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IoT-BASED ASSISTANT TEACHER ROBOT

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ABSTRACT

The Internet of Things (IoT) in the education sector has provided new learning opportunities. This paper discusses an IoT-based Assistant Teacher Robot that assists teachers in monitoring activities, such as student attendance, delivering instructions, and communicating with students. The robot is constructed using an ESP32 microcontroller with components such as an LCD, ultrasonic sensor, camera, Wi-Fi and Bluetooth modules, DC motors, an RFID module, and an L298N motor driver. The robot utilizes IoT connectivity to access online learning materials, respond to students' queries, and provide real-time feedback. The camera and sensors enable navigation, obstacle detection, and classroom monitoring while enabling smooth Teacher and student interaction. Remote updating and control are facilitated by wireless communication. This assistant robot minimizes the teacher's workload, and students become more active. This Assistant Teacher Robot facilitates an interactive and productive learning process. The system exhibits the potential of IoT and robotics in the contemporary education sector, facilitating intelligent classrooms.

KEYWORDS: *Internet of Things, Education, Assistant Teacher Robot, Intelligent Classroom.*

1. INTRODUCTION

In the fast-changing educational scenario, integrating technology has become a necessity to advance the learning process and enable educators to provide effective teaching. Among the most promising innovations in this field is the IoT Assistant Teacher Robot — an intelligent, interactive, and smart classroom buddy that helps teachers, communicates with students, and fosters a more efficient and dynamic learning process. IoT Assistant Teacher Robot uses the Internet of Things (IoT), artificial intelligence (AI), and smart sensors to communicate with the students, gather information, and learn about the needs of the classroom. The robot is capable of doing a variety of activities, ranging from attendance taking, student monitoring, answering questions, quizzes, and even assisting in the delivery of lessons with voice and visual supports.

Through automation of routine tasks and provision of real-time information, the Assistant Teacher Robot not only decreases the burden on teachers but also individualizes the learning experience for every student. Its integration with cloud platforms enables easy updates, data storage, and remote access, making it a precious resource in contemporary smart classrooms. The education sector is also facing a drastic change as a result of rising class sizes, student diversity, and the growing demand for personalized education. Conventional classroom structures based on one instructor performing multiple roles for dozens of students tend to struggle with staying efficient, focused, and engaged. This has generated rising anxieties over students' performance, teachers' exhaustion, and differential access to good-quality education. Teachers are often tasked with repetitive clerical tasks like taking attendance, grading papers, preparing course materials, and managing classroom behavior — all of which take precious time that might otherwise be used for teaching and student interaction.

In addition, in most areas, there is a lack of trained teachers, particularly in rural or underdeveloped communities, placing even more pressure on the education system. Paralleling this, the rise of smart technologies and IoT (Internet of Things) has presented new opportunities for automation, data collection, and real-time analytics across industries — including education. Yet, implementing such technologies within classrooms is in its initial stages, and institutions still do not have affordable, scalable solutions that elegantly fit into the learning ecosystem.

2. PROBLEM STATEMENT

In many educational institutions, especially in under-resourced or large classrooms, teachers face challenges in managing routine tasks such as attendance tracking, student engagement, and providing personalized support. Manual processes are time-consuming and reduce the time available for effective teaching. Additionally, students may hesitate to ask questions in class, limiting their learning experience. There is a need for an interactive, automated solution that can assist teachers by handling repetitive tasks, engaging students, and providing real-time support. This project aims to address these challenges by developing an IoT-based Assistant Teacher Robot that can detect student presence, record attendance, interact with students through voice and text, and utilize cloud-based AI to answer queries and conduct quizzes. By integrating IoT devices, speech recognition, and AI-driven responses, the system enhances classroom efficiency, supports teachers, and encourages student participation.

3. OBJECTIVES

In modern classrooms, there is an increasing demand for smart solutions to support teachers and enhance the learning experience. Teachers often spend valuable time on repetitive

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tasks such as taking attendance, answering frequently asked questions, and managing student engagement. This can limit personalized interaction and reduce teaching efficiency. Additionally, students may feel shy or hesitant to ask questions, which can hinder their learning. An IoT-based Assistant Teacher Robot provides a solution by automating routine classroom activities and offering interactive support using voice and AI. It ensures efficient attendance tracking, encourages student participation, and provides instant answers to queries through a cloud-connected AI system. Such a system not only reduces the teacher's workload but also makes learning more engaging, inclusive, and accessible. The need for this project is driven by the goal of creating smarter, more interactive classrooms that bridge the gap between technology and education.

4. LITERATURE SURVEY

In research paper, IoT based Virtual classroom [1], M. Kalimuthu et al. (2016) emphasized on the use of raspberry pi along with webcam which records the lectures for live streaming and also it uploads it to the cloud storage automatically to watch later. This system can greatly improve the learning, among the students.

In a study of Service Robot teaching Assistant in classroom [3], Anna-Maria Velentza et al. (2020) compared the students' attitudes regarding the use of service robots in education before and after having a class with the STIMEY robot in the role of their teacher' assistant. Results shown that the use of TAR can motivate students to follow a career in subjects that they find difficult and make those subjects more easily understandable.

The educational IoT tools and technologies that simplify the design, implementation, and testing of IoT applications are presented in research paper [6], Hercog D. et al. (2023).

In research paper [7], V. Pavani et al. (2024) highlights how ambient technologies like robotics and the internet of things (IoT) can replace screen-based interaction by integrating the user interface with the actual device.

Due to limitations in current systems, most current educational robots are either too expensive, limited in functionality, or difficult to integrate into existing school infrastructure. There is a gap in research on affordable, IoT-enabled assistant teacher robots that provide practical, real-time classroom support across various age groups and subjects.

With the development of the Internet of Things (IoT) and robots, the education system is shifting towards smart classrooms. This project presents an IoT-based Assistant Teacher Robot that will help teachers by performing tasks like providing instructions, observing students, and communicating with students.

5. METHODOLOGY

The methodology adopted in the development of the IoT-Based Assistant Teacher Robot is modular and iterative, combining embedded system design, IoT communication, cloud integration, and AI-based interaction. The objective is to create a robot capable of assisting teachers by detecting students, taking attendance, answering questions through AI, and conducting basic educational interactions. The broad intention was to develop an intelligent assistant that could recognize students, mark attendance, provide voice-based interaction, and offer education-based responses. The work began with an intense analysis of the problem and determining the system requirements. Major features like student detection, RFID-based attendance, voice interaction through a microphone and speaker, cloud-based speech processing, AI-driven responses, LCD output, and minimal obstacle detection and mobility were considered core elements.

6. PROBLEM ANALYSIS

The initial stage involves analyzing the needs of an assistant teacher robot. Based on the objectives, the following requirements were identified:

- Ability to detect the presence of students
- Automatic attendance using RFID technology
- Voice interaction using a microphone and LCD
- Cloud-based speech processing and AI response
- Display outputs via LCD
- Movement and obstacle detection

7. BLOCK DIAGRAM

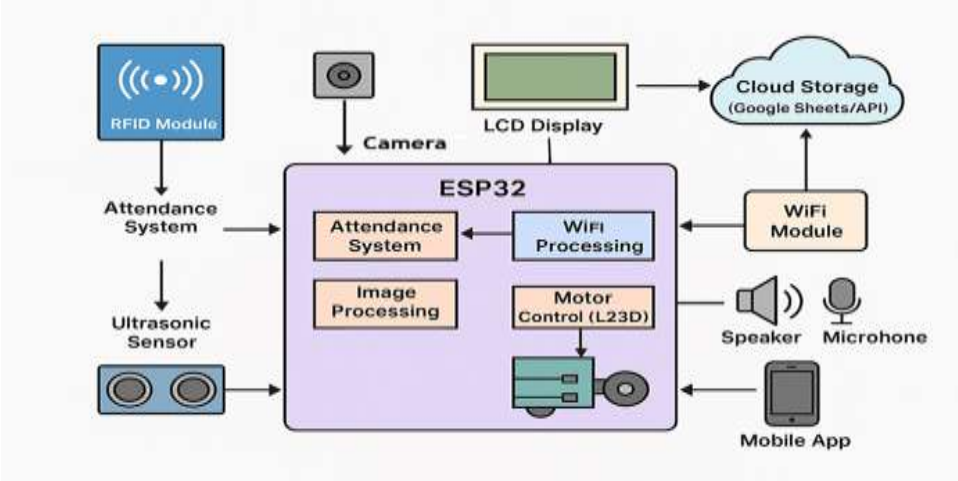

Fig. 1 IoT-Based Assistant Teacher Robot block diagram

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• The core controller of the robot is the ESP32, which manages key sensory and data handling functions.
• One of the primary features is the ultrasonic sensor, which is used for obstacle detection; it continuously sends distance measurements to the ESP32, allowing the robot to detect objects in its path and avoid collisions during movement.
• Another major component is the RC522 RFID module, which is used for automating student attendance. Each student carries an RFID card, and when the card is scanned by the module, the ESP32 reads the student's ID, confirms the attendance, displays a message on the LCD screen, and sends the data to the cloud for real-time record-keeping.
• The LCD is also used to show important information such as attendance confirmation, obstacle alerts, or other system messages, making it easier for students and teachers to interact with the robot.
• The robot is equipped with an INMP441 I2S digital microphone, which allows it to capture high-quality audio. This microphone can be used for basic voice input or announcements and may be expanded to support voice command features in the future using AI-based processing.
• The camera can be used to capture images for image processing required for face identification, in future.
• Mobility is managed separately using an Arduino Uno (ATmega328P), which controls the robot's wheels through an L298N / L23D motor driver. The movement commands are sent wirelessly via a Bluetooth module (HC-05), which is paired with a smartphone. This allows the user to direct the robot to move forward, backward, or turn, adding flexibility in navigation.
• While ESP32 handles all sensing, communication, and data processing, Arduino Uno is dedicated to physical movement, ensuring smooth and reliable robot operation.

The IoT-based Assistant Teacher Robot is an intelligent and interactive system designed to assist in educational environments by automating basic classroom interactions. It utilizes an ESP32 microcontroller as the core controller, interfacing with several components to simulate the behaviour of a teaching assistant. The system begins with an ultrasonic sensor that continuously monitors for nearby movement. When a student approaches, the sensor detects their presence based on distance and activates a 16x2 I2C LCD to greet the student with a message like "Hello." Once the student is in range, they are prompted to scan their RFID card using the RC522 RFID module. The ESP32 reads the RFID data and logs attendance either locally or by sending the data to the cloud, such as Google Sheets via Google Apps Script.

In addition to attendance, the robot is designed for interactive Q&A. A microphone module (e.g., INMP441) records the student's voice. This audio is then sent over Wi-Fi to cloud-based services like Google Cloud Speech-to-Text for conversion into text. The text question is processed using AI models like Gemini Pro or ChatGPT to generate an appropriate response. The answer is then displayed on the LCD and can optionally be played back via a speaker using a text-to-speech system.

This project combines hardware and cloud intelligence to mimic real-world teacher-student interaction, offering functions like automatic attendance, real-time voice-based Q&A, and obstacle awareness. It showcases the use of IoT in smart education and opens possibilities for more accessible and engaging learning environments.

8. RESULT

The IoT-Based Assistant Teacher Robot project effectively illustrates how automation and interaction from smart technology may improve learning environments. The system effectively used RFID to record student attendance, ultrasonic sensors to identify presence, and a microphone to capture queries and process them in the cloud for real-time responses. The robot was able to properly explain its responses due to the integration of an LCD and speaker, and its mobility and ability to avoid obstacles allowed it to navigate the classroom with ease. With response times of three to five seconds, the project achieved great accuracy in speech recognition and attendance tracking. With all factors considered, the robot proved to be an effective and engaging assistant that can assist educators, keep students engaged, and demonstrate the usefulness of IoT and AI in education.

9. CONCLUSION

The IoT-based assistant teacher robot is a revolutionary technology that maximizes the learning experience through the application of smart technologies. With an ESP32 controller, LCD, ultrasonic sensors, a camera, Wi-Fi and Bluetooth modules, an RFID module, and motorized wheels as its components, the robot is able to carry out interactive teaching, student monitoring, and movement.

The robot is suitable for today's education sector because of its connectivity feature, which enables remote access, real-time data transfer, and learning modification. The robot encourages involvement and accessibility, especially in isolated and underdeveloped locations, with its autonomous movement, obstacle recognition, and student interaction capabilities.

Overall, this project highlights what's possible when IoT and robotics are used in education. It offers a scalable, effective, and fun alternative to traditional teaching methods. In the future, features like smarter speech recognition, gesture controls, and improved sensors could make learning even more personalized.

10. Future Scope

The future looks bright for IoT-based assistant teacher robots, especially as AI, cloud computing, and automation keep getting better. These robots could soon offer even more student-centered learning by adapting lessons, understanding speech, and giving instant feedback. With cloud and big data, they'll be able to track student progress, help with grading, and provide useful insights. IoT sensors will keep making classrooms smarter and more connected, while features like AR/VR and multi-language support could make learning even more immersive and inclusive. As these technologies evolve, assistant teacher robots could truly transform how we teach and learn.

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