MazEscape

ECE 445 Project Proposal

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Table of Contents

1. Introduction

1.1 Problem

Modern-day theme park immersive games have become stale and predictable, so we wanted to make them more entertaining by seeing if it is possible to mix some of them. So, we devised a fun idea for a mix between a maze and an escape room where the participants will enter a labyrinth and answer questions to move onto the next level or to the next room and complete the game.

1.2 Solution

To tackle this challenge, we have decided that there will be a set of four smart lock systems, two of which will have an LCD screen along with a keypad with which the user will be able to interact with the whole system, and the other two will be the emergency escape lock system. Each set of smart lock systems will be attached to a door that will open up to the next part of the maze or the next level or to a door that will take them out of the maze and back to the starting point. The questions that will be asked on each of the smart locks will be related to small puzzles or general knowledge questions that they will get one chance to answer, as all the questions displayed will be multiple-choice. The players will answer the questions using the keypad by selecting one of four choices: A, B, C, or D.

There will be a total of two levels: an entry-level or the first level, which will be the first instance where the player will be asked to answer a question, and upon successfully answering the question, the system will unlock the gate and the player will be able to move onto the next level and which will be the second or the final level. The player will then again be asked to answer a question, and if they get the correct answer, they exit the maze and claim their prize. If, however, in any of the two levels, the player selects the wrong answer, then the smart lock will send a signal automatically to the escape smart lock system, which will be put on an escape gate to unlock the gate so that the player can leave the game and go back to the starting point. Each of the two smart locks, which will have an LCD screen, will also have a motion sensor so that the smart lock can automatically detect if a player has approached it, and then it can display its question.

The smart lock systems that ask questions will also be able to communicate with each other so that the user is not introduced to the same question.

The player will also have an additional option to leave the game by pressing a leave button on the keypad, upon which the smart lock system will send the escape lock system a signal to unlock the gate.

1.3 Visual Aid

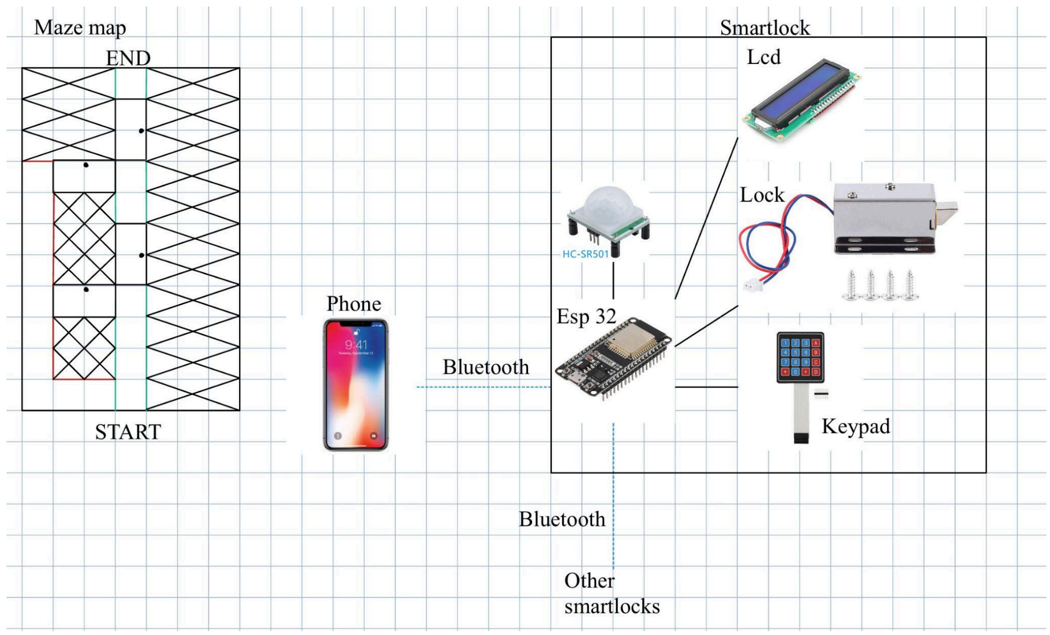

Figure 1. Visual Aid for MazEscape

1.4 High-level requirements list

- The system shall unlock the door within 2 seconds of receiving correct input from the participant to ensure a smooth and engaging user experience.
- The motion sensor must detect an approaching participant within 3-5 meters and trigger the display of the quiz question within 1 second to facilitate prompt interaction.
- The Bluetooth module integrated within the smart lock systems shall reliably exchange data—specifically transmitting quiz questions and lock/unlock commands.

2. Design

2.1 Block Diagram

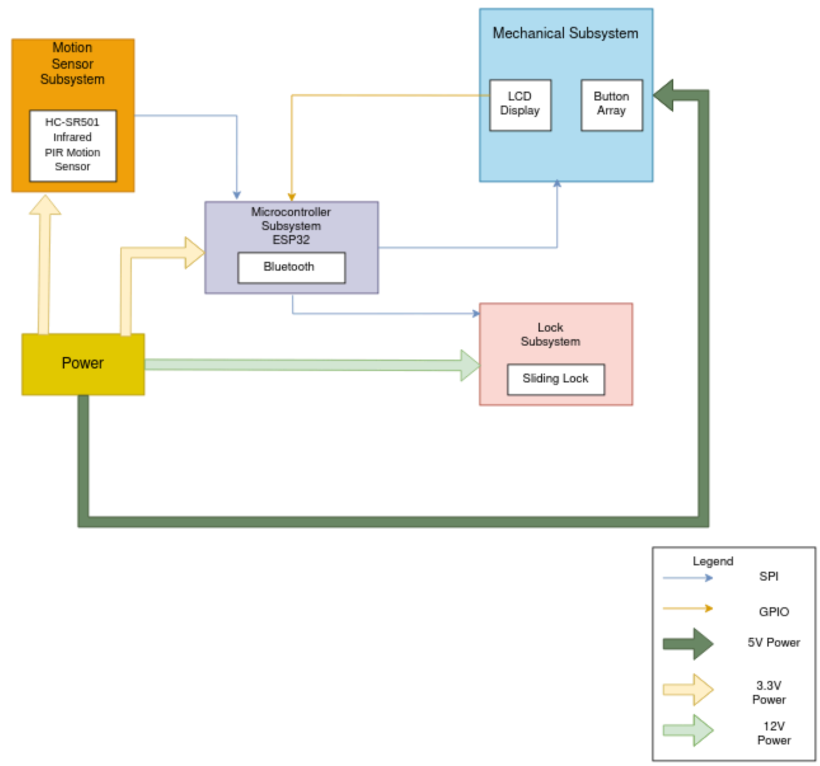

Figure 2. Block Diagram for the project

2.2 Subsystem Overview

- Mechanical Subsystem: We will use a 1602 LCD Display Module to display the problems the user will solve and a Numeric Keypad to input their answers. The LCD module will be very important for the user interface as all the information the user will need to use the device properly will be available on the LCD display. The user will be able to navigate the different functionalities using the keypad. The LCD module and the keypad will communicate via the SPI protocol with the microcontroller.

  Mechanical Subsystem Requirements: The LCD display must update content reliably at ≥60 Hz. The keypad must accurately capture and transmit inputs within 0.5 seconds. The SPI communication channel must operate at least 8 MHz without data loss.

- Microcontroller Subsystem: The ESP32 microcontroller will have different types of questions organized into various questions (MC questions about trivia and general knowledge questions answered with pressing buttons).

  Microcontroller Subsystem Requirements: All communication interfaces (SPI, digital I/O, WiFi/Bluetooth) must function within their specified quantitative limits.

- WiFi/Bluetooth Subsystem: We will use the ESP32 Microcontroller as a Wifi/Bluetooth module to connect all the LCD screens. The Bluetooth module will also allow the smart lock system to signal the escape lock system in case the player gets the question wrong or wants to leave the game.

  WiFi/Bluetooth Subsystem Requirements: The subsystem must operate effectively within a 30-meter range. It must interface seamlessly at 3.3V logic levels with the ESP32 microcontroller to relay commands accurately.

- Motion Sensor Subsystem: To have a unique and interactive experience, we will implement an HC-SR501 Infrared PIR Motion Sensor Module that will interact with the user by detecting them, and then once the user is detected, it will prompt them with a question to unlock the system.

  Motion Sensor Subsystem Requirements: The motion sensor must detect presence within a 3–5 meter range. Its response time must ensure the digital signal is output within 1 second of detection. The output signal must be at a 3.3V logic level to be compatible with the microcontroller’s digital inputs.

- Lock Subsystem: We will use a sliding solenoid lock when the questions are answered. It will unlock the door, and it will lock after the user closes the door. When the questions are fully answered, the sliding lock will be in the form of a rod and operated by a motor on command. The lock will be connected to a IRL40S212 power

Mosfet which will be connected to the microcontroller so that we may be able to reliably control it.

Lock Subsystem Requirements: The digital control interface must reliably receive 3.3V logic-level commands from the microcontroller. And the Power Mosfet must be able to operate under all conditions. The lock's full actuation cycle must be completed in a reasonable time.

2.3 Tolerance Analysis

One of the most important components of this project is the lock subsystem, and its reliable operation so that we may be able to lock and unlock the doors by operating solenoid connected to the lock.
The lock subsystem must operate in different load conditions, this is also our foremost safety concern as if a situation arises where the participant must leave the maze, reliable operation of the lock ensures that the participant is safe at all times within the maze.
We are using a 12V 0.4 Amp electromagnetic solenoid lock as our reference lock for this proposal [1].
We will need a current of 0.4Ampere and 12 volt DC source to ensure that our lock is able to operate at all times.
And as the ESP32 can only operate at a maximum level of 3.3 Volts we will be using a MOSFET to control the solenoid and connect it to the microcontroller [2].
Which means we will need a power MOSFET that will be able to operate within the following restrictions:

$VDS \geq 12\, Volts$
$VGS < 3.3 Volts$
$IDS \geq 0.4 Amperes$

And comparing these value to those of our power MOSFET:

$VDSmax = 40\, Volts$

$VGSmin = 1\, Volts$

$IDSmax = 195\, Amperes$

We see that our MOSFET will be able to operate in these restrictions [3].

3. Ethics and Safety

Our project is designed with a strong commitment to ethical integrity and user safety, fully aligning with IEEE and ACM ethical guidelines.

1) While we currently do not foresee any ethical dilemmas in the designing and building of this project we will ensure that we do not collect any data without the approval and knowledge of our participants.
2) Additionally we will also be conducting regular testing and maintenance of all our components and subsystems to ensure that they operate safely within their parameters, in accordance with the ACM Code of Ethics 2.1, striving to achieve a high quality in work [4].
3) One safety issue that we do foresee is: when a participant is in the middle of the maze and is forced to leave due to an unforeseen emergency, in such a scenario we will have the microcontroller send in a signal to unlock all the doors so that any participant may leave in a safe and organised manner. This is in accordance with the IEEE code of ethics 7.8.I.1 [5].

References

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