Abstract

Parking space management and fire safety are critical issues in modern infrastructures. This project presents the design and implementation of a Smart Parking Management and Fire Safety System using Arduino Mega 2560. The system automates vehicle entry and exit using a keypad-based ID authentication system, monitors parking slot occupancy using IR sensors, and ensures safety through gas/fire detection using an MQ-2 sensor. A servo motor controls the entry gate, while an LCD provides real-time system feedback. In case of fire or gas leakage, an audible alarm and visual warning are activated. The proposed system reduces human intervention, improves parking efficiency, cost-effective, reliable, and suitable for small to medium parking facilities.

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Chapter 1: Introduction

1.1 About the Project

The Smart Parking Management and Fire Safety System is an embedded system designed to manage parking slots efficiently while ensuring safety against fire hazards. The system controls vehicle access using predefined user IDs, monitors individual parking slots, and displays real-time status on an LCD. Additionally, it integrates fire detection to alert users during emergencies.

1.1.1 Motivations

- Increasing demand for automated parking systems
- Human error in manual parking management
- Need for fire safety in enclosed parking areas
- Integration of multiple sensors into one system
- Need for low-cost safety solutions in parking facilities
- Academic interest in embedded systems and automation

1.1.2 Key Features

- Automated vehicle entry and exit using keypad authentication
- Slot-wise parking management using IR sensors
- Servo-controlled gate operation
- LCD-based user guidance and status display
- Fire and gas detection using MQ-2 sensor
- Audible and visual fire alarm system

Chapter 2: Hardware, Software, and Tools Used

2.1 Hardware Components

Component	Description
Arduino Mega 2560	Main microcontroller
16×2 I2C LCD	Display system messages
4×4 Matrix Keypad	ID input for entry/exit
SG90 Servo Motor	Gate control
IR Sensors (4 pcs)	Entry detection and slot occupancy
MQ-2 Gas Sensor	Fire/gas detection
PIR Motion Sensor	Motion detection
Buzzer	Audible alarm
LEDs (Red, Green, White)	Status indication
Breadboard	Circuit prototyping
Jumper Wires	Connections
220Ω Resistors	LED current limiting

2.2 Software Environment

- Arduino IDE 2.0
- Programming Language: Embedded C/C++
- Libraries Used:
    - Wire.h
    - LiquidCrystal_I2C.h
    - Keypad.h
    - Servo.h

Chapter 3: Design and Methodology

3.1 Design Methodology

The system follows a modular design approach:

1. Input collection (Keypad, IR sensors, MQ-2)
2. Processing (Arduino Mega logic)
3. Output response (LCD, Servo, LEDs, Buzzer)

3.2.1 Block Diagram

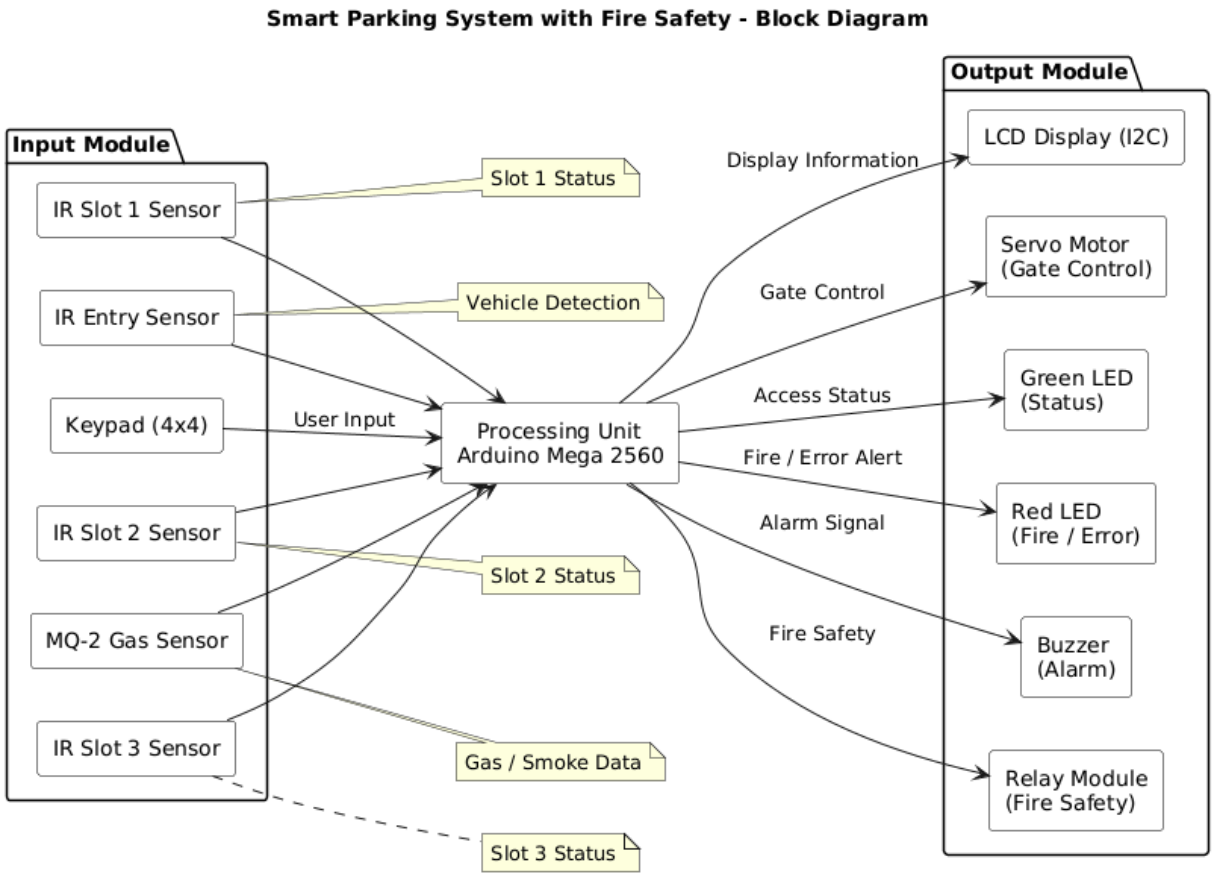


Figure 01:Block Diagram of Automatic Car Parking Arduino Project

3.2.1 Circuit Diagram

The circuit connects all sensors and actuators directly to the Arduino Mega's digital and analog pins. All components share a common 5V and GND supply via the breadboard.

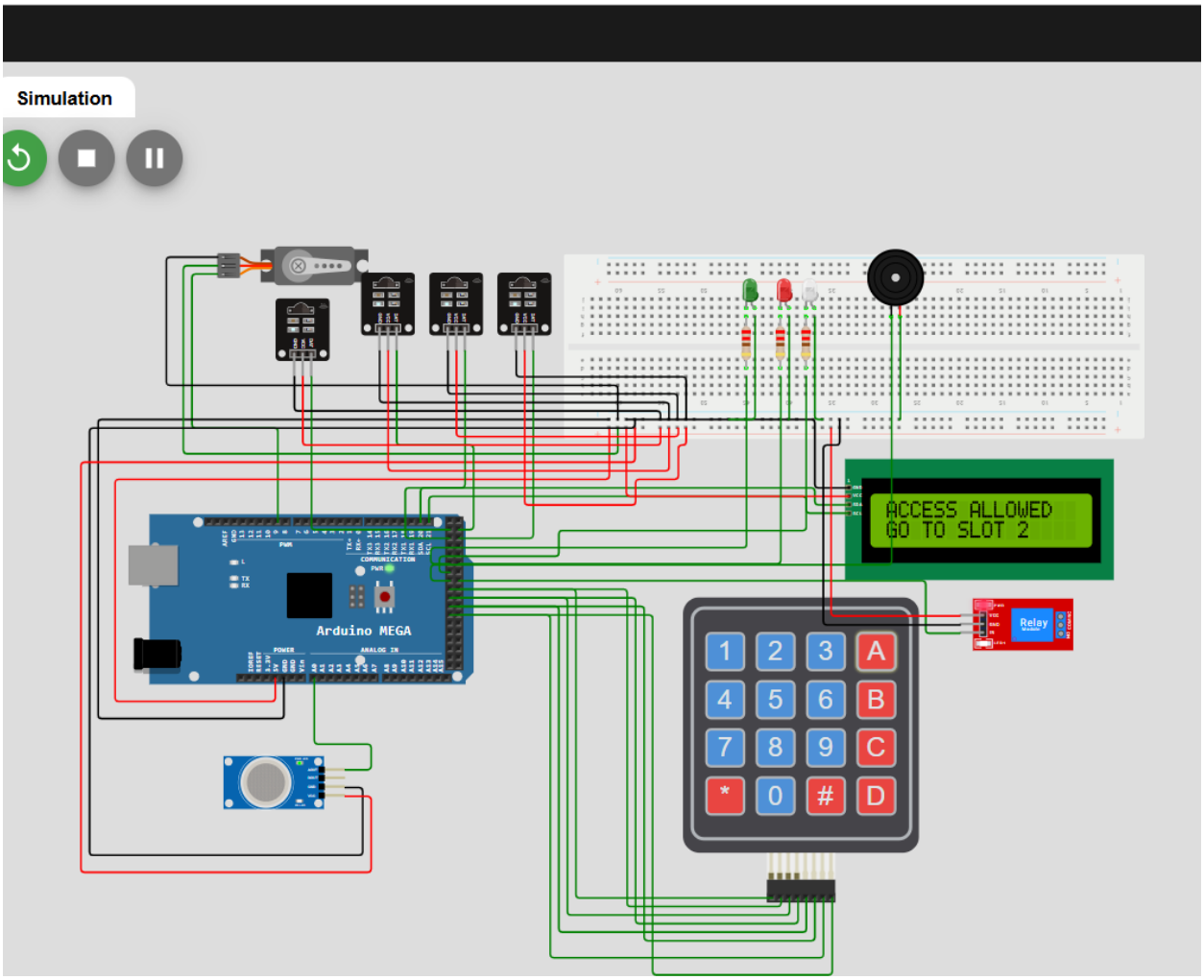


Figure 02:CircuitDiagram of Automatic Car Parking Arduino Project

3.2.2 Flow Chart

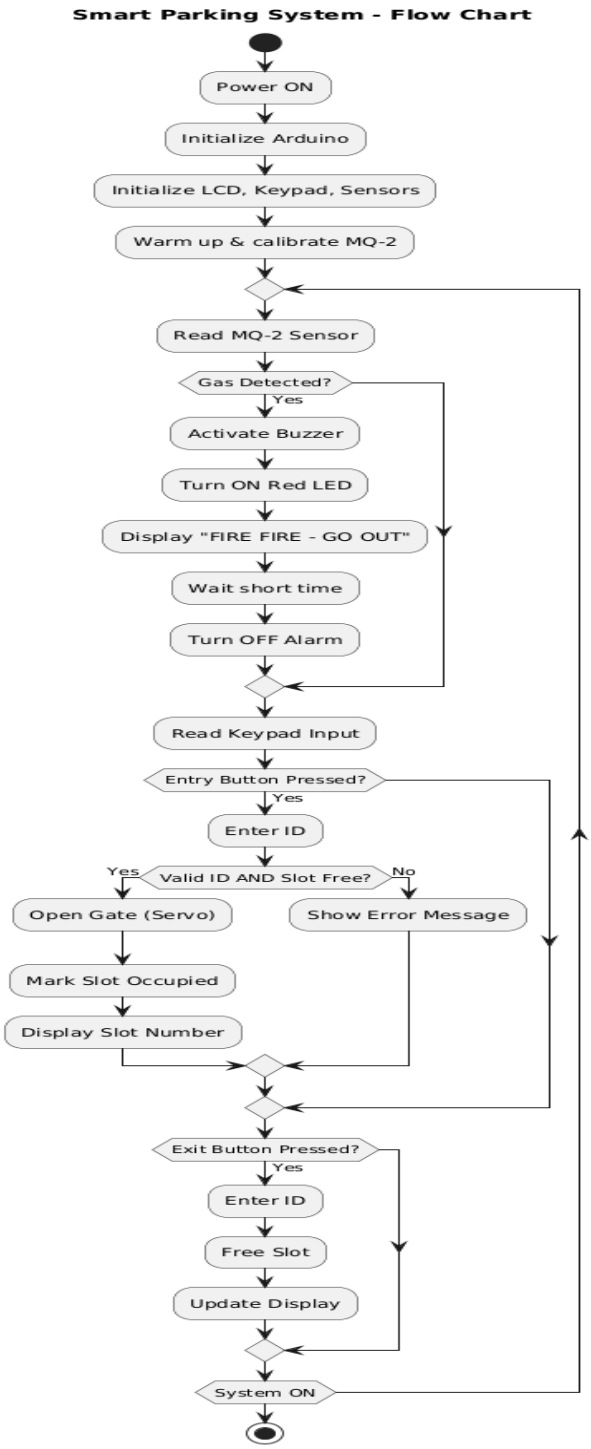
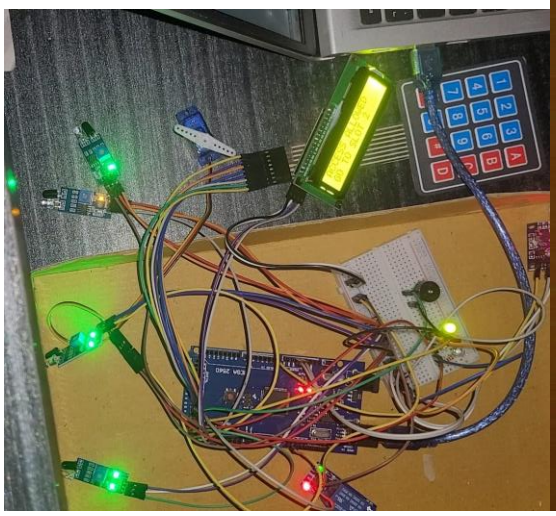


Figure 03:Flow Chart of Automatic Car Parking Arduino Project

Chapter 4: Results and Analysis

- The system successfully detects free and occupied parking slots
- Entry is restricted based on valid IDs
- LCD correctly displays system status and instructions
- Activates fire siren and warning display for a short duration
- Serial Monitor confirms sensor readings and system state



Chapter 5: Challenges Faced

- Initial LCD display issues due to I2C address mismatch
- MQ-2 sensor required proper warm-up and calibration
- Power distribution problems resolved using a common ground
- Pin management complexity solved by using Arduino Mega

Chapter 6: Conclusion

The Smart Parking Management and Fire Safety System demonstrates an effective integration of automation and safety using Arduino Mega 2560. The project successfully achieves secure parking control, real-time monitoring, and emergency response. This system can be expanded further with IoT integration, mobile applications, or RFID-based authentication.

References

1. Arduino Official Documentation – https://www.arduino.cc
2. MQ-2 Gas Sensor Datasheet
3. Servo Motor SG90 Datasheet
4. Keypad and IR Sensor Technical Notes