Princess Sumaya University for Technology

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Embedded Systems Project Proposal

Autonomous RC Medical Assistance Car

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Abstract

This report details the development of the Autonomous RC Medical Assistance Car, a project designed to address critical medical needs in emergency scenarios, particularly in hazardous or hard-to-reach environments. The vehicle operates autonomously using ultrasonic sensors for obstacle detection and features Bluetooth control for seamless integration with modern devices.

Key features include real-time environmental monitoring using temperature and humidity sensors, a medical fridge to maintain optimal storage conditions for emergency supplies, and an efficient power management system to ensure extended operation. By integrating advanced embedded systems and sensor technologies, the car delivers reliable performance and adaptability in diverse scenarios. This innovative design enhances the effectiveness of medical response and demonstrates practical applications of embedded systems in addressing real-world challenges.

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Introduction

Emergencies often demand swift and efficient responses, particularly in hazardous or inaccessible environments. Traditional methods of providing medical assistance face challenges such as limited accessibility, time constraints, and inefficiencies in disaster-stricken or crowded areas. Addressing these challenges requires innovative solutions that leverage advanced technologies.

The Autonomous RC Medical Assistance Car offers a practical and versatile solution designed to deliver timely medical aid during emergencies. This vehicle combines modern embedded system technologies with an intuitive design, enabling autonomous navigation, environmental monitoring, and Bluetooth-based remote control. Key features, such as ultrasonic sensors for obstacle detection, a medical fridge for preserving supplies, and adaptive lighting using an LDR with PWM, enhance the system's performance in diverse conditions.

Replacing traditional remote-control mechanisms with Bluetooth-based control allows seamless operation through smartphones or other devices. Additionally, the adaptive lighting system adjusts brightness according to environmental conditions, ensuring optimal visibility. This innovative solution demonstrates the practical application of embedded systems in creating cost-effective and scalable tools for real-world emergencies.

Goals

The Autonomous RC Medical Assistance Car aims to:

1. **Enable Autonomous Navigation**
   Use ultrasonic sensors to detect obstacles and navigate safely in dynamic environments.
2. **Provide Remote Control via Bluetooth**
   Allow seamless operation through smartphones or other devices.
3. **Monitor Environmental Conditions**
   Utilize temperature and humidity sensors for real-time data collection and effective operation in extreme conditions.
4. **Preserve Medical Supplies**
   Integrate a medical fridge to maintain optimal conditions for tools and medicines.
5. **Implement Adaptive Lighting**
   Adjust lighting dynamically with an LDR and PWM to ensure visibility in varying brightness levels.
6. **Optimize Power Efficiency**
   Use a rechargeable battery and power management system for extended operation.
7. **Ensure Scalability and Practicality**
   Design a cost-effective, versatile system suitable for various emergency scenarios.

Components Used

1. **Microcontroller**
   The PIC16F877A microcontroller is the central component of the system, responsible for coordinating all operations. It processes sensor inputs, executes control logic, and sends commands to actuators. The chosen microcontroller offers:
   - Multiple input/output pins for connecting sensors and actuators.
   - PWM capability for controlling motor speeds and LED brightness.
   - Energy-efficient performance to maximize battery life.
2. **Bluetooth Module**
   The Bluetooth module facilitates wireless communication between the car and a smartphone or other devices. It eliminates the need for traditional remote controllers by enabling commands through a user-friendly mobile app. Features include:
   - Reliable short-range communication.
   - Compatibility with modern devices.
   - Low power consumption to extend operational time.
3. **Ultrasonic Sensors**
   Ultrasonic sensors play a key role in autonomous navigation. They emit ultrasonic waves and measure the time it takes for the echo to return after hitting an obstacle. This information is used to calculate distances and avoid collisions. Sensor features include:
   - High accuracy in distance measurement.
   - Real-time obstacle detection.
   - Consistent performance in various environments.
4. **Temperature and Humidity Sensors**
   These sensors provide real-time data to monitor environmental conditions and ensure the medical fridge operates within optimal ranges. Their contributions include:
   - Monitoring temperature and humidity inside the fridge.
   - Safeguarding temperature-sensitive supplies like medicines and vaccines.
   - Enhancing system adaptability to diverse environments.
5. **Medical Fridge**
   The medical fridge is designed to preserve critical supplies at stable temperatures. Controlled by a thermostat, it ensures the integrity of its contents. Key features include:
   - Energy-efficient insulation.
   - Precise temperature control.
   - Lightweight design to minimize the car’s load.
6. **LDR (Light Dependent Resistor) with PWM (Pulse Width Modulation)**
   The LDR dynamically adjusts the lighting based on ambient brightness using PWM. This ensures visibility and conserves energy. For example:
   - Lights are at their brightest in dark environments.
   - Lights dim in well-lit areas to save power.
   - Smooth transitions for consistent lighting adjustments.
7. **DC Motors and Servo Motor**
   The car uses DC motors for propulsion and a servo motor for steering. These motors are controlled through PWM for precise operation. Key aspects include:
   - DC motors provide consistent torque for movement.
   - The servo motor ensures accurate steering and obstacle avoidance.
   - Smooth operation under varying load conditions.

8. **H-Bridge Motor Driver**
   The H-Bridge controls motor direction and speed using PWM signals. This allows the car to move forward, reverse, and turn. Features include:
   - Enhanced maneuverability in confined spaces.
   - Reliable motor performance.
   - Protection against motor overheating.
9. **Rechargeable Battery**
   The battery powers all components, balancing capacity and weight. Features include:
   - Long runtime to support extended use.
   - Rechargeable design to reduce operational costs.
   - Compatibility with the system's power needs.
10. **Power Management System**
    This system efficiently distributes power to all components, ensuring reliability. It includes:
    - Voltage regulation to protect electronics.
    - Monitoring of battery levels to prevent over-discharge.
    - Optimized energy use for prolonged operation.

Workflow Description

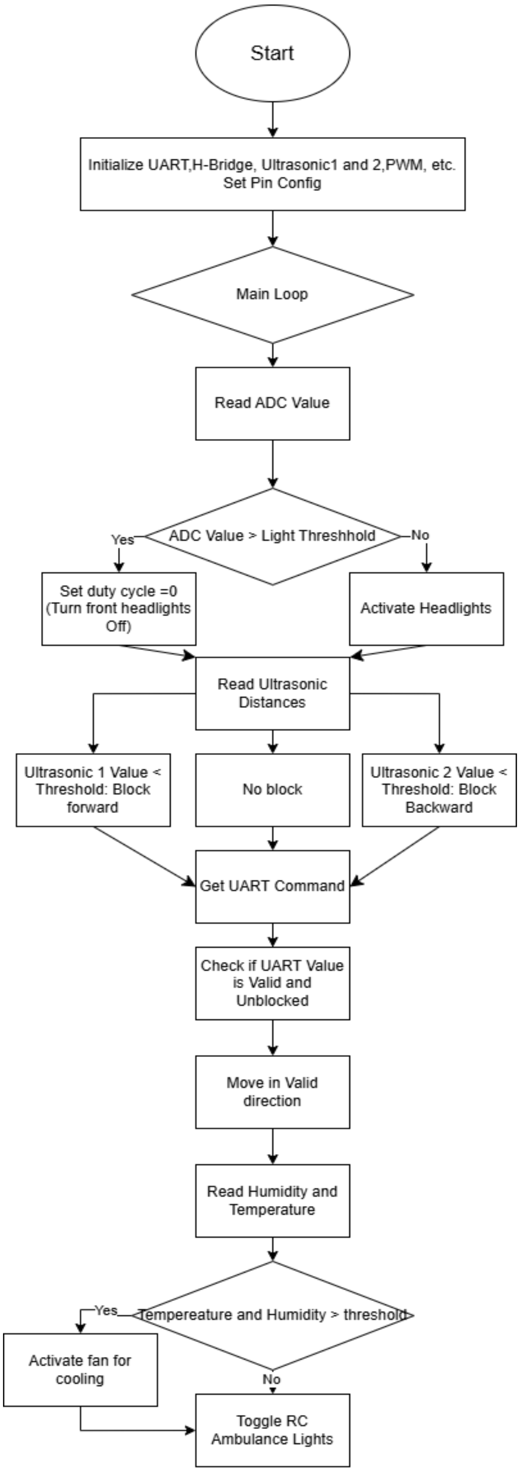
The workflow of the system follows these steps:

1. **Initialization**: The microcontroller initializes all sensors, the Bluetooth module, and the motors. The system connects to a smartphone via Bluetooth.
2. **Command Reception**: Commands sent from the smartphone are received via the Bluetooth module and processed by the microcontroller.
3. **Obstacle Detection**: Ultrasonic sensors continuously scan for obstacles, and the microcontroller adjusts the car's movement accordingly.
4. **Environmental Monitoring**: Temperature and humidity sensors monitor real-time conditions inside the medical fridge.
5. **Lighting Control**: The LDR and PWM dynamically adjust the brightness of the car's lighting based on ambient light levels.
6. **Actuator Control**: Based on commands and sensor feedback, the microcontroller operates the DC motors, servo motor, and medical fridge.
7. **Power Management**: The system ensures efficient energy distribution, balancing power demands across components.

Implementation

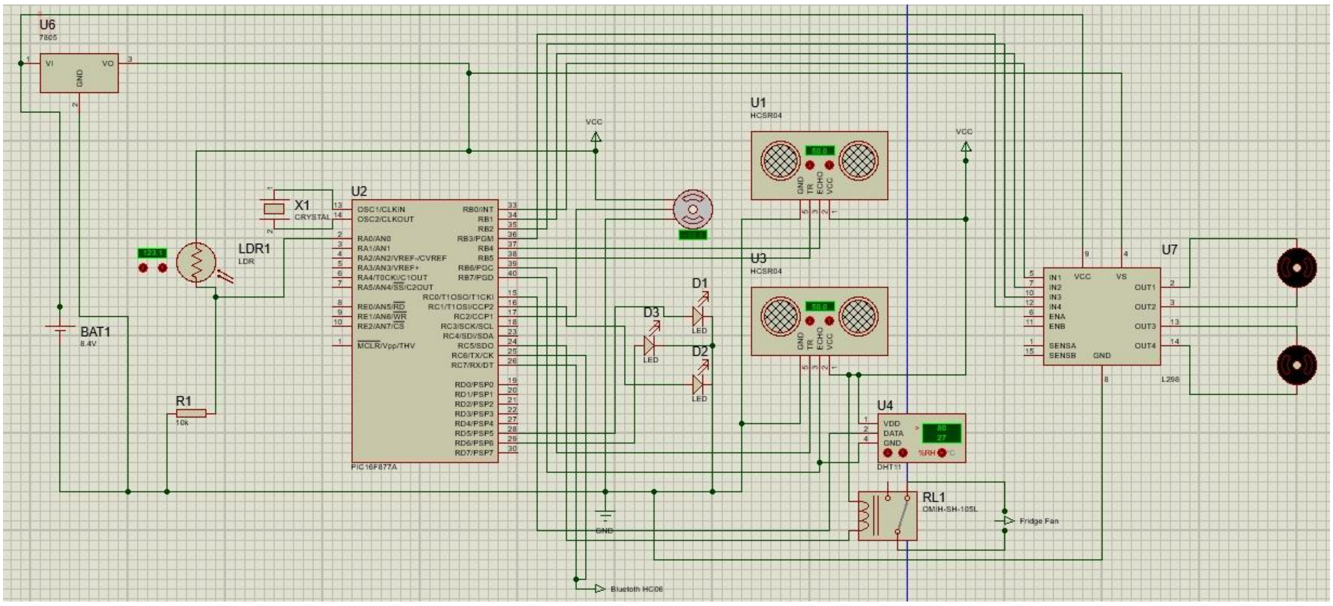
1. Software Logic and Flowcharts

The main control loop of the system continuously processes sensor data and dynamically adjusts the car's operations. This includes making decisions based on obstacle proximity detected by ultrasonic sensors and environmental readings from the temperature and humidity sensors. The car adapts its navigation to avoid collisions and ensures the medical fridge maintains optimal conditions for storing supplies.



2. Electrical Design

This schematic diagram represents the electrical design of our Autonomous RC Medical Assistance Car project. It illustrates how the microcontroller is connected to ultrasonic sensors, motors, the Bluetooth module, and power components, ensuring seamless coordination and operation. The diagram showcases the use of an H-Bridge for precise motor control, ultrasonic sensors for reliable obstacle detection, and a thermostat for maintaining the medical fridge’s optimal conditions. This setup emphasizes the efficient connectivity and functionality critical for the car's performance. A 4MHz oscillator is utilized in this design.



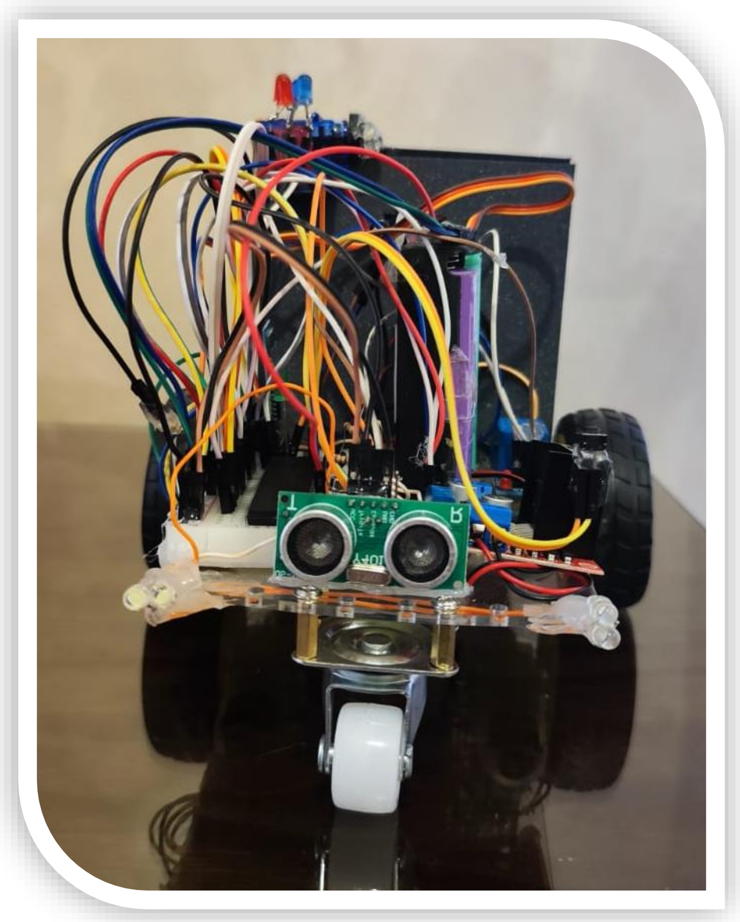
Challenges and Solutions

During the development of the Autonomous RC Medical Assistance Car, several challenges were encountered and resolved through systematic approaches. Below are the key challenges and their corresponding solutions:

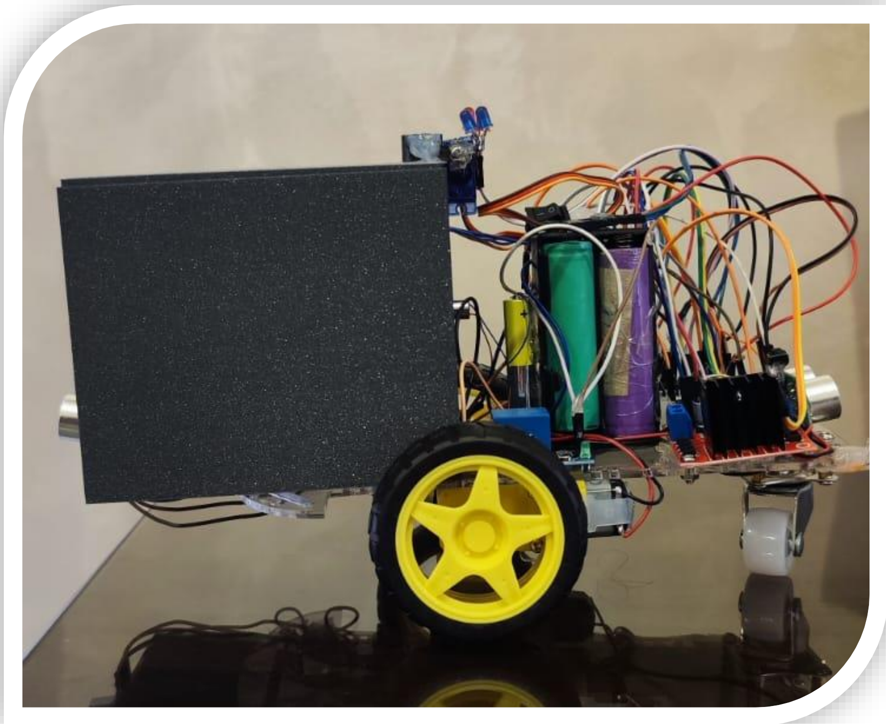
1. **Power Management**
   The system initially experienced high power consumption, which was addressed by selecting a 4 MHz oscillator instead of higher frequencies. This decision reduced power usage while maintaining sufficient processing capability. Additionally, PWM usage for components such as motors and LEDs were optimized to further conserve energy.
2. **Communication Issues**
   Bluetooth communication was inconsistent during testing, with occasional command drops. Reliability was improved by incorporating error-checking protocols in the UART communication process to ensure commands were properly received and executed.
3. **Servo Motor PWM Signals**
   While implementing PWM signals for the servo motor, the motor failed to respond correctly. The issue was diagnosed by consulting the servo's datasheet, which revealed a mismatch in signal frequency. After multiple adjustments to the frequency settings, the servo motor operated as expected.
4. **Inconsistent ADC Readings**
   The LDR provided inconsistent ADC readings under identical conditions during different runs. This was resolved by increasing the value of the pull-down resistor in the circuit, which stabilized the voltage levels and produced reliable readings.
5. **Development Workflow**
   To ensure proper functionality, all features were initially implemented on the EasyPIC board. This allowed for independent testing of each component and its corresponding code. After verifying functionality, the code was modularized into initialization and operation functions, such as ADC_init(), read_sensor(), and MOVE(), to improve maintainability and readability.

Layout and Design

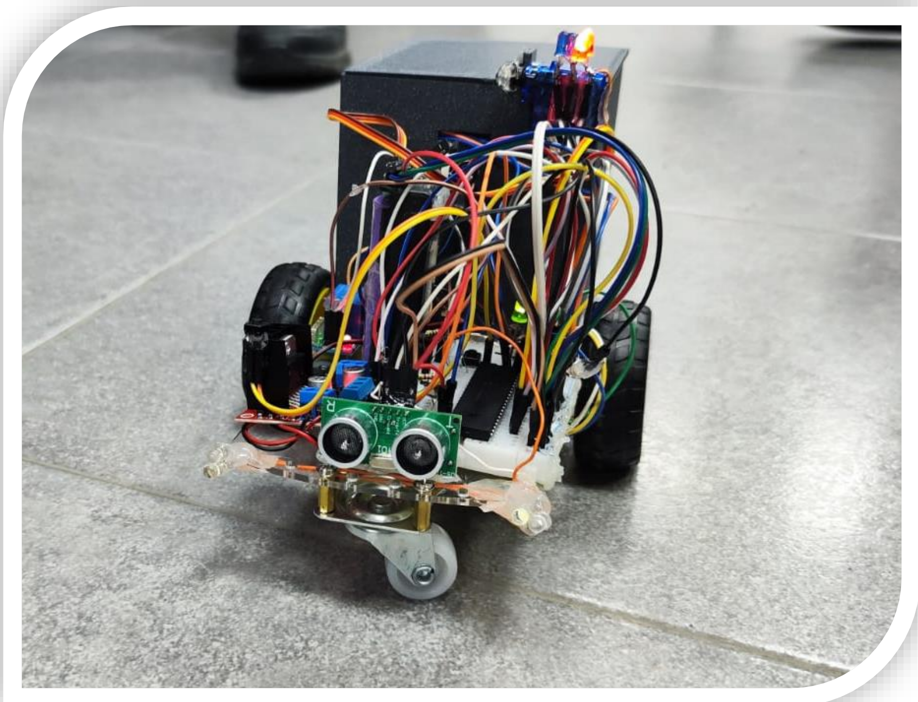
The Autonomous RC Medical Assistance Car is designed to house its components with functionality in mind. The microcontroller, sensors, motors, Bluetooth module, and medical fridge are arranged to optimize space and stability. Ultrasonic sensors are mounted at the front and rear for effective obstacle detection, while the LDR is positioned to accurately measure ambient light. The medical fridge is centrally located to minimize vibrations and maintain insulation. The layout ensures straightforward access to components for maintenance, balancing practicality and performance.



Front View of the RC Medical Car



Side View of the RC Medical Car



An Overall Picture of the RC Medical Car

Conclusion

The Autonomous RC Medical Assistance Car successfully integrates advanced embedded technologies to address medical emergency needs in challenging environments. With its autonomous navigation capabilities, the car ensures efficient and safe mobility even in hazardous conditions. Real-time monitoring through environmental sensors ensures that critical medical supplies are stored and transported under optimal conditions. Furthermore, the system’s scalable design allows for future enhancements, making it adaptable to various use cases such as disaster relief, industrial safety, and urban emergency response. This comprehensive approach highlights the project’s potential to transform emergency medical assistance into a more efficient and accessible service.

References

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