Enhancing Urban Parking Security through IoT, Faster R-CNN, OCR, and UVSS Integration: A Case Study of Delhi

Prabhat Verma[1], Vishal Jaiswal[2]

[1]*Research Scholar, Guru Gobind Singh Indraprastha University, Delhi, India*
[2]*Post Graduation Student, Indira Gandhi National Open University, Delhi, India*

Abstract – *Delhi, being a National capital of India and State, comprises of 1483 square kilometer of area having approximately 16.07 million registered vehicles, making smart public parking as a one of the major infrastructure requirement in the city. Currently, Urban parking infrastructure is suffering from two major challenges: first, a security problem caused by the increase in threats carried by vehicles in public spaces and second, an inefficiency due to the lack of an accurate knowledge of the movement of vehicles and the lack of a system to guide them. This paper proposes the comprehensive system design of an IoT based smart parking system with three core technological subsystems: (i) AI-powered Under Vehicle Surveillance System (UVSS) screening at all parking entry lanes for fuel leak detection and identifying the presence of an improvised explosive device (IED)in the vehicles; (ii) Vehicle Number plate identification using multi-stage Optical Character Recognition (OCR) pipeline; and (iii) Overhead vehicle density monitoring with Faster Region-based Convolutional Neural Network (Faster R-CNN). The study is directly inspired by incidents that have actually occurred, such as a vehicle packed with ammonium nitrate that was not detected in a public parking lot near Kashmere Gate on November 10, 2025, and which survived for more than three hours until a deadly explosion occurred. The overall architecture, choice of components, data flow design and inter-subsystem integration logic is presented in the paper for Enhancing Urban Parking Security through IoT, Faster R-CNN, OCR, and UVSS Integration. Overall, the study proposes an effective and scalable solution for enhancing parking security, reducing disaster risks, availability of space in parking and improving the protection of critical infrastructure and public spaces in Delhi.*

Key Words: Explosive detection, Smart Parking, Under Vehicle Surveillance system, etc.

1. INTRODUCTION

The volume of vehicle registered in the Delhi is increasing day by day. Additionally, Vehicles from the nearby states also come in National Capital for several works such as visiting Airports, hospitals, jobs, meetings, business activities, etc. Huge number of the vehicle needs the parking facility to park the vehicles for attending the desired works. However, the limited number of parking availability adds the additional 15-20 minutes to find a parking spot during peak hours in national capital. where an inefficient total of 15 minutes adds to the additional costs of the inefficiency being measured — such as fuel usage and increased air pollution in urban areas [3]. Traditional parking management systems, which are based on humans or basic sensor-based displays, have been found to be lacking in real-time, spatial awareness, vehicle identification and security screening that is required in modern urban environments. Today, most existing parking management systems are either manned by people or use basic sensor-based parking display, but they do not have the required spatial awareness, vehicle identification, and security screening function that is required in the modern urban setting.

Much of the research on the occupancy management aspect of this problem has been advanced by the development of smart parking. Smart parking research has significantly progressed the aspect of the problem related to occupancy management. The use of IoT-based sensor networks, computer vision and machine learning-based occupancy prediction models has been proven in various urban scenarios [1, 3, 5, 6]. A crucial factor, which has not been extensively discussed, is security, however. A current smart parking system allows all vehicles to enter without examination. There were no systems in the literature that physically screened vehicles at parking entry for any concealed threats or mechanical defects such as fuel leaks.

The incident that sparked the incident was the arrival of a white Hyundai i20 (HR26 CE 7674) carrying ammonium nitrate at 3.19 PM at a public parking area, next to Sunehri Masjid, Kashmere Gate, Delhi, on 10 November 2025. This car stayed undetected parked for more than three hours. The car blew up at 6:52 PM IST in front of Gate 1 at the Red Fort metro station, killing 15 and injuring over 20 people. The Indian government officially declared the attack a terrorist attack. There was no under-vehicle inspection system at the parking entrance [11, 12].

This paper addresses this need by proposing a comprehensive system design of an integrated smart parking and entry security platform. At each parking entry lane, it is unveiled that the design incorporates Faster R-CNN overhead vehicle detection, OCR-based number plate recognition and integration with law enforcement watchlist, slot occupancy sensing using the IoT and undercarriage imaging, hydrocarbon gas sensing, and explosive precursor chemical detection using UVSS all within a single fail-safe pipeline.

The performance numbers quoted are taken from published peer-reviewed peer studies on the single technologies. The integrated system has not yet been deployed physically and tested experimentally. This evaluation is the main direction of the future work stemming from this research.

The main contributions of this paper are:

- A novel integrated architecture combining smart parking management and mandatory vehicle security screening (not addressed as combined system in literature).
- Flow chart of each subsystem design including detailed component level design as follows: Faster R-CNN detection, OCR pipeline, IoT sensor fusion, UVSS imaging, gas sensing, chemical detection.
- A data flow and inter-subsystem integration design that includes barrier authorization logic, tiering of alerts and fail-safe defaults.
- The comparative gap analysis of published smart parking systems showing that security screening is not a systematic research area.
- A case-based study and policy-oriented analysis based on the forensic record of the 2025 Delhi Red Fort blast to create the evidence base for compulsory deployment of UVSS at public parking.

2. LITERATUR REVIEW

2.1 Profile and Parking Infrastructure of state.

Delhi comprises of 1483 square kilometre of area [14], having the registered population of around 23 million [15]. Further, the around 1.1 million vehicles enters or leaves Delhi from nearby states, making the need of secure parking at utmost priority. Demographic growth and the continuous movement of commuters from the National Capital Region created peer pressure on its road network and parking facilities. With only 2.1 lakh equivalent car parking spaces [17], responsibility of handling multi million vehicles per day and considering threat perception of the city, creates the requirement of secure and automatic parking lots across the state.

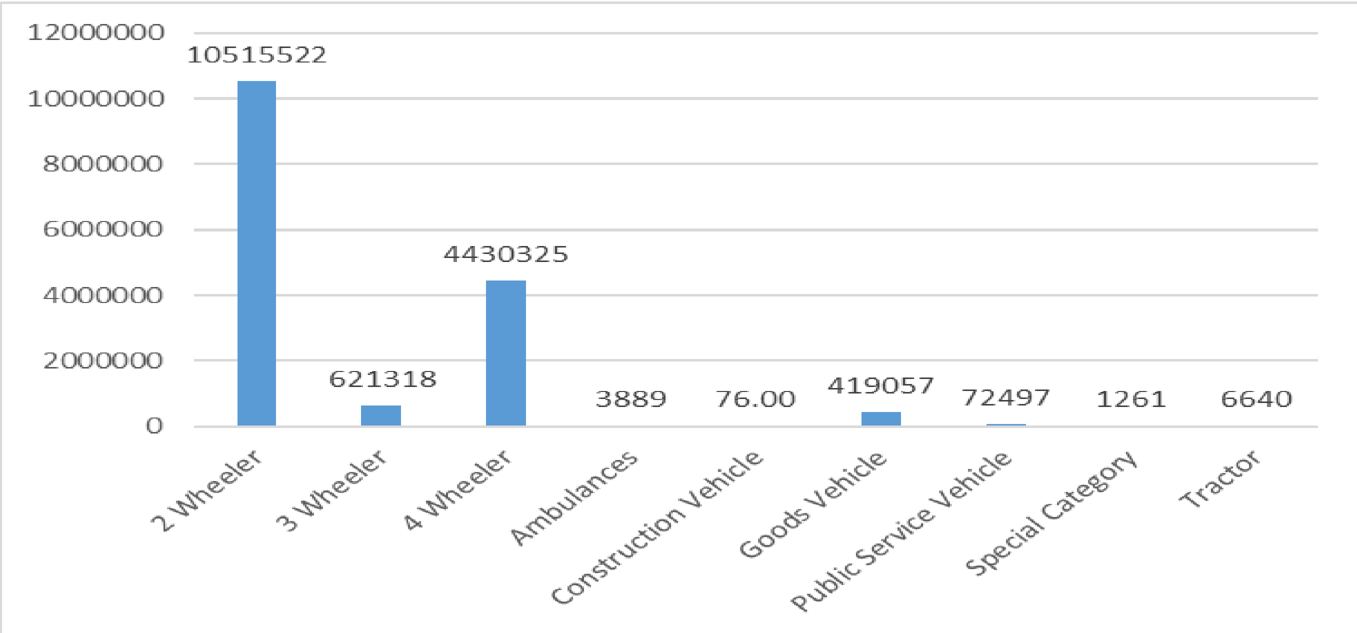

Fig: 1.0 Showing no of vehicles registered in Delhi till 10.07.2026 (Source: https://parivahan.gov.in)

2.2 IoT- Based Parking management

Elfaki et al. [1] developed an intelligent system for real-time control and monitoring of parking spaces, which consisted of microcontroller (ESP8266) installed in each parking stall and transmitting information via Wi-Fi to a central server. The system proved to be effective for tracking occupancy of a single facility and the notification of drivers, but was limited to binary readings only and not using any vehicle identification, classification or security screening. The architecture of the system shaped the design of the IoT communication layer of the proposed design with regard to its sensor telemetry communicating using lightweight publish subscribe protocols.

In [5] the idea of parking in IoT was expanded with an additional layer that is user facing, a mobile application layer where drivers can see which parking slots are available and go to them. Again, there was no computer vision, vehicle identification or security dimension. The mobile-interfacing design mentioned by Karandikar et al. is used to provide the Application Layer specification for Section 3.5 of this paper.

In [6] Provoost et al. proved that time-series data of parking availability can be used to train machine learning models that can forecast availability patterns to guide users proactively in advance of peak demand periods. This work is the most analytic in the provided corpus in terms of occupancy management dimension, encouraging the introduction of a predictive analytics module in the cloud Application Layer of the proposed architecture.

2.3 Computer Vision and Deep Learning for Vehicle Detection

Nebiker et al. [2] used low-cost, RGB-D cameras placed on mobile mapping vehicles to gather on-street parking statistics using an AI-based 3D object detection algorithm. It is a methodologically sound approach that is, unfortunately, not intended to be applied to ongoing monitoring; it does involve periodic visits to streets, but not permanent, persistent observation. The accuracy of their detection results obtained under controlled outdoor conditions is provided as a detection performance upper bound for their fixed camera deployment under similar conditions, and is used as a benchmark in the discussion in Section 4 of this paper.

The most recent framework for accurate object detection for surveillance applications is the Faster R-CNN architecture proposed by Ren et al. [8]. Faster R-CNN embeds the Region Proposal Network into the detection pipeline to avoid the computational burden of extracting region proposals from the pipeline, and thus achieves near real-time inference using embedded hardware. In Section 3.2, published benchmarks are referenced on the PASCAL VOC and MS COCO datasets, and also on the domain-specific parking detection datasets, which serve to provide characterisations of the expected detection performance.

2.4 Autonomous and Intelligent Parking Systems

A thorough review of the existing autonomous parking system solutions is presented in detail by Olmos Medina et al. [4] which classify the solutions based on sensing modality (camera, LiDAR, radar, ultrasonic), control architecture (centralized vs. distributed) and scalability. The lack of cross-system integration has been highlighted as the main problem hindering the deployment at an urban level, which is directly addressed by the proposed unified architecture in this paper. Sense modalities are discussed in the taxonomy, a taxonomy which is used to inform the sensor selection rationale in Section 3.

Overall, the literature that has been reviewed consistently shows that all such published smart parking systems have focused only on the problem of occupancy management and offering guidance to the driver. There is no research on security screening, which is defined as the process of screening people visiting a parking facility. That gap is the focus of the design of this paper.

2.5 Under-Vehicle Surveillance Systems (UVSS)

The Under-Vehicle Surveillance Systems have been in use for more than 20 years in areas with high security requirements: military bases, embassies, border crossings, airports, etc. Commercial systems such as the ISS SecurOS UVSS [7] and Vehant NuvoScan [10] are using high resolution line-scan camera arrays under entry lanes to snap full underbody images at speeds up to 30 km/h. AI anomaly detection modules, using a convolutional neural network network architecture, will process images captured through multiple sensors and compare them with baseline reference databases of images of the car's undercarriage, identifying any structural changes, pieces attached to the structure, or structural defects that match any of the concealed device images. The system not only scan the underframe of the vehicles but also helps in identifying prohibited items in boot area.

Academic research has not yet come to a conclusion on how to integrate the UVSS technology into the smart parking system set up in the urban context. In the security space the technology is mature, it is available and it is not a technological problem that it isn't being used in smart parking solutions, it's a design problem. This paper presents the first integrated architecture specification that integrates UVSS with the parking management using IoT.

2.6 Fuel Leak and Hazardous Gas Detection in Parking Structures

It is a known fact that fuel leakage can pose a fire and/or explosion risk from parked vehicles in enclosed or semi-enclosed parking structures. Hydrocarbon vapors can build up to potentially flammable concentrations over the course of a parking event when a vehicle with a damaged fuel system is parked in a restricted area. Currently, there is no way to identify this hazard if the parking system employs a smart parking system. The gas sensing pipeline used in the UVSS module design is based on the results of the gas detection research for hydrocarbons based on metal oxide semiconductor (MOS) sensors, which showed reliable detection of hydrocarbon vapors in concentration ranges which are relevant to the application, in the indoor environment [13]

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 13 Issue: 07 | Jul 2026 www.irjet.net p-ISSN: 2395-0072

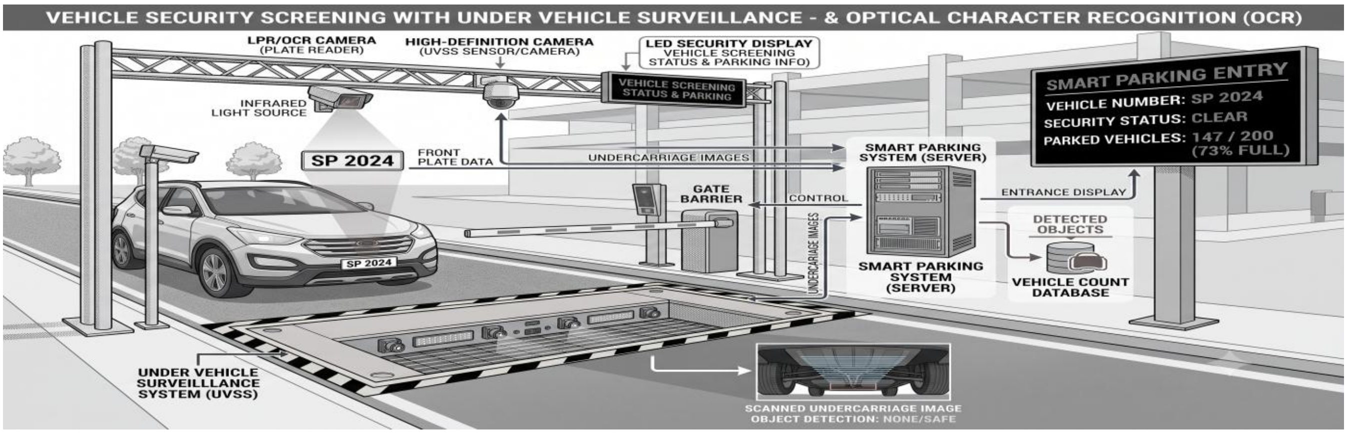

Fig: 2.0 Showing symbolic overview of the proposed smart parking. (Source: Self-Created by Author)

3.2 Faster R-CNN Vehicle Detection and Density Monitoring

The overhead vehicle detection subsystem consists of fixed IP cameras (2MP+ and 25-30fps), mounted above the parking zone, and a Faster R-CNN inference pipeline, each edge computing node co-located with each set of cameras. Compared to one-stage detectors (YOLO and SSD), the Faster R-CNN architecture is chosen as precision is more important than throughput in parking monitoring, and the computational burden of Faster R-CNN is not prohibitive, e.g., it would be feasible to run it on current edge hardware like the Nvidia Jetson series.

Performance Reference (Literature):

Faster R-CNN gets 73.2% mAP on PASCAL VOC 2007 and 42.7% mAP on MS COCO [8]. Domain specific parking detection studies show increased accuracy when using limited overhead parking data sets, the appearance space of which are more restricted than those of general object detection studies. These numbers are indicative of the expected detection capability in the proposed deployment needs to be empirically evaluated.

Once discovered, in post-detection a slot occupancy mapping algorithm calculates the IoU association between the detected vehicle bounding boxes with a pre-registered slot coordinate map that was established during initial system calibration. The spatial occupancy map is updated every inference cycle, which results in a real-time availability indication that is fed into the driver nav and operator display.

3.3 OCR Number Plate Recognition with Watchlist Integration

The OCR pipeline process vehicle crops from the output of the Faster R-CNN detector. The pipeline consists of 5 steps: (1) Lightweight Number plate detection model (2) Perspective Normalization (3) Adaptive preprocessing (Contrast-limited adaptive histogram equalization (CLAHE), morphological boundary enhancement, resolution standardization) (4) Character sequence recognition (CNN+RNN+Attention (CRNN)) (5) Output validation (regex for country-specific number plates).

An essential extra enhancement over standard ALPR capabilities is a Stage 6 watchlist matching stage. Before deciding whether to authorize or deny access to the barrier, the recognized plate string is sent to a law enforcement watchlist API. Any vehicles that display stolen vehicle registration, appear on the terrorist investigations watchlist or are found on active warrant lists trigger a security alert which prevents a vehicle from opening the barriers and alerts security personnel to trigger a physical inspection of the vehicle by the UVSS – a parallel screening process to the physical inspection performed at the UVSS.

Performance Reference (Literature): In the published literature, performance of the CRNN-based ALPR systems ranges between 94–99% when the conditions are well-controlled, but performance degrades when the vehicles are partially occluded, viewed at extreme angles, or presented under poor lighting conditions. All the above degradation sources are addressed in the pre-processing pipeline in Stage 3 before OCR inference.

3.4 AI-Powered Under-Vehicle Surveillance System (UVSS) Module

The module UVSS is the security gate of the proposed architecture. It is reinforced and rated as IP68 and is integrated into a ground casing in each entry lane. As a vehicle drives over the unit at a speed of 5-30 km per hour, three parallel detection pipelines are activated simultaneously:

Undercarriage Imaging & AI Anomaly Detection: Pipeline 1 is an on-vehicle high-resolution line-scan camera array that is constantly used to create a complete, composite undercarriage image (without blind spots) of a vehicle, with the camera array flanked by LED lights to provide consistent coverage across the entire image, eliminating shadows. An anomaly detection model based on a convolutional neural network pattern tests the captured image against a baseline database of images of the undercarriage of common vehicles, and identifies anomalies that match the features of attached objects, structural changes in the vehicle or hidden packages. This pipeline directly tackles the threat modality of the Delhi 2025 bombing where the bomb was placed inside the car or under the car.

Performance Reference (Literature):

Commercial UVSS platforms (ISS SecurOS UVSS [7] / Vehant NuvoScan [10]) are able to deliver high-resolution undercarriage imaging at vehicle speeds up to 30 km/h and with AI-based anomaly detection. Currently, there are no published independent accuracy results for the AI anomaly detection of undercarriage images in the open academic literature, but such results can be found in the technical documentation from vendors and validated with independent testing in future empirical studies.

As the vehicle crosses over, the hydrocarbon vapor concentration is sensed in the UVSS housing by a pair of hydrocarbon gas sensors in the form of metal oxide semiconductors (MOS), a type of semiconductor gas sensor: MQ-2 and MQ-135. A detection threshold is established above the ambient background reading from reference sensors placed outside of the vehicle travel path, to minimize false readings from vehicle exhaust. If the reading is above this threshold, it activates a fuel hazard alert (Priority-2) and the vehicle is not permitted to be authorized on the barrier, and will be routed to an inspection lane. This pipeline aims to combat the constant fire threat from vehicles that have fuel systems with leaks in parking areas inside or partially enclosed buildings.

In addition to the visual anomaly detection, this is enhanced by a dedicated chemical sensor array sensitive to the vapor signatures of the chemicals used in the IEDs that were found in the Delhi 2025 Red Fort bombing, ammonium nitrate, and other common chemical precursors found in conventional IEDs. If a Chemical Signature is positive, along with a visual anomaly detection result, the result is raised to Priority-0 (Maximum threat) which activates the barrier, notifies the Parking Operators console, and notifies a connected Security Control Center.

Design Note:

Ammonium nitrate can be measured at ambient temperatures. Technically, it is possible to detect this signature in an open or semi-open parking entry environment with current metal oxide sensor technology, but it remains to be determined how sensitive the sensors must be to the signature and how many false positives can be expected in real urban atmospheric conditions by conducting controlled field testing. This is yet a question that will be explored in the proposed future deployment study, which is an empirical question.

3.5 Barrier Authorization Logic

The barrier control logic is very strict, requiring that the UVSS visual anomaly pipeline returns a negative result, the gas sensor reading is below the hydrocarbon threshold, the chemical sensor array returns no explosive precursor signature and the OCR watchlist check returns no match. If one or more conditions is not met, the barrier is not authorized and the alert Tier is triggered. If the sensor communication timeout or processing failure, the whole system reverts to barrier-closed, so that if there is any infrastructure failure, it cannot be exploited as a bypass.

Table 1.0: Barrier authorization logic and alert tier specification.

Alert Priority	Triggering Condition	Barrier Action	Notification
Priority-0	Visual anomaly + chemical precursor detection	Immediate lockdown	Operator + Security Control Center
Priority-1	Visual anomaly only OR watchlist plate match	Barrier denied	Operator + Security Personnel
Priority-2	Fuel/hydrocarbon leak detected	Barrier denied	Operator + Maintenance
Priority-3	Sensor timeout / processing failure	Barrier denied (safe default)	Operator (system alert)
Authorized	All conditions negative	Barrier opens	Slot assigned to driver app

3.6 IoT Sensor Layer and Occupancy Fusion.

Each of the parking spaces contains an ultrasonic proximity sensor mounted overhead that transmits via ZigBee mesh network to zone gateway nodes within the parking zone. Gateway nodes collect the data from sensors and publish it through MQTT to the edge computing cluster. Slot occupancy state is computed by combining the sensor reading with the Faster R-CNN camera-derived occupancy determination, where the majority-vote or a Bayesian confidence model is used: if both sensor and camera agree on the same occupancy state on consecutive sensing cycles, the state is immediately updated, thus mitigating the effects of transient noise on the occupancy map; if they disagree, the state is kept unchanged until the two sources reach consensus, which is typically within a few cycles. Occupancy map is fused to the cloud dashboard and driver application in real time.

3.7 Communication and Application Layers

The Communication Layer is based on MQTT over Wi-Fi 6 for sensor-to-edge telemetry, HTTPS REST APIs for edge-to-cloud data ingestion and WebSocket for real-time streaming to the dashboard. The Application Layer presents the system to three classes of users: parking zone operators through a web dashboard that presents zone status (full/empty), status (alert), and entry event log; drivers through a mobile app that presents available parking slots and navigational guidance; and city traffic management centers through an open REST API that feeds zone-level occupancy data for use in other city traffic management systems.

4. COMPARATIVE ANALYSIS OF EXISTING SYSTEMS

A comparison of the existing systems is included. Comparative analysis of existing systems is included. Table 2 shows the comparison of proposed system with the key prior works reviewed in Section 2 for the functional dimensions addressed by this design. The comparison points out the lack of a consistent security screening system in all the published systems.

No existing published system integrates vehicle detection, number plate recognition, occupancy sensing, fuel hazard detection and security screening into one integrated system. The absence of this is not an oversight but an area of design that can be a lifesaving risk, as the 2025 Delhi Red Fort bombing demonstrates when it comes to public parking facilities.

Table 2.0: Functional comparison of existing smart parking systems and the proposed integrated design

System	Vehicle Detection	Plate Recognition	Occupancy Sensing	Fuel Leak Detection	IED / Security Screening	Watchlist Matching
Elfaki et al. [1] (2023)	No	No	Sensor only	No	No	No
Nebiker et al. [2] (2021)	Yes (3D)	No	Camera only	No	No	No
Provoost et al. [6] (2020)	No	No	ML prediction	No	No	No
Olmos Medina et al. [4] (2025)	Survey	Survey	Survey	No	No	No
Karandikar et al. [5] (2026)	No	No	Sensor only	No	No	No
Proposed System	Yes (Faster R-CNN)	Yes (CRNN OCR)	Fused (sensor + camera)	Yes (gas sensor)	Yes (UVSS + chemical)	Yes (API)

5. SECURITY POLICY ANALYSIS: LESSONS FROM THE 2025 DELHI RED FORT BOMBING

Delhi Red Fort bombing 2025 is the greatest recorded case study of how urban parking management and public security are linked. Based on police forensic reports, this incident was reconstructed in detail using verified news reports [11, 12] and the following sequence of events was identified relevant to this paper:

- Before entering into Delhi the vehicle had explosives loaded or assembled.
- The vehicle did not get stopped by the vehicles at either Daryaganj or Kashmere Gate, which are high-density neighbourhoods in close proximity to a number of important heritage and transit facilities.
- The car was parked in a public place close to Sunehri Masjid, Kashmere Gate at 3.19 PM. Admitted without inspection.
- The parking area time was 3:29 hrs. None of the parking management systems reported on its length of stay, modification of the under carriage or its chemical signature.
- The car took off from the parking lot at 6:48 PM. The explosion was of a bomb hit in the Red Fort Metro Station at 6.52 PM near gate 1.

This chain could have connected with 3 of the proposed capabilities in Section 3.4 of the UVSS. The undercarriage AI anomaly detection pipeline would have seen a change in structure or extra weight which is common with an explosive device. The chemical detection array would have detected the ammonium nitrate vapor. If the vehicle had done so, either signal alone or both signals together would have prevented the vehicle from entering the parking area and would have generated a Priority-0 alarm prior to entering the parking area.

The analysis also results in a direct policy prescription legislation should be enacted to require all public parking facilities located near historic sites, government facilities, mass transit and high-density commercial areas in Indian cities to install UVSS. The 2025 attack shows that the threat is not only real, but is also present and is taking advantage of an existing weakness in current infrastructure. The proposed architecture is technically feasible to fill that gap and is deployable.

6. LIMITATIONS AND FUTURE WORK

This paper proposes a system design and architecture. Prior to the proposed system being considered validated, the following limitations need to be addressed:

Lack of empirical assessment: No empirical assessment (physical deployment or controlled experiment). This paper's performance characterization is based on published benchmarks of constituent technologies in isolation. The immediate research focus for future work is an integrated deployment evaluation, which measures the accuracy of the deployments (deployment level of detection), the performance of the OCR (OCR accuracy), the performance of the UVSS (rates of anomalies detected), the sensitivity of the gas sensors, and the end-to-end latency of the system as a whole.

No real environmental baseline data from open urban parking has been used to calibrate the chemical detection pipeline for the explosive precursor chemical. In the outdoor environment, the concentration of vapors, wind dilution, humidity, and other interfering chemical backgrounds are quite different than in the laboratory. Extensive field calibration work is necessary prior to use.

There is no public academic dataset available for training/benchmarking the anomaly detection model with labelled images of vehicle undercarriage. Empirical model evaluation requires the development of such a dataset, comprising representative examples of both normal and modified vehicles, as well as examples of threat simulation, over a representative range of vehicle types. Geographic generalizability: The design is driven by and focused on conditions of cities in India (climate, vehicle fleet type, number plate format, regulatory environment). The adaptation to other geographic locations would involve re-evaluation of the specifications of the components, especially the calibration of the gas sensors and training the OCR model.

Data protection issues under relevant legislation: The use, storage and processing of images of the undercarriage and number plates involve issues of data protection and compliance with relevant legislation. The architecture needs to be audited prior to deployment for compliance with national and local legislation for vehicle surveillance.

Strict law is also required which mandates the usage of aforesaid or equivalent technologies, to ensure secure and safe parking lots across the state.

Future usage of this mechanism can be implemented on critical infrastructures like Parliament buildings, Religious places, Interstate Bus terminals, Train Depots, Hospitals, Malls, etc.

7. CONCLUSIONS

The study proposes parking lots with under vehicle surveillance system, optical character recognition and density monitoring with convolutional neural networks, ensures that every vehicle being parked is duly checked and inspected automatically, barring the movement and deployment of explosive and other prohibited items in the vehicles.

The comprehensive design needs government nod by ensuring strict rules & guidelines for parking lots and subsidy policy for installing upgraded system in existing parking spaces so that technology can be implemented at the earliest for strengthening security mechanism in state of Delhi.

The proposed solution provides a solution to two different but related urban infrastructure problems: security gaps resulting from the lack of physical vehicle inspection at public parking facilities; and operational inefficiency of unguided parking search in dense urban environments.

The automated safe secure parking lots can handle security related issue more efficiently as compare to traditional parking procedure, presently being used at maximum parking lots. This study is foundational study that sets the basis and reasons of the empirical programme.

REFERENCES

[1] A. O. Elfaki et al., "A Smart Real-Time Parking Control and Monitoring System," Sensors, vol. 23, 2023.

[2] S. Nebiker et al., "Outdoor Mobile Mapping and AI-Based 3D Object Detection with Low-Cost RGB-D Cameras," Remote Sensing, vol. 13, p. 3099, 2021.

[3] Urban mobility studies on Indian metropolitan cities, 2026. (Drivers spend 15–20 minutes searching for parking during peak hours).

[4] J. S. Olmos Medina et al., "An Overview of Autonomous Parking Systems: Strategies, Challenges, and Future Directions," Sensors, vol. 25, 2025.

[5] V. Karandikar et al., "Smart Parking Lot Helper: A Technological Advancement in Parking Management," International Journal of Current Engineering and Technology, 2026.

[6] J. C. Provoost et al., "Predicting Parking Occupancy via Machine Learning in the Web of Things," Internet of Things, vol. 12, p. 100301, 2020.

[7] ISS SecurOS, "SecurOS UVSS: Under Vehicle Surveillance System," 2025. [Online]. Available: https://uvss.tech/

[8] S. Ren et al., "Faster R-CNN: Towards Real-Time Object Detection with Region Proposal Networks," IEEE Trans. Pattern Anal. Mach. Intell., vol. 39, no. 6, pp. 1137–1149, 2017.

[9] B. Shi, X. Bai, and C. Yao, "An End-to-End Trainable Neural Network for Image-Based Sequence Recognition," IEEE Trans. Pattern Anal. Mach. Intell., vol. 39, no. 11, pp. 2298–2304, 2017.

[10] Vehant Technologies, "NuvoScan Under Vehicle Scanning System," 2025. [Online]. Available: https://www.vehant.com/

[11] "2025 Delhi Car Explosion," Wikipedia, Accessed: June 2026. (For overview only; supplement with news sources).

12] Business Today, "Red Fort Blast: i20 Entered Delhi at 8:04 AM, Left Parking at 6:22 PM," Nov. 11, 2025.

[13] K. Galatsis et al., "A Vehicle Air Quality Monitor Using Gas Sensors for Improved Safety," Sensors and Actuators B: Chemical, 2000.

[14] Government of NCT of Delhi, "Delhi State Action Plan, 2026," 2026. [Online]. Available: CAQM Portal PDF. [Accessed: Jul. 13, 2026].

[15] A. Verma, "Delhi population reaches 2.3 crore," The New Indian Express, Jun. 16, 2026. [Online]. Available: The New Indian Express article.

[16] Department of Environment, Government of NCT of Delhi, Delhi State Action Plan on Climate Change. New Delhi, India: Government of NCT of Delhi, 2019. [Online]. Available: Delhi State Action Plan on Climate Change.

[17] TOI City Desk, "Delhi's parking makeover: 232 new parking sites, multi-level hubs to tackle city's space crunch," The Times of India, Jun. 15, 2026. [Online]. Available: The Times of India article.