Fastag Fraud Detection System

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Abstract: The increasing adoption of FASTag for electronic toll collection has streamlined vehicular payments across toll plazas in India but has also introduced new risks of fraud. This paper presents a machine learning-based approach for detecting fraudulent transactions in FASTag systems, implemented in Python. By analyzing transaction patterns, identifying anomalies, and employing classification and anomaly detection algorithms, our proposed system detects potential fraud in real time. This solution aims to reinforce the security and integrity of the FASTag ecosystem, safeguarding against unauthorized usage and financial loss. Our study includes a review of existing fraud detection methods in digital payment systems, followed by an evaluation of our approach through performance metrics such as accuracy and precision. Experimental results demonstrate the system's effectiveness in identifying suspicious activities, thus providing a valuable tool for enhancing security in electronic tolling infrastructure.

1 INTRODUCTION

The FASTag system, introduced by the National Highway Authority of India (NHAI), has revolutionized toll collection by enabling RFID-based, cashless electronic toll collection (ETC) on national highways. This system, which mandates the use of FASTag for all vehicles, has significantly improved traffic flow by reducing congestion at toll plazas and has promoted transparency and accountability in tolling operations. With the widespread adoption of FASTag, millions of transactions are processed daily across India's extensive highway network, making toll collection faster, more efficient, and more convenient. However, the rapid expansion of the FASTag system has led to new security challenges, including the risk of fraudulent activities that undermine the trustworthiness and integrity of the ETC framework. These frauds include unauthorized account access, cloning of FASTag accounts, and exploitation of system vulnerabilities, posing a risk to both toll operators and users .The rise in FASTag-related fraud calls for effective and efficient fraud detection mechanisms to identify and mitigate risks in real-time. Traditional rule-based approaches often fall short when dealing with high-volume, dynamic transaction data due to the complex and evolving nature of fraudulent patterns. To address this gap, this paper presents a machine learning-based framework for fraud detection in FASTag transactions, utilizing techniques such as linear regression and logistic regression. Machine learning (ML) offers powerful tools to detect anomalies within high-frequency transaction data, with supervised models like linear and logistic regression proving effective in binary classification tasks and predicting probabilities based on transaction patterns. By analysing features derived from transaction histories, our system seeks to distinguish between legitimate and suspicious transactions, improving the overall security of the FASTag ecosystem .The proposed solution centres on developing a comprehensive fraud detection model using Python-based machine learning techniques tailored for real-time FASTag transactions. In the preprocessing stage, linear regression aids in understanding and normalizing transactional data patterns, enhancing feature engineering by iden-

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tifying underlying trends and detecting anomalies in transaction amounts and frequencies. This analysis helps to capture seasonal variations and scale data effectively, ensuring that key patterns associated with fraud are highlighted. Logistic regression, renowned for its binary classification capabilities, is employed as the primary model to distinguish between "fraudulent" and "non-fraudulent" transactions. By training the model on historical labelled data, it gains the ability to recognize prevalent fraud tactics, such as account cloning, unauthorized transactions, and unexpected frequency of usage, thereby improving its detection accuracy. To further enhance accuracy, the model undergoes iterative training and hyperparameter optimization, fine-tuning aspects like regularization and feature weights to reduce false positives and increase detection reliability. Additionally, the model continuously learns from new data, enabling it to dynamically adapt to evolving fraud patterns. Such an approach not only enhances the operational security of the FASTag system but also aligns with regulatory compliance requirements, strengthening the overall trust and robustness of the electronic toll collection ecosystem. The remainder of this paper is structured as follows: Section II provides a literature review on existing fraud detection techniques in electronic payment and toll collection systems. Section III outlines the methodology, describing data preprocessing, feature extraction, and the machine learning algorithms employed. Section IV presents experimental results, including model performance and accuracy metrics, and discusses the implications of these findings. Finally, Section V concludes the paper and suggests potential future directions for enhancing this fraud detection system. Through this work, we aim to contribute to the growing body of literature on the application of machine learning in securing digital payment and tolling infrastructures, ultimately promoting a safer, more reliable FASTag ecosystem

2 RELATED WORKS

1. (Oza,) Enhancing Integrity of Toll Gates: Fastag Fraud Detection: delves into the application of blockchain technology to strengthen data sharing, security, and privacy within Intelligent Transportation Systems (ITS), with a focus on toll collection and FASTag systems. Recognizing vulnerabilities in existing tolling methods, the authors propose a blockchain-based framework to counteract fraud and enhance data integrity by decentralizing data management and ensuring transparency through immutable transaction records. The paper highlights how blockchain can streamline economic efficiency within ITS by reducing the need for third-party verifications, lowering operational costs, and accelerating transaction processes. Additionally, integrating blockchain with the Internet of Vehicles (IoV) is explored as a way to create a cohesive and secure ITS ecosystem. This integration would enable real-time data exchange between vehicles, toll stations, and other ITS components, thereby enhancing data privacy and transparency in tolling operations. By positioning blockchain as a foundational layer, the paper suggests a future in which tolling systems are not only fraud-resistant but also more secure, resilient, and scalable.

2. (Bhavar et al., 2023) Fastag Fraud Detection: A Literature Survey: provides a comprehensive overview of existing research and methodologies applied to detect fraudulent activities within the FASTag electronic toll collection system. This literature survey examines various types of fraud associated with FASTag transactions, such as unauthorized access, account cloning, and system exploitation. The authors analyse both conventional and machine learning-based approaches that have been proposed for fraud detection in digital payment systems, highlighting their strengths, limitations, and applicability to FASTag. The survey also explores various machine learning techniques, including supervised and unsupervised learning methods, that have been effectively applied to similar fraud detection systems, such as credit card and online payment fraud. By identifying gaps in the current research, the authors emphasize the need for robust, real-time fraud detection frameworks that can adapt to evolving fraud tactics. The paper concludes by suggesting potential directions for future research, including the integration of advanced machine learning algorithms and real-time data analysis to enhance the security and reliability of the FASTag ecosystem.

3. (Gunjal et al., 2023) A Survey On FAScam: FAStag Fraud Detection System: presents a comprehensive overview of FAScam, a proposed system designed to detect fraud in the FASTag ecosystem. The authors discuss the growing prevalence of FASTag as a digital payment solution for toll collections in India, along with the associated vulnerabilities that lead to fraudulent activities such as cloning, unauthorized transactions, and manipulation of user accounts. The survey details various machine learning and data mining techniques that can be employed in FAScam for effective fraud detection. It highlights the importance of feature selection and the use of historical transaction data to train models that can distinguish between legitimate and fraudulent activities.

The paper emphasizes the need for real-time detection mechanisms that can alert users and operators of suspicious transactions promptly. Additionally, the authors evaluate existing fraud detection methodologies and frameworks in electronic toll collection systems, pointing out their limitations and proposing enhancements through the integration of advanced algorithms. The survey concludes by underscoring the significance of developing a robust, adaptable, and user-friendly fraud detection system that can not only protect users but also bolster the overall integrity of the FASTag system in India's transportation infrastructure.

4. (Roy and Savant, 2022) A Research Paper on Fast Toll System: provides an in-depth analysis of the FASTag system, focusing on its operational mechanisms, benefits, and challenges. The authors discuss how FASTag, an electronic toll collection (ETC) solution introduced by the National Highways Authority of India (NHAI), leverages RFID technology to facilitate seamless and cashless toll payments. By eliminating the need for cash transactions, FASTag significantly reduces congestion at toll plazas, enhances traffic flow, and promotes digital payment adoption. The paper highlights the various advantages of implementing a FASTag system, including increased efficiency in toll collection, reduced operational costs, and improved user convenience. It also discusses the environmental benefits of reduced idle time at toll booths, which contributes to lower vehicle emissions. However, the authors acknowledge the challenges faced by the FASTag system, particularly concerning fraud and security vulnerabilities. They emphasize the need for effective fraud detection mechanisms to safeguard user accounts and transaction integrity. The paper calls for further research and development in the areas of machine learning and data analytics to enhance the security features of the FASTag system, ultimately ensuring a more reliable and efficient toll collection process. In conclusion, the authors advocate for continued innovation and improvements in the FASTag infrastructure to address existing challenges and ensure its successful implementation in India's transportation network.

5. (Kumar et al., 2022) FASTag RFID Scam: examines the vulnerabilities and challenges associated with the FASTag electronic toll collection system in India. The authors provide an overview of the FASTag system, which utilizes Radio Frequency Identification (RFID) technology to facilitate seamless and automated toll payments. While the system aims to streamline toll collection and reduce congestion at toll plazas, the paper highlights various fraudulent activities that have emerged as a result of its implementation. The authors discuss different types of scams related to FASTag, including the cloning of FASTag devices, unauthorized access to user accounts, and exploitation of system weaknesses. They emphasize that these fraudulent practices not only pose financial risks to users but also undermine the overall integrity and trustworthiness of the electronic toll collection system. To address these issues, the paper calls for the development of robust security measures and advanced fraud detection mechanisms. The authors advocate for the application of machine learning and data analytics to monitor transaction patterns, detect anomalies, and identify potentially fraudulent activities in real time. By implementing such solutions, the authors believe that the security of the FASTag system can be significantly enhanced, providing better protection for users and toll operators alike. In summary, the paper emphasizes the need for ongoing vigilance and improvement in the FASTag system to combat fraud and ensure its success.

6. (Sumangla et al.,) Enhancing Road Safety and Toll Efficiency: provides a comprehensive overview of the FASTag system and its implications for electronic toll collection in India. The study begins by detailing the inception and evolution of FASTag, highlighting its role in promoting cashless transactions and streamlining toll payments across the country's extensive highway network. By leveraging Radio Frequency Identification (RFID) technology, FASTag has significantly reduced waiting times at toll plazas and improved the overall efficiency of the toll collection process. discusses the benefits of the FASTag system, including increased transparency, reduced operational costs, and enhanced convenience for users. The paper outlines the various features of FASTag, such as real-time transaction tracking and automatic toll deductions, which contribute to a more user-friendly experience. Additionally, the author addresses the government's initiatives to promote the adoption of FASTag among vehicle owners, emphasizing its mandatory use for vehicles on national highways. However, the paper also acknowledges the challenges and limitations associated with the FASTag system. These include issues related to user awareness, technical glitches, and the potential for fraud, which can undermine user trust in the system. The study emphasizes the importance of implementing robust security measures and fraud detection mechanisms to protect users from potential scams. In conclusion, this paper serves as a valuable resource for understanding the impact of FASTag on India's toll collection landscape. It underscores the need for continuous improvements and innovations in technology to ensure the sustainability and effectiveness of electronic toll systems in the fu-

ture.

7. (Oza,) A Descriptive Study on FASTag: Electronic Toll, Standing Tall: presents an innovative approach to improving both road safety and toll collection efficiency through the integration of seat belt detection technology with the FASTag billing system. The authors begin by highlighting the importance of seat belt use in reducing road accidents and enhancing passenger safety. They note that despite existing laws mandating seat belt use, compliance remains a challenge, leading to higher rates of injuries and fatalities in vehicle accidents. To address this issue, the paper proposes a system that automatically detects whether passengers are wearing seat belts before a vehicle is allowed to pass through a toll plaza. By combining this seat belt detection mechanism with the FASTag system, the authors propose that vehicles not complying with seat belt regulations could face additional toll charges or alerts, thereby incentivizing safer driving behavior. This dual approach aims to reinforce traffic safety regulations while simultaneously streamlining the toll collection process. The paper discusses the technical implementation of this integrated system, including the use of sensors for seat belt detection and the necessary modifications to existing FASTag infrastructure. The authors provide insights into the potential benefits of this integration, such as improved compliance with safety regulations, reduced accident rates, and enhanced overall efficiency at toll plazas. In conclusion, the paper emphasizes the significance of leveraging technology to create a safer driving environment while optimizing toll operations. The integration of seat belt detection with the FASTag system represents a proactive step towards achieving these goals, ultimately contributing to better road safety and efficient toll collection practices.

3 METHODOLOGY

1. Linear Regression: This is used in the preprocessing stage to set up some sort of baseline patterns and trends in the transactional data. The mathematical form of the linear regression can be represented as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon$$

Where:

- Y is the dependent variable, e.g., the amount of the transaction.
- $X_1, X_2, \ldots, X_n$ are the independent variables, e.g., time and vehicle type.
- β_0 is the y-intercept.
- $\beta_1, \beta_2, \ldots, \beta_n$ are the coefficients of the variables.
- ε is the error term.

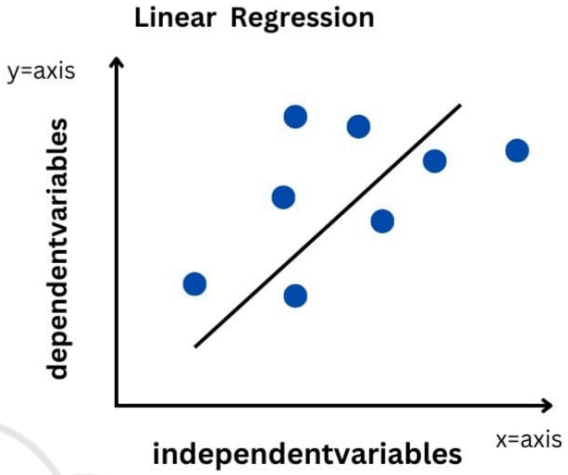


Figure 1: Linear Regression

2. Logistic Regression: This is considered the primary model for fraud detection, using logistic regression as a strategy for binary classification, where each transaction is categorized as either "fraud" (1) or "non-fraud" (0). The mathematical model of logistic regression is presented in the following equation:

$$P(Y = 1 \mid X) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n)}}$$

Here,

- $P(Y = 1 \mid X)$ is the probability that a transaction is fraudulent given the features X.
- e is the base of the natural logarithm.
- $\beta_0, \beta_1, \ldots, \beta_n$ are the coefficients estimated during the training process to improve predictive accuracy.

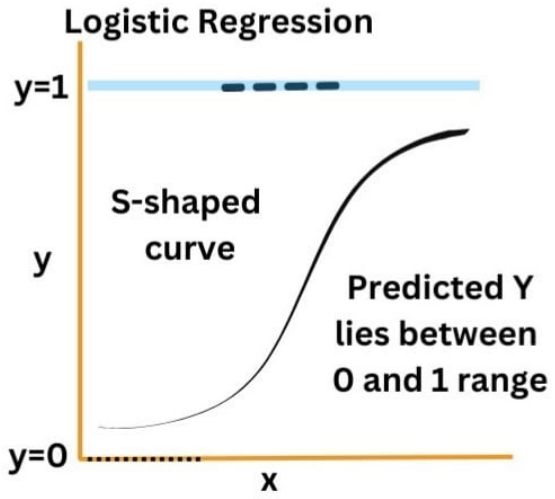


Figure 2: Logistic Regression

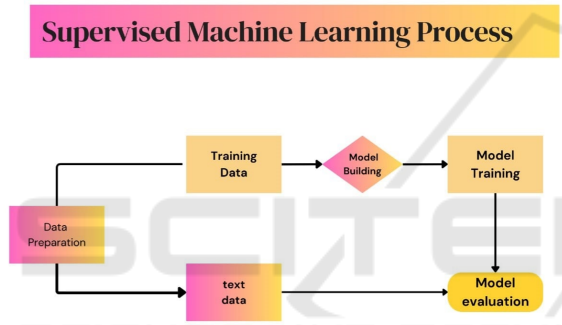


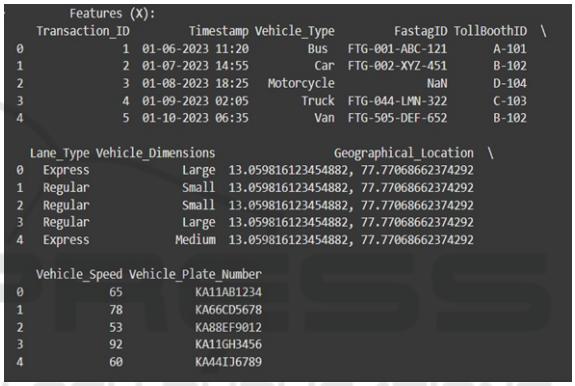
Figure 3: Surpervised Machine Learning

4 RESULTS

The results of the given study are actually a fraud detection system of toll transactions through FASTag data. The system detected some fraudulent transactions based on specific anomalies or inconsistencies. For example, Transaction 1 may be fraudulent because of mismatched vehicle dimensions and type or an amount not paid in the transaction (for example, wide discrepancies between what was charged and what was paid). Transaction 2 may be fraudulent due to a problem like duplicate usage of FASTag or anomalies in the usage of lane type. Transaction 3 is labeled as "Not Fraud," which means there is no apparent anomaly in its associated features. High-speed variations, missing FASTag IDs, or suspiciously low transaction amounts may also trigger flags as observed in Transactions 4, 5, 6, 7, and 8. This system would most probably be using rules combined with machine learning algorithms to analyze patterns and deviate from the same to alert about possible fraud.

Figure 4: results

This fraud detection system analyzes multiple features like vehicle dimensions, speed, lane type, and payment discrepancies to detect anomalies in FASTag transactions.Here we have a transaction amount significantly differing from the amount paid. So we are able to identify fraudulent activity.



Features (X):

	Transaction_ID	Timestamp	Vehicle_Type	FastagID	TollBoothID
0	1	01-06-2023 11:20	Bus	FTG-001-ABC-121	A-101
1	2	01-07-2023 14:55	Car	FTG-002-XYZ-451	B-102
2	3	01-08-2023 18:25	Motorcycle	NaN	D-104
3	4	01-09-2023 02:05	Truck	FTG-044-LMN-322	C-103
4	5	01-10-2023 06:35	Van	FTG-505-DEF-652	B-102

	Lane_Type	Vehicle_Dimensions	Geographical_Location
0	Express	Large	13.059816123454882, 77.77068662374292
1	Regular	Small	13.059816123454882, 77.77068662374292
2	Regular	Small	13.059816123454882, 77.77068662374292
3	Regular	Large	13.059816123454882, 77.77068662374292
4	Express	Medium	13.059816123454882, 77.77068662374292

	Vehicle_Speed	Vehicle_Plate_Number
0	65	KA11AB1234
1	78	KA66CD5678
2	53	KA88EF9012
3	92	KA11GH3456
4	60	KA44IJ6789

Figure 5: results

5 CONCLUSIONS

In conclusion, this paper presents concept of the FASTag fraud detection system is an effective tool for identifying anomalies in toll transactions by analysing various data points, including vehicle details, payment discrepancies, and behavioral patterns. By leveraging this system, authorities can significantly reduce revenue leakage, ensure smoother toll operations, and maintain the integrity of automated toll collection processes. Continuous refinement of the system with more advanced machine learning algorithms and real-time monitoring can further enhance its accuracy and reliability. This approach not only deters fraudulent activities but also fosters trust among road users in the digital toll collection system.

Table 1: Performance Matrix of Algorithms

Algorithm Name	Performance Matrix
Logistic Regression	0.75
Random Forest	0.75

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