GFuel: A Fuel Allowance Management System using Blockchain

JISHNU R[1], MANAS MANOJ[2], SIDHARTH A[3], VISHNU PRAKASH[4], SEBIN KURIAKOSE[5], RAKHEE M[6]

[1, 2, 3, 4, 5, 6] *Department of Computer Science and Engineering, Muthoot Institute of Technology and Science*

Abstract*—GFuel is an innovative platform that transforms fuel allowance management for government and private entities. Using advanced technology, including AI-powered cameras, machine learning, and blockchain, it enhances transparency and accountability in fuel consumption tracking. By using license plate recognition at fuel stations, GFuel seamlessly records data on a secure blockchain ledger, eliminating physical receipts and automating administrative tasks. This innovative system also minimizes the likelihood of fraudulent claims, fostering efficiency and integrity in fuel allowance management.Beyond administrative efficiency, GFuel empowers law enforcement agencies to enhance public safety efforts and demonstrates a commitment to responsible resource management, ulti- mately benefiting taxpayers and upholding the integrity of public service.

***Index Terms*—Fuel Allowances, License Plate Recognition, Blockchain, OCR**

I. INTRODUCTION

In today's business landscape, efficient resource management is vital for organizational success, with fuel being a significant operational expense for many companies. Traditional fuel allowance systems often suffer from inefficiencies and lack transparency, prompting the need for innovative solutions.

Our project GFuel introduces a Fuel Allowance System for companies, leveraging blockchain technology to transform fuel management processes. By integrating technologies such as license plate recognition, database management, blockchain, and web interfaces, our system aims to automate fuel transactions while ensuring transparency and reliability.

This paper provides an overview of our GFuel's architecture, functionalities, and implementation methodology. Through hardware integration, machine learning, and blockchain technology, our system offers a robust solution to streamline fuel management and enhance accountability.

By offering real-time tracking and recording of fuel transactions, our system enables companies to minimize errors and improve operational efficiency. The transparency provided by blockchain instills trust among stakeholders, contributing to better resource allocation and organizational performance.

II. BACKGROUND

In the current paradigm of fuel allocation for employees, conventional methods heavily rely on manual paperwork and submission processes. Two predominant approaches are commonly observed:

1. Letter of Intent (LOI) Method- This method entails the fuel station maintaining a Letter of Intent detailing the fuel quantity dispensed and the corresponding employee. Duplicate copies of the LOI are retained, with one copy kept by the fuel station and another by the employee. At the close of each month, the fuel station forwards all LOIs to the employer, who then disburses funds accordingly.

2.Receipt Submission Method- Alternatively, employees physically refuel their vehicles at the designated fuel station and preserve fuel receipts for later reimbursement. These receipts are subsequently submitted to the employer as proof of expenditure.

Despite their prevalence, these traditional approaches exhibit inherent limitations:

1. Susceptibility to Misuse and Fraud- The reliance on manual submission processes presents opportunities for both employees and fuel stations to engage in fraudulent activities, potentially resulting in misappropriation of funds.

2. Inefficiencies in Record-Keeping- The manual handling of paper receipts and LOIs is inherently time-consuming and prone to errors. Moreover, the risk of misplaced or damaged documents further compounds administrative challenges.

3. Transparency Deficits- With limited mechanisms for verifying the authenticity of submitted documents, the current system lacks transparency, leading to uncertainties regarding the accuracy and legitimacy of fuel transactions.

4. Potential for Data Errors- Human error in manual data entry and processing introduces the risk of inaccuracies in recording fuel consumption, undermining the reliability of the entire system.

Recognizing the shortcomings of existing fuel allocation methods, our project, GFuel, endeavors to pioneer a transformative solution. By harnessing cutting-edge technologies such as blockchain, machine learning, and web interfaces, GFuel aims to revolutionize fuel management practices, offering streamlined processes, heightened accuracy, and enhanced accountability. Through GFuel, we envision a future where fuel allocation transcends the confines of manual paperwork, ushering in an era of efficiency, transparency, and integrity in corporate fuel management.

III. PROPOSED SYSTEM

A. Problem Statement

Due to inefficient fuel management practices in both public and private organizations, errors, improper usage, and low transparency have become prevalent. This project is designed to remedy these issues by creating an Automated Fuel Allocation System that employs blockchain and license plate recognition technologies. By implementing this system, the fuel transactions between employees can be streamlined, secured against manipulation, and made accountable.

B. Proposed Solution

The proposed system employs license plate recognition and blockchain technology to ensure only authorized vehicles receive fuel allowances, eliminating chances of misuse and paper receipts and automate the entire process. It also assists law enforcement in tracking missing or wanted vehicles, improving fleet management and saving taxpayer funds.

IV. METHODOLOGY

A. Hardware Integration

The seamless integration of hardware components, including the camera and Raspberry Pi, forms the backbone of the fuel allowance system. Strategically positioned at petrol pump stalls, the camera captures vehicle fronts, enabling subsequent license plate recognition (LPR). These images are swiftly transmitted to the Raspberry Pi for processing. The Raspberry Pi makes the necessary API calls to execute the LPR algorithm and also manages the interaction with the Ethereum blockchain. This dual responsibility streamlines the system's operation, ensuring efficient data processing and blockchain integration. The compatibility and reliability of the hardware components are pivotal for seamless real-time operations.

B. License Plate Recognition

The LPR module employs advanced transfer learning techniques to accurately extract license plate numbers from captured images. Leveraging a pre-trained neural network, such as Inception ResNetV2, the system fine-tunes its classification heads for optimal performance. TensorFlow and Keras frameworks, coupled with ReLU activation functions for hidden layers and sigmoid activation for the output layer, optimize the model's efficiency. The LPR model is hosted on a local server and the Raspberry Pi makes necessary API calls to run it. Upon verification of the data obtained against the company's employee database, authorized transactions proceed and the Solidity Smart Contract is called. Continuous model optimization and training further refine the system's accuracy and reliability.

C. Blockchain Integration

The integration with the Ethereum blockchain ensures transparency, security, and immutability of fuel transactions. Smart contracts, executed by the Raspberry Pi, enable seamless recording of verified transactions on the blockchain in real-time. This integration enhances accountability and trust among stakeholders, fostering greater transparency in fuel management processes.

The system works by running a Hardhat server on the local network of a host computer, into which the smart contract is deployed. Then using ngrok, we expose the local network to the internet and generate a url. Using the url and ethers library we can interact with the smart contract deployed from the Raspberry Pi and add the data as required to the blockchain.

D. Blockchain Smart Contract Algorithm

-Contract Initialization:

1.Define a Purchase structure with fields: price, date, and customerID.

2. Create an array to store Purchase records.

-Function addPurchase(uint256 _price, uint256 _date, uint256 _customerID):

1. Create a new Purchase struct with the provided values.

2.Add the new Purchase to the purchases array.

-Function getPurchase(uint256 index):

1.Check if the index is within bounds.

2.Retrieve the Purchase struct at the specified index and return its price, date, and customerID.

E. Website Interface

The React-based website interface provides an intuitive platform for employees and employers to manage fuel allowances efficiently. Secure login portals grant access to transaction records, fund allocations, and settlement statuses for employees. Meanwhile, employers can oversee transaction details and initiate settlements as necessary. Robust user authentication mechanisms safeguard sensitive data, instilling trust within the system. Considerations for web development, such as scalability and responsiveness, ensure optimal performance across various devices. Overall, the website interface enhances user experience and facilitates transparent fuel management within the organization, complementing the system's hardware and blockchain integration seamlessly.

V. EXPERIMENTS AND RESULTS

We achieved precise license plate detection using the YOLOv5 model and accurate character extraction using PyTesseract's OCR capabilities. By hosting this model on a dedicated server, we ensured that image data is processed efficiently.

Dataset	Number of Examples
Training	6176
Validation	1765
Test	882
Total	8823

Figure 1: Dataset

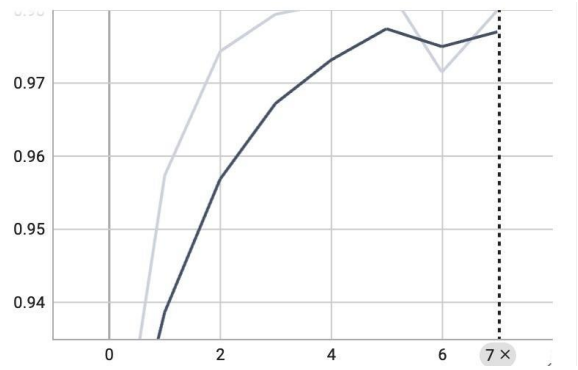


Figure 2: Precision

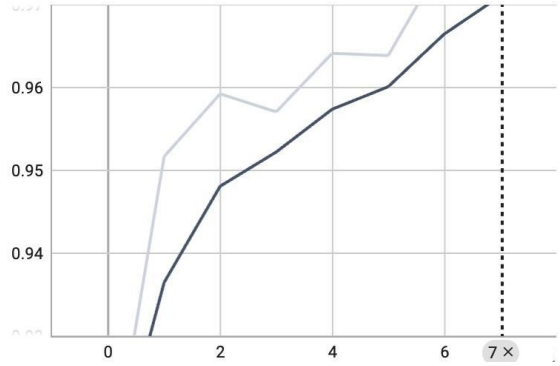
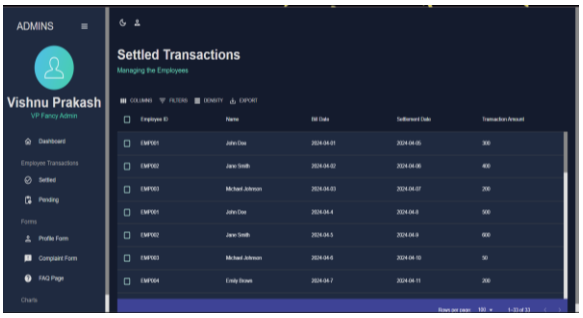


Figure 3: Recall

The workflow begins with a Raspberry Pi, which captures vehicle images using its camera module. These images are then sent to the server using a POST request, which starts the OCR process. Upon receipt, the server uses OCR to extract the license plate number from the image.

The extracted license plate number is validated against data stored in a MongoDB database. A fuel invoice is automatically generated after a successful match, which indicates the presence of the license plate. Most importantly, these invoices are recorded in a blockchain ledger, which ensures record integrity and transparency.



Users benefit from an easy-to-use web interface that allows them to view their total fuel invoices and make payments conveniently. This seamless front-end integration improves user experience and facilitates interaction with the system.

VI. CONCLUSION AND FUTURE SCOPE

GFuel represents a fusion of blockchain technology and license plate recognition, poised to revolutionize manual fuel allocation processes. This innovative solution offers transparency, efficiency, and security, promising heightened operational efficiency, accountability, and prevention of misuse. GFuel signifies a transformative shift in how organizations manage fuel allocation, heralding a future of optimized resource utilization and streamlined financial processes.

Moving forward, GFuel envisions several key avenues for future development and expansion:

1. Mobile App for Employees- Developing a dedicated mobile application for employees to access real-time information regarding their fuel usage, expenses, and compliance with organizational policies can significantly enhance user-friendliness and transparency.

2. Alternative Energy Integration- Exploring partnerships with electric vehicle infrastructure providers can allow GFuel to seamlessly integrate alternative energy sources into the platform, accommodating the growing trend towards sustainable transportation.

3. Global Collaboration- Considering the expansion of GFuel on a global scale and working towards standardization can foster interoperability and consistency in fuel allocation processes across diverse regions and industries.

4. Integration with E-Government Initiatives- Aligning GFuel with broader e-government initiatives can promote digital transformation and improved governance, contributing to the modernization of public services and enhancing overall efficiency in fuel management.

These future scope initiatives underscore GFuel's commitment to continuous innovation and adaptation, ensuring its relevance and effectiveness in meeting evolving industry needs and global challenges. Through strategic expansion and integration efforts, GFuel aims to solidify its position as the premier solution for modern fuel allocation management, driving efficiency, sustainability, and transparency in corporate operations.

ACKNOWLEDGMENT

This project stands as a testament to the collective effort invested by numerous individuals and institutions who have played a pivotal role, both directly and indirectly. We express our sincere gratitude to our mentor *Ms. Rakhee M (Head of Department of Computer Science and Engineering, MITS, Kochi, Kerala, India)* for her invaluable guidance and motivation as well as for her critical assessment of our work and valuable suggestions.

REFERENCES

[1] Neharkar, S., Ingale, G., Jatte, S., Jawale, M. and Deokar, A., 2020. VehiChain: Blockchain-based Service for Storing Vehicle Records.

[2] Q. Wang, L. Huang, S. Chen and Y. Xiang, "Blockchain Enables Your Bill Safer," in IEEE Internet of Things Journal, vol. 9, no. 16, pp. 14162-14171, 15 Aug.15, 2022, doi: 10.1109/JIOT.2020.3016721.

[3] Nikhil Sontakke; Shivansh Rastogi; Sejal Utekar; Shriraj Sonawane.(Volume. 8 Issue. 7, July - 2023) “A Novel Approach for Invoice Management using Blockchain"."International Journal of Innovative Science and Research Technology (IJISRT), www.ijisrt.com. ISSN - 2456-2165 , PP :- 3034-3038.

[4] Xu and Y. Huang, "Segment Blockchain: A Size Reduced Storage Mechanism for Blockchain," in IEEE Access, vol. 8, pp. 17434-17441, 2020, doi: 10.1109/ACCESS.2020.2966464.

[5] J. Park, E. Lee, Y. Kim, I. Kang, H. I. Koo and N. I. Cho, "Multi-Lingual Optical Character Recognition System Using the Reinforcement Learning of Character Segmenter," in IEEE Access, vol. 8, pp. 174437-174448, 2020, doi: 10.1109/ACCESS.2020.3025769.

[6] Q. Huang, Z. Cai and T. Lan, "A Single Neural Network for Mixed Style License Plate Detection and Recognition, " in IEEE Access, vol. 9, pp. 21777-21785, 2021, doi: 10.1109/ACCESS.2021.3055243.

[7] Y. Yin, W. Zhang, S. Hong, J. Yang, J. Xiong and G. Gui, "Deep Learning-Aided OCR Techniques for Chinese Uppercase Characters in the Application of Internet of Things," in IEEE Access, vol. 7, pp. 47043-47049, 2019, doi: 10.1109ACCESS.2019.2909401.

[8] Q. -D. Nguyen, N. -M. Phan, P. Krömer and D. -A. Le, "An Efficient Unsupervised Approach for OCR Error Correction of Vietnamese OCR Text," in IEEE Access, vol. 11, pp. 58406-58421, 2023, doi: 10.1109/ACCESS.2023.3283340.

[9] S. Luo and J. Liu, "Research on Car License Plate Recognition Based on Improved YOLOv5m and LPRNet," in IEEE Access, vol. 10, pp. 93692-93700, 2022, doi: 10.1109/ACCESS.2022.3203388.

[10] Henry, C., Ahn, S. Y.,\& Lee, S.-W. (2020). Multinational License Plate Recognition Using Generalized Character Sequence Detection. IEEE Access, 8, 35185–35199. doi:10.1109/access.2020.2974973

[11] I. H. El-Shal, O. M. Fahmy and M. A. Elattar, "License Plate Image Analysis Empowered by Generative Adversarial Neural Networks (GANs)," in IEEE Access, vol. 10, pp. 30846-30857, 2022, doi: 10.1109/ACCESS.2022.3157714.

[12] Akhtar, Z., Ali, R. Automatic Number Plate Recognition Using Random Forest Classifier. SN COMPUT. SCI. 1, 120 (2020).

[13] D. Li, R. Du, Y. Fu and M. H. Au, "Meta-Key: A Secure Data-Sharing Protocol Under Blockchain-Based Decentralized Storage Architecture," in IEEE Networking Letters, vol. 1, no. 1, pp. 30-33, March 2019, doi: 10.1109/LNET.2019.2891998.

[14] Sarmah, s. (2018). Understanding Blockchain Technology.8.23-29.10.5923/j.computer.20180802.02.

[15] J. Liu and Z. Liu, "A Survey on Security Verification of Blockchain Smart Contracts," in IEEE Access, vol. 7, pp. 77894-77904, 2019, doi: 10.1109/ACCESS.2019.2921624.

[16] JN. Ivanov, Q. Yan and A. Kompalli, "TxT: Real-Time Transaction Encapsulation for Ethereum Smart Contracts," in IEEE Transactions on Information Forensics and Security, vol. 18, pp. 1141-1155, 2023, doi: 10.1109/TIFS.2023.3234895.

[17] Y. Zou, Y. Zhang, Jun Yan, X. Jiang, T. Huang, H. Fan, Z. Cui , "A Robust License Plate Recognition Model Based on Bi-LSTM," in IEEE Access, vol. 8, pp. 211630-211641, 2020, doi: 10.1109/ACCESS.2020.3040238.

[18] M. -X. He and P. Hao, "Robust Automatic Recognition of Chinese License Plates in Natural Scenes," in IEEE Access, vol. 8, pp. 173804-173814, 2020, doi: 10.1109/ACCESS.2020.3026181.

[19] W. Weihong and T. Jiaoyang, "Research on License Plate Recognition Algorithms Based on Deep Learning in Complex Environment," in IEEE Access, vol. 8, pp. 91661-91675, 2020, doi: 10.1109/ACCESS.2020.2994287.

[20] M. S. Al-Shemarry, Y. Li and S. Abdulla, "An Efficient Texture Descriptor for the Detection of License Plates From Vehicle Images in Difficult Conditions," in IEEE Transactions on Intelligent Transportation Systems, vol. 21, no. 2, pp. 553-564, Feb. 2020, doi: 10.1109/TITS.2019.2897990.