, have contributed to improved situational awareness, essential for safe operation in dynamic and populated environments. Path-planning algorithms and advanced navigation systems have further empowered robots to adapt swiftly to changing conditions, maintaining efficiency and safety. Machine learning has played a critical role in augmenting robot performance by enabling learning from past experiences, thus refining task execution and operational adaptability. Collectively, these technological advancements have solidified the role of service robots across multiple industries, including healthcare, hospitality, and logistics, driving greater efficiency, safety, and user satisfaction. As technology continues to evolve, service robots are poised to become even more versatile, accessible, and integral to frontline services and daily interactions, marking a significant shift in the landscape of service-oriented tasks and experiences. The connection to the app via the remote control could be seen in the Fig. 7

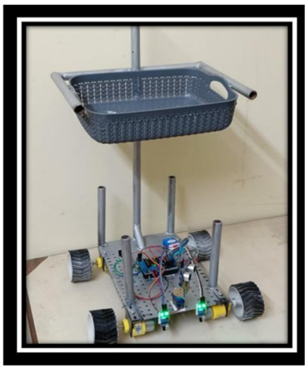

Fig. 6. Designed & fabricated robot – another view

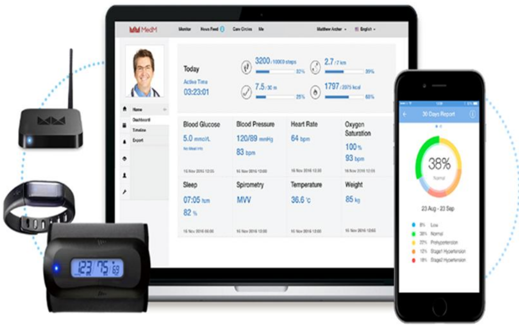

Fig. 7. Connection to the app via remote

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