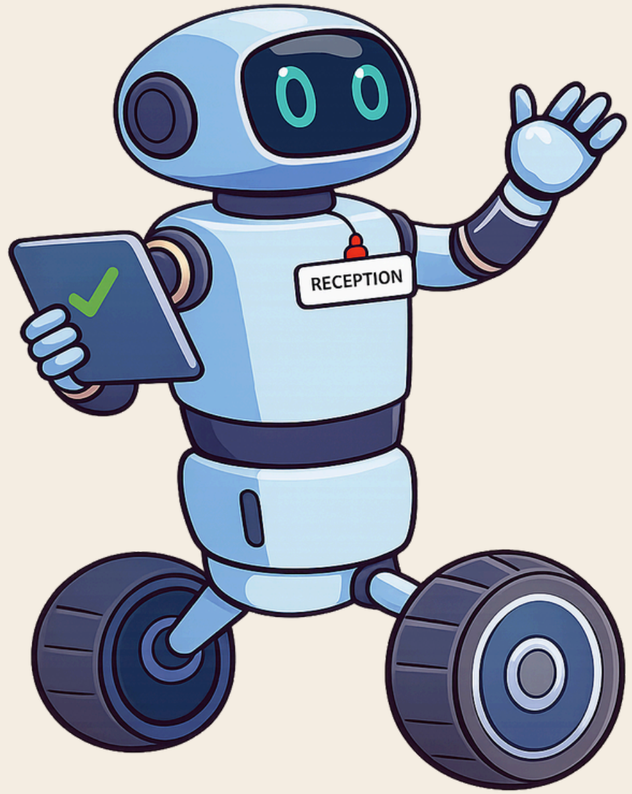
JAN 2026

# SALAMO!

Hardware Graduation Project




By Siwar Diab & Sewar Asaad

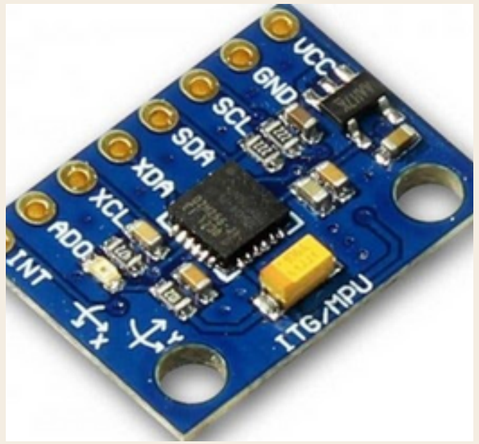
# INTRODUCTION

This project presents a self-balancing reception robot designed to welcome and interact with visitors in a modern and friendly way. The robot uses sensors, a camera, and artificial intelligence to detect people, recognize emotions, and respond using sound and visual expressions. By combining self-balancing control with human–robot interaction, the system aims to improve reception services and provide an engaging user experience.

# SELF-BALANCING SYSTEM

The first and most important part of our project is the self-balancing system. The robot is designed as a two-wheel inverted pendulum, which means it cannot stand without continuous control. We used an MPU6050 sensor to measure the tilt angle and applied a PID control algorithm on the Arduino Mega to keep the robot upright. This part was developed and tested independently to ensure stable and reliable balancing before adding any interaction or AI features.

# COMPONENTS

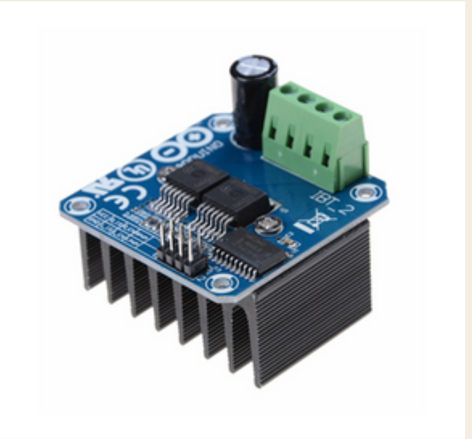



MPU6050


Arduino mega

Wheels

DC motors



BTS7960

# PID CONTROL ALGORITHM

To maintain balance, we used a PID control algorithm. The controller continuously calculates the error between the desired upright position and the current tilt angle. Based on this error, it adjusts the motor speed to correct the robot’s position and prevent falling.

| | |
|---|---|
| P | reacts to current tilt |
| I | corrects drifting |
| D | reduces oscillation |

# AI & INTERACTION SYSTEM

### Ultrasonic

Detects the presence of a user

### Raspberry Pi

Processes camera input and runs AI algorithms

### Camera

Captures real-time visual data

### Audio Interaction

Plays emotion-based and guidance audio messages

### Emotion Recognition

Classifies facial expressions

### Tiny Display

Displays animated digital eye expressions

### Hand Gesture Detection

Allows users to select options by fingers

### User Interaction Flow

Ensures smooth and natural interaction

# COMPONENTS

Raspberry PI


Camera

Tiny Display

Esp32


Ultrasonic

Speakers

# PRESENCE DETECTION

**(Ultrasonic)**

The interaction starts when the ultrasonic sensor detects a person in front of the robot. This ensures the system responds only when a user is present and remains idle otherwise.

# VISION & EMOTION RECOGNITION

**(Camera + AI)**

Once a person is detected, the camera is activated. The Raspberry Pi processes the camera input to verify a human face and recognize facial emotions such as happy, sad, angry, or neutral. We used lightweight AI models to perform this in real time.

# USER FEEDBACK AND INTERACTION

**(Audio + Screen)**

Based on the detected emotion, the robot responds using audio messages through the speaker and visual expressions displayed as digital eyes on the tiny screen. This combination makes the interaction more natural and easier for users to understand.

# SYSTEM INTEGRATION

To ensure smooth operation, we separated responsibilities between components. The Arduino handles balancing, the Raspberry Pi handles vision and AI processing, and the ESP32 controls the display. This design ensures that interaction features do not affect real-time balance control.

# SYSTEM WORKFLOW


The robot stays idle until a person is detected, then activates the camera, analyzes emotions, responds using audio and visual feedback, and processes user input. If the user leaves at any point, the system safely returns to the idle state.

# LIMITATIONS

Movement Limitation

- No left/right movement (2-wheel design)

Height Limitation

- Taller robot = higher center of mass
- Stability decreases

Drifting While Standing

- Sensor noise
- Motor dead zones
- Continuous correction needed

Load Sensitivity

- Small weight changes affect balance
- Re-tuning needed

Environmental Dependency (Vision)

- Lighting affects camera accuracy
- Camera angle matters

# FUTURE WORK

- Improved voice interaction
- Better stationary stability
- Mobile balancing navigation
- Enhanced vision robustness

# CONCLUSION

- Self-balancing achieved
- Intelligent human–robot interaction implemented
- System successfully integrated

Jan, 2026

# THANK YOU

Thanks For Listening!

Presented by Siwar & Sewar.