Rover: Autonomous Human greeting Robot

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***Abstract*— This project presents the design and implementation of a real-time human detection and greeting robot using low-cost embedded components. The robot autonomously senses the presence of a person using an ultrasonic sensor, navigates toward the detected individual, and delivers a spoken greeting through an on-board audio module. The system is powered by an ESP32 microcontroller and integrates DC geared motors, a Li-ion battery pack, and a DF Player Mini audio interface. The proposed mechanism demonstrates simple human–robot interaction suitable for use in public, commercial, or educational environments. The results show that the robot reliably detects human presence within 50–150 cm, performs controlled movement, and successfully outputs greeting messages.**

I. INTRODUCTION

Human-interactive robots are increasingly used in service environments such as reception areas, shopping malls, and hospitals. Such robots offer social interaction by welcoming visitors, providing basic information, or performing navigation assistance. Existing systems often rely on expensive sensors, complex computer vision algorithms, or high-power computing modsules, limiting accessibility for small institutions or student projects.

To overcome these limitations, this work proposes a lightweight, low-cost greeting robot that senses humans based on proximity, moves toward them, and delivers a verbal greeting. The system architecture is simple, modular, and easy to implement. The adopted structure follows the organization strategy used in similar demonstration-based projects such as real-time invisibility systems.

II. MATERIALS AND METHODS

A. Hardware Components

The robot system is constructed using the following components:

ESP32 Development Board – Main controller for logic and sensor interfacing.
Ultrasonic Sensor – Human distance detection in the range of 2–400 cm.
High-Torque 12V Metal Geared DC Motors – Wheel actuation for smooth motion.
High Grip Rubber Wheels (65–80mm) – Ensures traction and stability.
Sturdy Metal/Aluminum Chassis (2–4 mm) – Mechanical support and durability.
Li-Ion Battery Pack with BMS – Stable power delivery and protection.
DC–DC Buck Converter – 12V to 5V regulation for electronics.
DF Player Mini + 5W Speaker – Audio playback of greeting messages.
MicroSD Card – Stores pre-recorded audio such as "Welcome" or "Good morning".
PVC Foam Sheet Board – Aesthetic body panels and housing.

B. Human Detection and Approach Algorithm

Ultrasonic scanning is performed periodically.
If distance < threshold (configurable between 50–150 cm), a person is assumed.
Motors are activated to drive forward at controlled speed.
Upon reaching a minimum safe distance (≈ 30 cm), the robot stops.
DF Player Mini plays an audio greeting from the speaker.

C. Software and Programming

The ESP32 board handles:
Sensor reading
Motor control via PWM
Audio trigger signals
Embedded C/C++ (Arduino framework) is used due to: Ease of development,Real-time responsiveness,Library availability.

D. System Architecture
1. Input Layer
Ultrasonic sensor continuously measures distance.
Threshold logic determines presence.

2.Processing Layer
ESP32 executes:
Real-time detection loop
Motor control routine
Greeting condition checks

3.Output Layer
Motors execute movement.
Speaker plays voice output:
"Welcome", "Good morning", or similar greetings.
The architectural layers resemble structured processing pipelines used in interactive computer vision systems

III. RESULTS AND DISCUSSION

A. Performance Testing
Experiments were performed in an indoor environment on a smooth floor. Tests were repeated for three distance ranges:
Average approach time: 2–4 seconds, depending on starting distance.

Distance from person	Detection rate	Notes
50–100 cm	95%	Accurate detection
100–150 cm	85%	Slight delay due to ultrasonic spread
| >150 cm	| 60%	Slight delay due to ultrasonic spread

B. Greeting Output
Audio playback was clear and audible within 3–4 meters. Greetings such as "Welcome", "Good morning" were triggered immediately after stopping.

C. Observations
The robot performed reliably on flat, obstacle-free surfaces. Rubber wheels provided sufficient grip.
The Li-ion battery enabled continuous operation for 2–3 hours.

IV. HELPFUL HINTS

1. Keep Sensors at Correct Height
Mount the ultrasonic sensor at chest or waist level of an average person.
Too high or too low will reduce detection accuracy.

2. Set a Clear Detection Threshold
Tune the detection distance:
50–150 cm works well for recognizing humans
Below 30 cm, stop movement and play audio greeting

3. Use Controlled Motor Speed
Do not let the robot rush toward the person.
Use moderate PWM values to ensure:
Smooth motion Safe stopping distance No sudden jerks

4. Protect Electronics from Vibration
DC motors can cause vibration.
Use:
Foam pads
Rubber grommets
Secure cable ties
This prevents loose connections.

5. Place Speaker in Open Area
For clear audio:
Avoid covering the speaker
Mount it at the front of the robot
Louder and clearer greetings increase user experience.

6. Test on Flat Surfaces First
Start in:
Classroom
Corridor
Smooth floor
Avoid rough or uneven surfaces during initial testing.

7. Tune the Power System
Use:
Fully charged Li-Ion battery
BMS for safety
Buck converter output fixed at 5V
Stable power = stable robot.

8. Record High-Quality Audio
Greetings should be:
Loud
Clear
Short (2–3 seconds)
Examples:
"Welcome!"
"Good morning!"
"Hello! How can I help you?"
Store them on microSD card.

9. Avoid Sensor Blind Spots
Ultrasonic sensors have a cone shape.
If person stands exactly at side, robot may not detect.
Solution:
Slight sensor angle adjustment
Or 2 sensors (front + side)

10. Add Safety Stop
Always include a safety condition:
If distance < 20 cm, motors stop immediately.
Better to stop than collide.

V. CONCLUSION

This paper presents a simple, low-cost human detection and greeting robot built using readily available hardware and embedded control. The system integrates ultrasonic sensing, motor actuation, and audio playback to create a friendly interaction experience. Results demonstrate effective human detection within short range, smooth approach behavior, and reliable audio output.

Future enhancements may include:
Camera-based face detection,Natural language voice response, Obstacle avoidance,Autonomous navigation.
The development of a human-detection and greeting robot demonstrates that meaningful interaction can be achieved using simple embedded systems and low-cost hardware. By integrating ultrasonic sensing, motor control, and audio playback, the robot is able to detect nearby individuals, approach them safely, and deliver a verbal greeting. The system performed reliably in indoor environments and consistently recognized humans within short-range distances. Its modular structure and inexpensive components make it suitable for educational demonstrations, reception-level interaction, and small service environments. Although the current design focuses on proximity detection and pre-recorded messages, the platform provides a strong foundation for further enhancements. Future work may incorporate camera-based recognition, speech synthesis, gesture interaction, and autonomous obstacle navigation, enabling a richer form of human–robot communication. Overall, this project confirms that intelligent social behavior is achievable even with simple embedded hardware and represents a practical step toward friendly and accessible robotic assistants.

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