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Reliable Shuffling Number Pad for Vehicle Lock System Using Touch Screen

Panjavarnam B[1], Sivaranjani R[2], Jayashree G[3], Lavanya G[4], Thrisha S[5]
Department of Electronics and Communication Engineering Sri Sai Ram Engineering College, Chennai

Abstract: The rapid growth of urbanization and vehicle usage has heightened concerns regarding road safety and vehicle theft, posing significant challenges for both individuals and authorities. Addressing these issues, the Puzzle Lock System for Vehicle Safety integrates innovative biometric access control, accident detection, and real-time alert systems to ensure enhanced security and safety. This project employs a Raspberry Pi at its core, coupled with components such as fingerprint sensors, vibration sensors, GSM modules, and a touch display, to create a multi-functional and reliable solution. The system restricts vehicle access to authorized users through fingerprint recognition, while an intelligent accident detection module monitors and alerts emergency contacts in real time during critical situations using vibration sensors and gyroscopic data. Toggling numbers on a touch screen refers to the ability to change or switch between numbers when a user interacts with the screen. For example, when you tap a button, the number displayed could increase, decrease, or switch between different values. The goal is to make it easy for users to interact with the touch screen by simply tapping to change the displayed number or value. A theft prevention mechanism captures and communicates unauthorized access attempts using onboard cameras and notifies the owner via GSM modules, allowing location tracking and immediate action. A theft prevention mechanism captures and communicates unauthorized access attempts using onboard cameras and notifies the owner via GSM and GPS modules, allowing location tracking and immediate action. The project also integrates an IR-based collision detection feature to assess proximity during crashes, further enhancing safety measures. Developed with a focus on affordability, efficiency, and practicality, the proposed system ensures robust vehicle security and addresses limitations in existing solutions, such as privacy concerns with camera-based methods or dependency on single-mode alerts. Test results demonstrate the system's high accuracy in access control, prompt response during accidents, and ease of operation, paving the way for an advanced, user-friendly approach to vehicle safety in modern urban environments.

Keywords: Vehicle Safety, Biometric Access Control, Accident Detection, Theft Prevention, Raspberry Pi, Fingerprint Sensor, GSM, Vibration Sensor, Collision Detection, Real-Time Alerts, Smart Vehicle Security System.

I. INTRODUCTION

In today's fast-paced world, the exponential increase in vehicle ownership has led to a corresponding rise in safety concerns, encompassing both theft and accidents. According to global reports, vehicle theft is a significant issue, with millions of vehicles stolen annually, resulting in substantial financial losses and emotional distress for owners. Simultaneously, road accidents remain a leading cause of fatalities worldwide, often caused by driver negligence, lack of real-time emergency response systems, and ineffective accident prevention mechanisms. These challenges underscore the urgent need for a comprehensive solution that enhances both vehicle security and safety. Traditional methods for vehicle safety and theft prevention, such as manual locks and basic alarm systems, are often insufficient in addressing these issues. They are either too simplistic to deter sophisticated theft attempts or too reliant on single functionalities, limiting their efficiency. Advanced solutions such as camera-based security systems or algorithm-driven theft detection are prone to privacy issues and inconsistencies, especially under conditions like poor visibility or obstruction. Furthermore, existing accident detection systems are often delayed in alerting emergency contacts, which can lead to life-threatening delays in medical assistance. The Puzzle Lock System for Vehicle Safety has been developed as an innovative and robust solution to bridge these gaps. This system integrates multiple advanced technologies to create a secure and intelligent vehicle management system. By leveraging biometric access control using fingerprint sensors, the system ensures that only authorized individuals can access the vehicle. This eliminates the risks associated with traditional key-based mechanisms and enhances security. Accident prevention and detection are addressed through the deployment of vibration sensors which monitor vehicular dynamics and detect collisions or sudden impacts. In the event of an accident, the system promptly alerts predefined emergency contacts via GSM communication, providing real-time updates on the vehicle's location using GPS modules.

To further enhance security, unauthorized access attempts are monitored and recorded, with alerts sent to the vehicle owner via SMS and email, including captured images of the intruder. The system also incorporates an intelligent IR-based collision detection module to monitor proximity and prevent accidents caused by close-range vehicular interactions. Additionally, its modular design, powered by a Raspberry Pi, enables seamless integration of hardware components such as fingerprint scanners, touch displays, and buzzers, alongside software modules programmed using Python. The proposed system aims to provide a holistic, cost-effective, and reliable solution for vehicle security and accident management. By addressing the limitations of existing systems and introducing multi-functional features, the Puzzle Lock System for Vehicle Safety is positioned as a significant step forward in ensuring road safety and reducing vehicle theft in the modern urban landscape.

II. COMPONENTS INTEGRATION

The Puzzle Lock System for Vehicle Safety is meticulously designed to integrate advanced hardware components and software technologies to deliver a comprehensive safety and security solution for modern vehicles. At its core is the Raspberry Pi, a versatile microcontroller responsible for managing data flow and coordinating the system's operations. This central unit interfaces seamlessly with a fingerprint sensor mounted on the vehicle door, ensuring that access is granted only to registered users. The fingerprint sensor scans input data and communicates it to the Raspberry Pi, which verifies the identity by comparing it with a pre-stored database. If the authentication is successful, the vehicle unlocks, otherwise, security protocols are initiated, including capturing the intruder's image via a web camera and triggering alerts. The system's touch display acts as an interactive interface, displaying prompts for user authentication, system status, and alert messages. It simplifies user interaction by allowing inputs and providing visual feedback. To address road safety, an IR sensor is integrated to monitor the proximity of objects and vehicles, aiding in collision detection by alerting the driver through visual and audible signals if a hazard is detected. Complementing this, the system utilizes a vibration sensor and MEMS technology to monitor the vehicle's movements. These sensors work in tandem to detect sudden impacts, rollovers, or abnormal vibrations indicative of an accident. Once if an accident is detected, the GSM module springs into action by sending an SMS alert to pre-configured emergency contacts. The alert includes critical details such as the type of event and the vehicle's real-time location, retrieved from the GPS module. This module continuously tracks the vehicle, ensuring its position is always available, whether for theft recovery or emergency response. For theft prevention, the system employs a dual mechanism: the fingerprint sensor restricts unauthorized access, and the web camera captures and transmits images of any unauthorized attempt, with alerts sent via the GSM module to the owner. Additionally, the system features a buzzer, which provides immediate audible warnings during unauthorized access, accident detection, or proximity alerts. This serves as both a deterrent for potential intruders and a notification system for drivers and passengers. The power supply unit ensures stable and continuous operation of all components, preventing any system downtime. This tightly integrated setup of sensors, communication modules, and interactive interfaces is controlled by custom Python-based software running on the Raspberry Pi. The software ensures real-time processing of data from various inputs and triggers corresponding actions swiftly and accurately. By combining biometrics, communication technologies, and advanced sensors, the system delivers a multi-functional, reliable, and cost-effective solution, addressing key challenges in vehicle safety and security with precision and innovation.

III. WORK FLOW

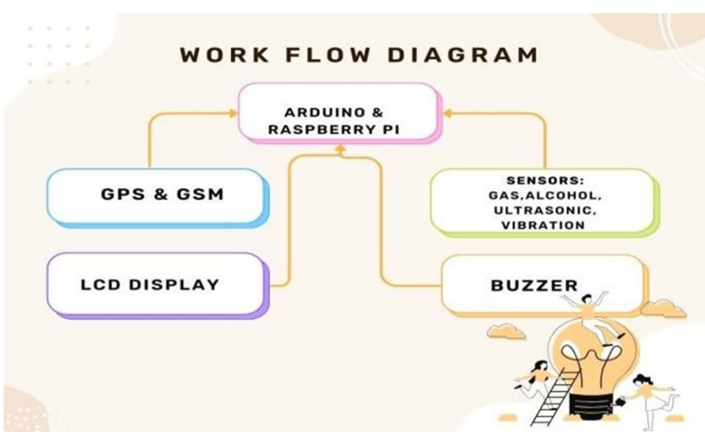

Fig.1 Work Flow Diagram

Fig.no.1 represents the workflow of the Puzzle Lock System for Vehicle Safety begins with the initialization of the Raspberry Pi, which acts as the system's central controller and interfaces with all connected components. Upon system activation, the fingerprint sensor becomes operational, awaiting user input. When a user attempts to access the vehicle, the sensor scans the fingerprint and sends the data to the Raspberry Pi for authentication. The system cross-references the scanned input with pre-stored fingerprints in its database. If the fingerprint matches an authorized user, the system unlocks the vehicle and transitions into an active state. If authentication fails, the system triggers an immediate response: the onboard camera captures the image of the unauthorized individual, and the buzzer activates to provide an audible alert. Simultaneously, the GSM module sends an alert message to the vehicle owner with relevant details, including images. Once the vehicle is operational, the system continuously monitors its safety parameters through integrated sensors. The vibration sensor and MEMS technology actively track vehicle movement, orientation, and vibrations. In the event of a significant impact, rollover, or other abnormal conditions, the system identifies it as an accident. This triggers an automated safety protocol where the GSM module sends SMS alerts to emergency contacts, including the precise GPS location of the incident. The camera captures images of the vehicle's surroundings, which are sent via email to designated recipients, enabling swift assessment and response. For collision prevention, the IR sensor constantly monitors the proximity of nearby objects or vehicles.

If an imminent collision is detected, the system issues visual and audible warnings via the touch display and buzzer, providing the driver with the opportunity to take corrective action. The touch display serves as a central interface for displaying system status, authentication results, and alert messages, ensuring seamless communication with the user. In addition to its safety features, the system addresses theft prevention through its multi-layered security mechanisms. The fingerprint sensor prevents unauthorized access, and any failed attempts immediately activate the camera and buzzer. The GSM module notifies the vehicle owner with real-time updates, and the GPS module tracks the vehicle's location in case of unauthorized movement. The system's modular design, powered by Python-based software running on the Raspberry Pi, ensures real-time processing and swift responses. The workflow is designed for robustness, with continuous monitoring, immediate alerts, and intuitive user interaction, providing a comprehensive solution for vehicle safety and security.

IV. IMPLEMENTATION PROCESS

The implementation of the Puzzle Lock System for Vehicle Safety involves the seamless integration of hardware and software components, ensuring reliable performance and achieving the system's objectives of enhanced safety and security. The process begins with the hardware setup, where the Raspberry Pi is configured as the central processing unit. All sensors and modules, including the fingerprint sensor, vibration sensor, MEMS sensor, IR sensor, GSM module, GPS module, touch display, web camera, and buzzer, are connected to the Raspberry Pi through its GPIO pins and communication interfaces such as UART, I2C, and SPI. Each component is strategically installed within the vehicle, with the fingerprint sensor placed on the door for access control, the vibration and MEMS sensors positioned to monitor vehicle dynamics, and the IR sensor aligned to detect external proximity. The camera is mounted to capture images of unauthorized access attempts or external conditions during incidents, while the buzzer is positioned for optimal sound projection to alert users.

The power supply unit is designed to deliver a stable voltage to all components, ensuring uninterrupted functionality even during extended operations. On the software side, Python scripts are developed and loaded onto the Raspberry Pi to manage the workflow of the system. These scripts enable real-time processing of data from various sensors, decision-making based on predefined conditions, and activation of corresponding actions such as unlocking the vehicle, sending alerts, or triggering alarms. The software also includes logic for communication via the GSM module, allowing the system to send SMS alerts and email notifications, complete with GPS coordinates and captured images.

The implementation further involves creating a user-friendly interface on the touch display, which displays prompts for fingerprint authentication, system status updates, and critical alerts. Extensive testing is conducted at every stage to ensure the hardware and software operate seamlessly under various scenarios, such as valid and invalid access attempts, simulated accidents, and proximity detection. Calibration of sensors, such as adjusting sensitivity levels for the vibration and MEMS sensors, ensures accurate detection of abnormal events while minimizing false triggers. This systematic and integrated approach ensures the system's robustness and efficiency. By combining advanced hardware components with sophisticated software logic, the Puzzle Lock System for Vehicle Safety delivers a reliable, real-time solution for vehicle security, accident detection, and theft prevention, providing a significant leap forward in automotive safety technology.

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V. EXISTING METHODOLOGY

The existing systems for vehicle safety and security rely on standalone technologies that primarily address individual issues such as theft prevention or accident detection. While these methods provide some level of security, they lack a comprehensive and integrated approach to tackle multiple safety concerns simultaneously. For instance, accident notification systems often rely on basic vibration sensors to detect crashes and subsequently send alert messages. However, these sensors may not capture all types of collisions or abnormal driving behaviors accurately. Similarly, smart helmets are equipped with alcohol sensors to monitor a driver's sobriety, but their application is limited to scenarios where drivers consistently wear the helmet, making them less effective for broader vehicle security. Camera- based theft control systems are another prevalent technology, utilizing face recognition algorithms to identify authorized users. Although they offer enhanced security, these systems often raise privacy concerns due to their continuous monitoring and potential misuse of personal data. Additionally, face recognition systems are susceptible to deception, such as the use of masks or individuals with similar facial features. Algorithm-based accident detection systems that leverage GPS and predefined algorithms for crash alerts are also widely used. However, they are heavily reliant on stable network availability, which poses a significant limitation in areas with weak or no connectivity.

A. *Interpretations*

1) Privacy Concerns: Camera-based methods often violate user privacy, especially during authentication or monitoring.
2) Limited Effectiveness: Algorithm-based approaches and face recognition systems can be easily deceived by masks or similar faces.
3) Dependence on Network Availability: GPS-only systems fail to function in areas with weak or no network coverage.
4) Inconsistent Results: Smart helmets and vibration-only sensors lack precision in detecting all types of crashes or abnormal conditions.
5) Fragmented Features: Many systems focus on individual aspects, such as theft or accidents, rather than providing an integrated solution.

VI. PROPOSED METHODOLOGY

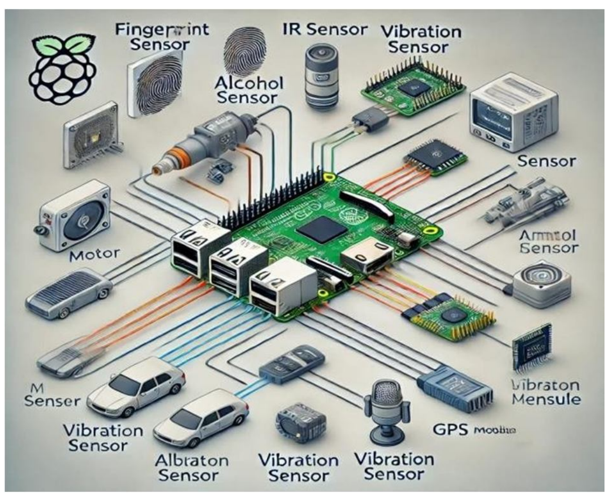


Fig.2 .A Glimpse of Futuristic Idea

The proposed methodology introduces an innovative Raspberry Pi-based Puzzle Lock System for Vehicle Safety, designed to overcome the limitations of existing systems by integrating multiple advanced technologies into a single, comprehensive solution. This system emphasizes both safety and security, ensuring a robust approach to preventing theft, reducing accidents, and enhancing user experience. One of the standout features is biometric access control, which uses fingerprint sensors to authenticate users. This ensures that only authorized individuals can access and operate the vehicle, eliminating the risks associated with traditional key-based systems that are prone to duplication or loss. For accident detection, the system combines vibration sensors with MEMS technology to accurately identify incidents such as rollovers, crashes, or sudden impacts. This dual-sensor approach significantly reduces false alarms and ensures prompt detection of emergencies.

To address theft prevention, the system employs real-time alerts and visual monitoring. Unauthorized access attempts are captured by a web camera, while a GSM module sends alerts and GPS location data to the vehicle owner, enabling quick action. Additionally, the system includes collision prevention capabilities by integrating IR sensors that monitor the proximity of surrounding objects or vehicles. These sensors provide timely alerts to the driver, helping to avoid accidents caused by negligence or blind spots. Communication is a key aspect of the proposed system. Using a GSM module, the system sends real-time SMS and email notifications to emergency contacts during accidents or theft attempts. These notifications include GPS coordinates and captured images, ensuring precise and actionable information is shared. The system also offers a user-friendly interface with a touch display that provides authentication prompts, displays alerts, and allows easy interaction, making it intuitive and accessible for all users. The proposed methodology comes with several advantages. Enhanced security is achieved through the biometric system, which eliminates the vulnerabilities of key-based or camera-based access methods. Accurate accident detection minimizes false alarms, ensuring reliability in identifying genuine emergencies. Real-time alerts improve response times by instantly notifying emergency contacts or vehicle owners during critical events. Unlike camera-based systems, the use of fingerprint sensors addresses privacy concerns, offering a secure yet non-invasive solution. Furthermore, the system's integrated approach combines theft prevention, accident detection, and collision avoidance into a single platform, making it a versatile and holistic safety mechanism. By leveraging the affordable yet powerful capabilities of Raspberry Pi and open-source software like Python, the system also ensures cost-effectiveness, making it a viable alternative to expensive commercial solutions.

VII. RESULT AND ANALYSIS

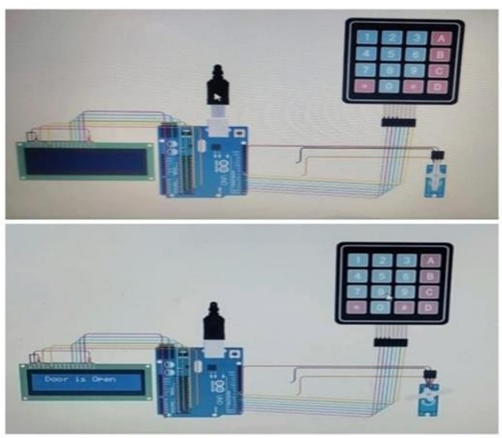


Fig.3. Phase One Output

Fig.No.3 represents that initial stage of the project that is bought in the tinker cad it is mentioned above.

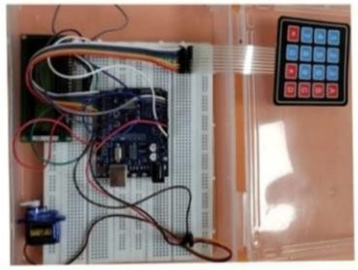
A. Arduino IDE

The development environment used to write and compile the code for the Arduino board.

1) Phase 1: Simulation using Tinker CAD: Phase 1: Simulation using Tinker CAD

In the initial phase, the project was simulated in Tinker CAD, a virtual environment for designing and testing circuits. The goal was to verify the puzzle lock system's design and logic before proceeding to hardware implementation. Components such as the microcontroller, gas sensors, ultrasonic sensors, and buzzers were virtually connected and tested. This phase ensured that the password verification logic worked as expected, with the system responding accurately to inputs. It helped identify and rectify initial flaws in the logic or circuit design, saving significant time and effort during later stages.

Additionally, the flexibility of modifying circuit layouts in a virtual space enabled thorough experimentation without material costs. This step established a strong foundation for the system's successful hardware implementation. The visual representation of the system provided better clarity on how individual components interact, making debugging easier. Additionally, the flexibility of modifying circuit layouts in a virtual space enabled thorough experimentation without material costs. This step established a strong foundation for the system's successful hardware implementation.



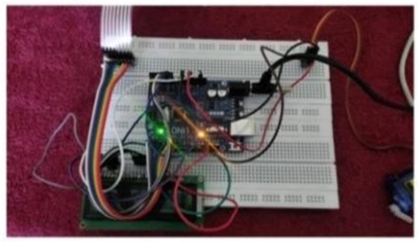


Fig no.4 Phase two output

2) Phase 2: Implementation with Standard Keypad (No Shuffling):

Fig.No.4 represents the detailed description of the phase two output. They are as follows

- Arduino Uno Board: The central processing unit (brain) of the system. It controls the other components and executes the code.
- LCD Display: Displays information like "Door is Open" or other messages.
- Keypad: Allows the user to input a code to unlock the door.
- Door Lock Mechanism: This could be a solenoid lock, a motor-driven lock, or any other mechanism that can be controlled electronically.
- Connecting Wires: Used to establish connections between the various components.
- Power Supply: Provides the necessary power to run the system software.

In this phase, the system was implemented using a basic physical keypad without a shuffling mechanism. The hardware setup included sensors and a keypad for password input, which were connected to the microcontroller. The system's behavior was tested by entering correct and incorrect passwords. Successful inputs activated the system, while incorrect passwords triggered the alarm and kept the vehicle in a locked state. This phase validated the hardware functionality and ensured the proper integration of sensors and control systems, laying the groundwork for advanced features.

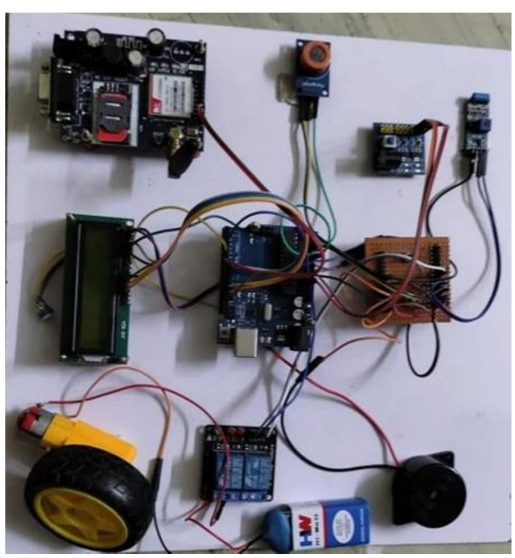


Fig.5. Phase three output

3) Phase 3: Vehicle Movement upon Correct Password:

Fig.No.5 represents the image shows an Arduino-based setup with various components connected to it. There appears to be a GSM module for communication, a gas sensor, a relay module, a motor controller, and an LCD display. The Arduino board acts as brain which process the inputs from the sensors and relay module, making decisions based on the data, and then controlling the motor and sending messages through the GSM module. The LCD display likely shows information about the system's status or sensor readings.

This phase focused on integrating motor controls to simulate vehicle movement. A DC motor was added to represent the vehicle's ignition system. The motor's activation was tied to password validation, enabling movement when the correct password was entered. Incorrect inputs resulted in no action, and safety measures like alarms were triggered. The successful completion of this phase demonstrated the system's ability to control vehicle movement securely, ensuring that only authorized access led to activation.

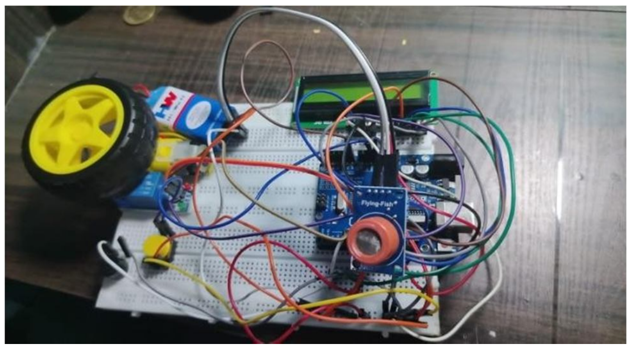


Fig.6. Phase Four Output

4) Phase 4: Full System with Touch screen and Shuffling Mechanism:

Fig No.6 represents the image shows an Arduino-based setup with various components connected to it.

The integrated a touch screen interface with a dynamic number-shuffling mechanism to enhance security. Additionally, an alcohol sensor was implemented to detect intoxicated drivers. The system was designed to shuffle the keypad numbers on the touch screen, making it difficult for a drunk driver to enter the correct password. Tests showed that sober individuals could successfully input the password and activate the vehicle, while drunk individuals struggled with the shuffling mechanism and were denied access. This phase ensured the system achieved its primary goal of enhancing vehicle safety and preventing drunk and driving accidents.

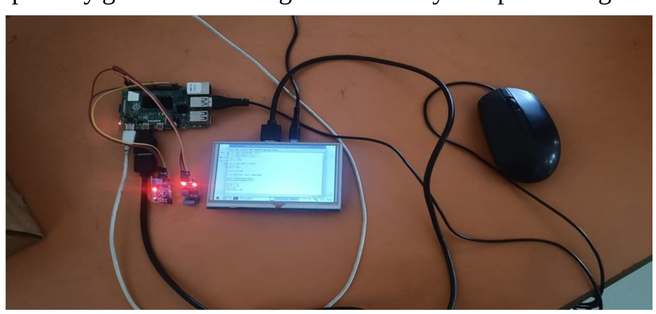


Fig 7.Phase Five output

5) Phase 5: Final output:

Fig No.7 represents the image shows an final output

The final phase marks the successful integration and testing of all hardware and software components of the Puzzle Lock System for Vehicle Safety Using Shuffling Number Pad. In this phase, the complete system is assembled, comprising a Raspberry Pi acting as the main controller, connected to essential modules such as the alcohol sensor, touch display, and peripheral devices like a USB mouse for interface control. The 5-inch LCD touch screen displays the program output, confirming that the software is running smoothly and responding to input/output commands. All the components, including the alcohol detection sensor, shuffling keypad algorithm, and alert mechanism, have been successfully tested and integrated. The system locks the vehicle upon detecting alcohol and requires the correct password to be entered on a shuffled keypad, simulating the real-time vehicle safety logic.

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Furthermore, the setup also includes communication modules that trigger alerts to family or friends if unauthorized access is attempted. This final output validates that the system works as intended and effectively enhances vehicle safety by preventing drunk driving. With this, the design, implementation, and testing stages are completed, demonstrating a functional prototype ready for further development or deployment.

VIII. CONCLUSION

The Puzzle Lock System for Vehicle Safety is a groundbreaking initiative designed to tackle the critical issues of vehicle theft and road safety, particularly accidents caused by drunk driving. The project successfully integrates multiple technologies, such as a dynamic password-protected ignition system, touch screen interface with number shuffling, and alcohol detection sensors, to create a robust security mechanism. The phased approach in development, starting with simulation in Tinker CAD and progressing to physical implementation with advanced features, ensured meticulous testing and validation at every stage, resulting in a system that is not only functional but also highly reliable. This system showcases the potential of embedded systems in addressing real-world problems, offering a comprehensive and innovative solution. The integration of GSM technology for notifications enhances the system's usability by keeping the owner informed of unauthorized access attempts or critical safety events. Moreover, the use of Python programming enables seamless interaction between hardware components, allowing for efficient processing and control. The alcohol detection mechanism, in particular, stands out as a vital feature that directly contributes to reducing accidents caused by impaired driving. The project's significance extends beyond its technical accomplishments. It highlights the importance of creating accessible, user-friendly solutions that can adapt to diverse environments, from personal vehicles to commercial applications. Its scalability opens doors for implementation in larger systems, such as fleet management and public transportation. Additionally, the system aligns with global safety initiatives, making it a timely and relevant contribution to the field of automotive security. Looking forward, the project lays a solid foundation for future advancements in smart vehicle systems. Features like biometric authentication, AI-driven safety analysis, and integration with IoT-enabled infrastructures can further enhance its capabilities. By addressing both current challenges and anticipating future needs, this system represents a significant step towards smarter, safer, and more secure transportation solutions. In conclusion, the Puzzle Lock System for Vehicle Safety is not only a testament to the team’s technical expertise and innovative approach but also a valuable contribution to the advancement of vehicle safety technology.

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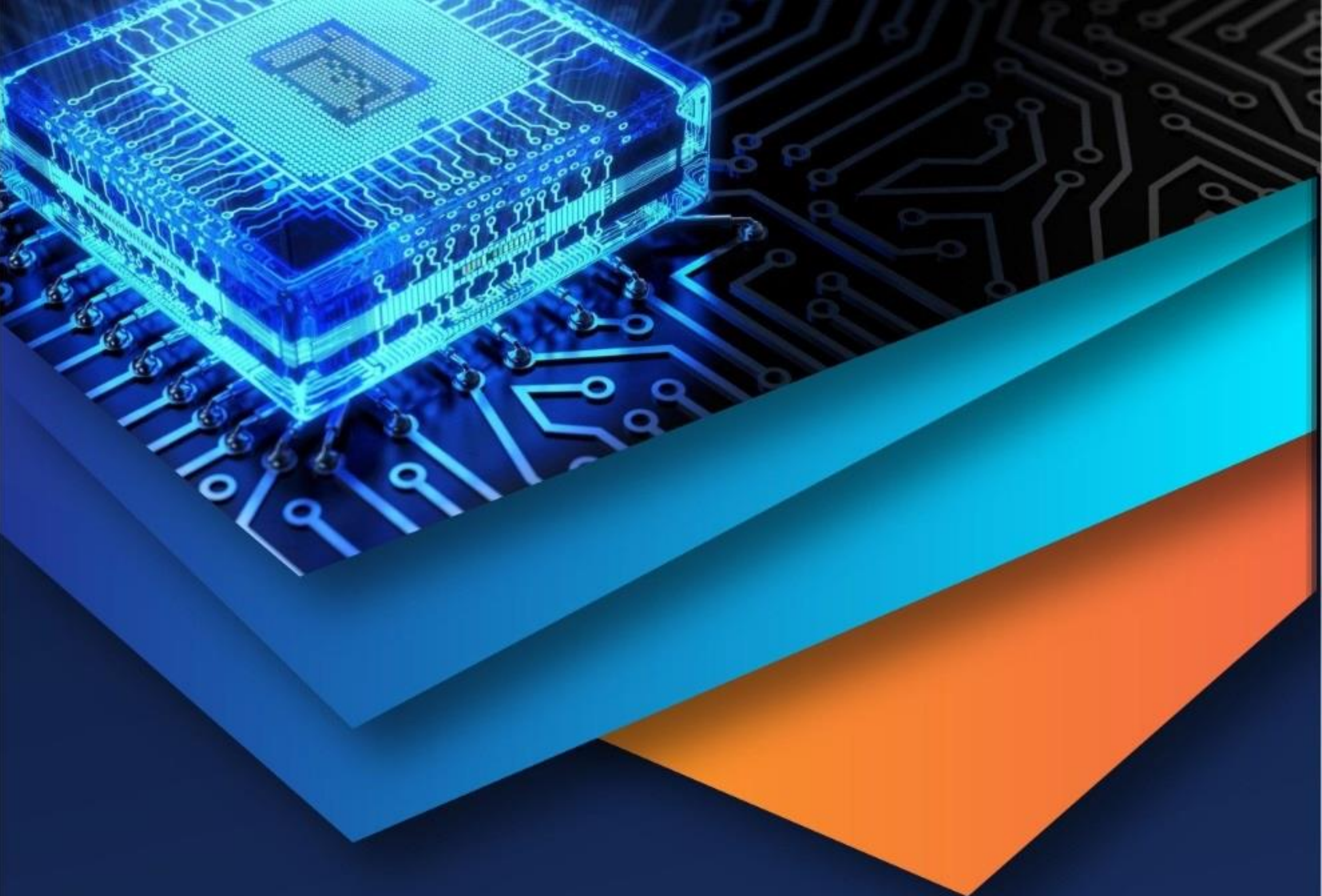

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