Review Paper on Vehicular Preventive Access to Juvenile & GPS Navigated Unauthorized Parking Alert System

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Abstract

The exponential growth of vehicles in urban areas has created critical challenges in managing parking spaces and preventing unauthorized vehicle use. Conventional GPS-based navigation systems provide parking availability but fail to indicate the legality of parking zones, leading to congestion and violations. Similarly, the misuse of vehicles by juveniles has emerged as a major safety concern.

The reviewed thesis titled *"Vehicular Preventive Access to Juvenile & GPS Navigated Unauthorized Parking Alert System"* presents an innovative solution integrating **Global Positioning System (GPS)** technology with **biometric access control** to address these issues simultaneously. The system employs a GPS-based alert mechanism that warns drivers when approaching unauthorized parking zones and a fingerprint-based key authentication system to restrict vehicle access to authorized users only.

This review evaluates the design, methodology, and implementation strategy of the proposed model, emphasizing its feasibility, cost-effectiveness, and potential societal impact. The research successfully demonstrates how combining embedded systems, IoT, and biometric security can lead to smarter, safer, and more disciplined vehicular environments.

Introduction

With the rapid increase in urbanization and individual vehicle ownership, modern cities face a dual challenge — *the shortage of authorized parking spaces* and *the rise of unauthorized or unsafe vehicle access*. The imbalance between the growing number of vehicles and limited parking infrastructure has resulted in congestion, random parking, and traffic inefficiency. Conventional GPS-based systems can help drivers locate nearby parking areas but fail to indicate whether those areas are legally authorized or not.

Another significant concern is the increasing involvement of **juvenile drivers** in road accidents due to unauthorized vehicle access. Although stringent traffic regulations exist, enforcement alone cannot prevent such incidents. Hence, technological interventions have become essential to complement legal measures and enhance road safety.

The reviewed thesis, *"Vehicular Preventive Access to Juvenile & GPS Navigated Unauthorized Parking Alert System"*, proposes a dual-purpose solution that merges **GPS navigation** and **biometric authentication** into a single integrated model. The first subsystem — a **GPS-based unauthorized parking alert** — identifies and

warns drivers approaching restricted zones through coordinate-based geofencing. The second subsystem — a **fingerprint-controlled ignition access** — prevents juveniles or unauthorized persons from operating vehicles.

Together, these systems demonstrate how embedded technologies and IoT principles can be effectively utilized to build a safer and smarter urban transportation environment. The approach not only improves traffic discipline but also ensures responsible vehicle usage, aligning with the global vision of **smart city and intelligent transport systems (ITS)**.

Review of Problem Statement

Unauthorized Parking Issue

The steady growth in the number of vehicles has intensified the issue of parking management in urban centers. Despite the presence of conventional GPS navigation systems, drivers often remain uncertain about whether an identified parking location is legally permissible. This leads to **unauthorized parking**, which in turn causes traffic congestion, fines, and inefficiency in road use.

Existing systems mainly focus on locating vacant spaces but fail to distinguish between *authorized* and *restricted* zones. The thesis identifies this as a critical gap and proposes the use of **GPS coordinates (latitude and longitude)** to define "No Parking Areas." By associating alerts with these bounded coordinates, the system is capable of notifying drivers when their vehicle approaches or enters an unauthorized region.

This GPS-based alert mechanism provides a **proactive solution** that not only informs but also discourages drivers from violating parking norms, thereby reducing road chaos and improving overall traffic flow.

2.2 Juvenile Vehicle Access Issue

Parallel to the problem of parking management, another serious concern addressed in the thesis is the **unauthorized access of vehicles by juveniles**. Across various cities, reports indicate a rising number of accidents involving underage drivers, often resulting from unrestricted key access and lack of preventive systems.

While laws exist to penalize guardians and vehicle owners in such cases, preventive technological measures remain limited. The thesis identifies this gap and introduces a **biometric access control system** using a **fingerprint-based key authentication mechanism**. This ensures that only registered users can unlock and operate the vehicle.

Such an approach directly addresses the root cause — by denying physical access rather than relying solely on legal enforcement. It not only prevents underage driving but also enhances vehicle security, functioning as an **anti-theft feature** as well.

Review of Proposed Solution

The thesis proposes a **dual-purpose integrated system** designed to address two separate but interrelated problems — unauthorized parking and juvenile vehicle access. The innovation lies in combining **GPS-based alert mechanisms** with **biometric authentication** to create a unified smart vehicle control framework.

GPS Navigated Unauthorized Parking Alert System

The first part of the proposed system focuses on identifying and preventing unauthorized parking using **GPS technology**.
It utilizes the **NEO-6M GPS module** connected to an **Arduino UNO microcontroller**. The module retrieves real-time latitude and longitude coordinates of the vehicle and compares them with predefined sets of coordinates that represent restricted or "No Parking" zones.

When the system detects that the vehicle is entering or surpassing these restricted coordinates, it triggers an **audio alert** through a **DF Mini MP3 Player** connected to a speaker. The alert functions as a real-time reminder for drivers, warning them before parking in an unauthorized area.

This subsystem effectively uses the **principles of geofencing** and **location-based alerts**, turning basic GPS navigation into a smart enforcement tool for better urban traffic management.

Vehicular Preventive Access to Juvenile System

The second part of the system focuses on **restricting vehicle access** to unauthorized or underage users. This module is based on a **biometric verification mechanism** that incorporates a **GT511C3 fingerprint sensor**, **RF transmitter–receiver pair (FS1000A)**, and **Arduino Nano** microcontroller.

The fingerprint scanner captures and verifies the identity of the user. If the fingerprint matches one stored in the authorized database, an encrypted signal is transmitted wirelessly via the RF module to the receiver embedded in the vehicle's **keyport**. Upon successful verification, the **DC motor** is activated through an **L293D motor driver**, which opens or closes the shutter of the key port, thereby granting or denying access.

This system ensures that the vehicle can only be accessed by registered users, thus preventing both **juvenile misuse** and **vehicle theft**. Additionally, the inclusion of LED indicators (red, green, yellow) provides instant feedback on authentication status for ease of operation.

Integrated Impact

By combining these two modules, the thesis creates a **comprehensive vehicular control model** that enhances both traffic regulation and vehicle security.

The proposed system is **cost-effective**, **modular**, and **scalable**, making it suitable for implementation in both **personal vehicles** and **public transport systems**.

Together, these innovations contribute significantly to **smart city initiatives**, promoting safer roads and more efficient parking management through technology-driven automation.

Review of System Design

The thesis presents a comprehensive system design that effectively integrates **mechanical**, **electrical**, **electronic**, and **logical** components into a unified smart vehicle framework. Each subsystem — GPS navigation and biometric access — is supported by well-documented design schematics and circuit explanations.

Mechanical Design

The mechanical layout demonstrates how the hardware modules are physically positioned within the vehicle.

- For the **GPS parking alert system**, the module is embedded within the vehicle dashboard along with the microcontroller and audio alert speaker.
- For the **juvenile preventive system**, the **key and keyport mechanism** is clearly illustrated, showing how the **biometric scanner** and **RF transmitter** interact with the **receiver and motorized shutter** embedded near the door lock.

These mechanical diagrams provide a clear understanding of how electronic modules fit within real vehicle components, highlighting the design's practicality.

Electrical and Electronic Design

The electrical design showcases the interconnection between major modules such as **Arduino UNO/Nano**, **GPS (NEO-6M)**, **DF Mini MP3 Player**, **Fingerprint Sensor**, **RF Transmitter & Receiver**, and **Motor Driver (L293D)**.

- **Power Supply:** The system operates within 3.3V–5V, using regulated DC sources compatible with the Arduino platform.
- **Signal Communication:** Serial communication through UART connects GPS, RF, and fingerprint modules for seamless data transfer.
- **Control Logic:** The Arduino processes location or fingerprint data and triggers the appropriate output device — either an alert tone or motor action.

The **electronic design** includes circuit diagrams that illustrate how the RF transmitter encodes and sends authentication signals to the receiver, which then activates the motor for keyport access. The detailed explanation of voltage flow, diode protection, and switch feedback shows strong technical understanding.

Logical Design

Logical flow diagrams for both subsystems are provided, depicting a clear algorithmic structure.

- **GPS Parking Alert Logic:**
  - Initialize GPS module.
  - Retrieve real-time coordinates.
  - Compare coordinates with restricted zones stored in memory.
  - Trigger audio alert if coordinates match unauthorized areas.
- **Juvenile Access Logic:**
  - Initialize fingerprint sensor.
  - Capture user fingerprint and compare with database.
  - If a match is found, transmit encrypted signal to receiver.
  - Activate motor driver to open or close the keyport shutter.
  - If mismatch occurs, deny access and remain locked.

These flowcharts accurately represent the **stepwise logical reasoning** behind each operation, ensuring reliability and efficient decision-making within the embedded system.

Evaluation of Design Approach

The thesis excels in **diagrammatic representation**, ensuring clear visualization of each component and process. However, while schematic and theoretical designs are comprehensive, **practical implementation data** such as testing results, timing accuracy, and real-environment performance are not included.

Incorporating simulation data (e.g., using MATLAB, Proteus, or TinkerCAD) or real-world testing outcomes would further validate the system's operational efficiency.

Review of Technologies Used

The thesis effectively utilizes a combination of **embedded systems**, **IoT technologies**, and **biometric sensors** to achieve the dual goals of traffic management and vehicle access control. The choice of components reflects a careful balance between **cost-efficiency**, **availability**, and **technical feasibility**.

GPS Technology

The project employs the **NEO-6M GPS Module**, a reliable and widely used receiver that communicates satellite data to determine the vehicle's exact geographical coordinates.
This module connects to the **Arduino UNO** through a UART serial interface and provides continuous updates on **latitude**, **longitude**, and **time**.

By programming pre-defined coordinate boundaries into the Arduino, the system performs a comparison in real time. When the vehicle enters a "No Parking" zone, the Arduino triggers an audio alert through the **DF Mini MP3 Player**.

This demonstrates an intelligent application of **geofencing** and **spatial awareness**, allowing the system to function as a low-cost parking violation prevention tool.

Satellite and Communication Technology

The GPS system operates via signals from multiple satellites orbiting Earth, enabling precise localization even without an internet connection.
The thesis also references **satellite communication principles** for understanding how signals are transmitted, synchronized, and interpreted by ground-level GPS modules.

Such use of global navigation satellite systems (GNSS) highlights how **space-based technology** can be integrated with embedded hardware for everyday civil applications like parking regulation and route monitoring.

Fingerprint Authentication Technology

For biometric access, the project utilizes the **GT511C3 Optical Fingerprint Sensor**, which offers accurate recognition with a low false acceptance rate (FAR < 0.001%) and a fast response time (< 1 second).
The sensor captures and compares fingerprint templates stored in its internal database. Upon a successful match, it signals the **Arduino Nano**, which activates the **RF transmitter** to communicate with the receiver installed in the vehicle door or dashboard.

This technology ensures **exclusive access** to authorized individuals and serves a dual purpose — preventing **juvenile misuse** and **unauthorized entry**.

RF Communication System

The **FS1000A Transmitter-Receiver Pair** provides wireless communication between the key and keyport.

- The **transmitter** encodes the fingerprint verification signal.

- The **receiver** decodes it and activates the **DC motor** via the **L293D motor driver** to open or close the keyport shutter.

This system operates at **433 MHz frequency** using **Amplitude Shift Keying (ASK)** modulation, allowing reliable short-range data transmission suitable for vehicle environments.

Microcontroller Platforms

The use of **Arduino UNO and Arduino Nano** microcontrollers simplifies the hardware integration process and enables modular coding. These boards manage data from sensors, execute logic comparisons, and control actuators.
Their open-source nature, affordability, and flexibility make them ideal for **prototype development** and educational research.

Overall Technological Evaluation

The selection of technologies reflects a **strategic design philosophy** — using existing, affordable hardware to create an intelligent and socially impactful solution.
However, the project could be further enhanced by adding:

- **Cloud connectivity** for remote monitoring,
- **Mobile app interfaces** for user alerts, and
- **Machine learning models** to predict traffic or unauthorized parking patterns.

These additions would elevate the system from a prototype to a fully-fledged **smart mobility platform**.

Critical Evaluation

The thesis *"Vehicular Preventive Access to Juvenile & GPS Navigated Unauthorized Parking Alert System"* presents an innovative and socially relevant solution by combining two independent systems — **GPS-based parking alert** and **biometric vehicle access control**. The following section critically evaluates the project's **strengths, weaknesses, innovation level, and practical applicability**.

Strengths

1. **Innovative Dual-Function Concept:**
   The integration of GPS-based parking management with biometric vehicle access control represents a creative and original approach. Unlike traditional models that focus on a single aspect, this dual-purpose design addresses both *urban parking issues* and *juvenile safety* simultaneously.
2. **Low-Cost Implementation:**
   The use of readily available components such as Arduino boards, RF modules, and fingerprint sensors makes the system cost-effective and scalable for academic, experimental, and commercial adaptation.
3. **Societal Relevance:**
   The project directly contributes to public welfare by promoting road safety, reducing parking violations, and preventing underage driving. These objectives align well with the goals of *smart city* and *intelligent transportation system (ITS)* development.

4. **Technical Feasibility:**
   The proposed model is practical and easy to prototype, requiring minimal infrastructure changes. The modular architecture allows flexibility in upgrading or integrating new technologies, such as IoT or cloud services.
5. **Comprehensive Documentation:**
   The thesis provides detailed circuit diagrams, logical flowcharts, and datasheets for each component, making replication and further research simpler.

Limitations

1. **Lack of Experimental Validation:**
   While the theoretical and schematic design is well-documented, the thesis lacks real-world testing data. Parameters such as response time, accuracy rate, GPS latency, or environmental interference effects are not provided.
2. **Limited Range of RF Communication:**
   The FS1000A RF module used in the design operates within a short range (typically up to 100 meters). For larger vehicles or commercial applications, more advanced communication modules such as Bluetooth Low Energy (BLE) or Wi-Fi could improve performance.
3. **Absence of Cloud and Mobile Integration:**
   The system operates in standalone mode without remote monitoring capabilities. A mobile app or cloud server connection could enhance usability by allowing real-time vehicle access control and alert tracking.
4. **No Artificial Intelligence Component:**
   The system relies on static coordinate data and direct sensor responses. Incorporating AI-based pattern recognition or adaptive geofencing could improve the system's intelligence and predictive ability.

Comparative Evaluation

When compared with similar research projects, this thesis demonstrates a **higher degree of practical integration** between multiple technologies. Previous studies typically focus on either smart parking using GPS or security access using RFID/biometrics. However, this system merges both functions under a single embedded control platform — a unique feature that adds novelty and interdisciplinary depth.

Overall Assessment

Overall, the thesis stands out as a **technically feasible and socially meaningful contribution** to the field of electronics and communication engineering.

Its primary strength lies in conceptual innovation and implementation simplicity. With further testing, cloud connectivity, and AI enhancement, this project could evolve into a **commercially deployable intelligent vehicle safety system**.

Comparison with Related Work

The thesis under review distinguishes itself from previous studies and patents by introducing a **hybrid vehicular safety framework** that combines GPS-based navigation alerts with biometric access control. While earlier research has explored individual aspects of parking systems and electronic vehicle keys, this work merges them into a unified design with dual functionality.

Comparison with Previous GPS-Based Parking Systems

Earlier research, such as the IEEE publication *"Towards an Intelligent GPS-Based Vehicle Navigation System for Finding Street Parking Lots"* [1], focuses on helping drivers locate nearby parking spaces using GPS and historical occupancy data. Similarly, *"GPS-Based Parking System for Unplanned Metro-Cities"* [2] utilizes real-time GPS data visualization to identify vacant parking zones.

While these systems improve convenience, they **do not address the legality** of parking zones. Abdul Rahim's proposed design extends beyond availability tracking by introducing **geofenced "No Parking" coordinates**, which automatically trigger alerts when a vehicle enters unauthorized zones. This enhancement adds a *regulatory and preventive* layer to conventional GPS guidance.

Comparison with Prior Vehicle Access Control Systems

Patent literature, including *"Electronic Vehicle Key"* (US20010028295A1) [4] and *"Key System"* (JP2004084249A) [5], proposes remote-controlled vehicle access mechanisms. These inventions typically rely on **radio frequency identification (RFID)** or transponder-based systems to enable or disable ignition through signal validation.

However, these systems can be compromised if the key is lost or duplicated, since **authentication depends solely on device possession**.

The thesis under review overcomes this limitation by integrating **biometric verification** within the key itself, ensuring that only registered fingerprints can activate the transmitter and consequently unlock the vehicle. This advancement enhances both **security and accountability**.

Distinguishing Features of the Reviewed Work

Feature	Previous Works	Current Thesis
Parking Focus	Finding available parking lots	Preventing unauthorized parking via GPS-based alerts
Access Mechanism	RFID or remote key	Biometric (fingerprint) verification with encrypted RF signal
Intelligence Level	Static navigation guidance	Dynamic alert based on restricted coordinates
Social Relevance	Focused on convenience	Targets safety, law enforcement, and underage prevention
Integration	Single-function systems	Dual-system integration: GPS + Biometric Access

This comparison clearly shows that the reviewed thesis introduces a **multi-dimensional system**, advancing the field from simple location or security aids to **intelligent vehicular governance tools**.

Research Contribution Summary

The thesis bridges two research domains:

- **Intelligent Transportation Systems (ITS)** — through geolocation-based parking regulation.
- **Vehicular Security Systems** — through biometric identity control.

By integrating these domains, the author contributes a **novel prototype model** that demonstrates how low-cost embedded technology can provide **smart urban mobility solutions**. This interdisciplinary combination makes the work not only technically relevant but also **socially transformative**.

Applications and Future Scope

The reviewed thesis introduces a dual-function vehicular system that can significantly contribute to **smart city infrastructure**, **public safety**, and **personal vehicle security**. The design's flexibility allows it to be implemented across multiple sectors, ranging from individual automobile users to traffic management authorities.

Practical Applications

1. **Smart Traffic Management Systems:** The GPS-based unauthorized parking alert mechanism can be integrated into **municipal traffic management frameworks**. This would allow cities to monitor and regulate no-parking zones dynamically, reducing congestion and ensuring smoother traffic flow.
2. **Personal Vehicle Safety:** The fingerprint-based vehicle access system enhances personal vehicle security. It can prevent unauthorized use, theft, and misuse by minors, thereby acting as both an **anti-theft** and **safety enforcement** system.
3. **Public Transportation Fleet Management:** Transport companies can use this system to ensure that only authorized drivers operate public buses, taxis, or school transport vehicles. This feature enhances **accountability** and **driver verification**.
4. **Institutional and Government Vehicles:** Organizations with official vehicles can maintain control over usage through biometric access, ensuring only designated personnel operate the vehicles.
5. **Insurance and Law Enforcement Support:** The GPS module can provide data useful for **insurance claim validation** and **law enforcement investigations**, offering an additional layer of evidence in case of misuse or accidents.

Future Enhancement Opportunities

While the current system functions effectively as a prototype, there are several ways it can be expanded into a large-scale commercial product:

1. **Mobile App Integration:** A smartphone application could be developed to display alerts, track vehicle status, and receive real-time notifications when the car enters unauthorized zones.
2. **Cloud Connectivity:** By connecting the GPS and biometric systems to a cloud database, authorities or owners could remotely monitor parking violations, vehicle location, and access logs.
3. **AI and Machine Learning Implementation:** Artificial intelligence could be used to predict and prevent unauthorized parking through pattern recognition, and to enhance fingerprint identification accuracy.
4. **Camera-Based Object Detection:** Integrating a camera module with AI-based image processing could visually confirm parking conditions and improve the reliability of unauthorized zone detection.
5. **Advanced Communication Modules:** Upgrading from RF to **Bluetooth Low Energy (BLE)**, **LoRa**, or **Wi-Fi** modules could extend operational range and enable IoT-based remote control.
6. **Commercial Adaptation:** Automotive manufacturers could integrate this dual system directly into vehicles as part of **next-generation security and smart navigation systems**.

Vision for Long-Term Impact

The thesis lays the foundation for **intelligent vehicular governance**, where vehicles themselves participate in maintaining lawful, safe, and efficient road use.
By merging **IoT connectivity**, **biometric verification**, and **AI-based geofencing**, future systems can move toward **autonomous rule enforcement**, reducing dependence on manual regulation.

Such innovation aligns perfectly with the broader vision of **sustainable smart cities**, where technology enhances both mobility and civic discipline.

Conclusion

The reviewed thesis, *"Vehicular Preventive Access to Juvenile & GPS Navigated Unauthorized Parking Alert System"*, represents a **remarkable synthesis of embedded technology, IoT integration, and social responsibility**. By addressing two major challenges — unauthorized parking and juvenile vehicle misuse — the author successfully proposes a dual-purpose system that enhances both **traffic regulation** and **vehicular safety**.

The GPS-based parking alert module introduces a proactive way to prevent parking violations through coordinate-based geofencing, while the fingerprint-enabled ignition system ensures that only authorized users can operate a vehicle. Together, these mechanisms establish a **technological model of deterrence**, where prevention is achieved through automation rather than manual enforcement.

From a research perspective, the work demonstrates strong **technical feasibility**, sound **design architecture**, and clear **societal relevance**. However, future work should focus on real-world validation, mobile connectivity, and AI-based optimization to improve intelligence and scalability.

In conclusion, this thesis stands as a promising contribution to the domains of **smart city mobility, intelligent transportation systems (ITS), and automotive security**. It exemplifies how low-cost embedded systems can be leveraged for large-scale impact, promoting safer, smarter, and more disciplined transportation ecosystems.

References

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