CSE / EEE / ETE 499A (Section 02)

Final Report (CO5)

Project Title: TOLLKEEPER.AI, *an automated toll payment system*

Submitted To

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Date: 05/11/2023

Group- 08

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Abstract

Tollkeeper.ai, an automated toll payment system

Bangladesh's toll payment industry must catch up, relying heavily on manual, cash-based systems despite neighboring countries' successful transitions to digital toll collection. In response, TollKeeper.ai, a transformative project, addresses these archaic practices by introducing a digital toll payment process. This initiative eliminates printed receipts and physical cash transactions, replacing them with digital payment methods such as credit cards, debit cards, and mobile financial services. TollKeeper.ai has the potential to benefit transportation and courier service companies, enhancing transparency in toll collection.

The project employs machine learning to recognize vehicle number plates and plans to launch it as an Android app. While Bangladesh has introduced an Intelligent Transport System for data collection, it lacks automated toll payment capabilities, causing congestion at expressway toll booths. TollKeeper.ai seeks to resolve this issue. However, several challenges, such as security concerns, regulatory hurdles, public perception, and operational matters, must be addressed for the project's success and impact on Bangladesh's toll collection industry. Collaboration with government bodies is also envisioned for the widespread adoption of TollKeeper.ai in the nation's toll plazas.

Introduction

Bangladesh's toll payment industry has remained entrenched in manual, cash-based practices. Unlike many other nations that have transitioned to digital and automated toll collection systems, Bangladesh still heavily relies on physical cash transactions at toll plazas, even as neighboring countries such as India have successfully implemented comprehensive digital procedures like FASTag for their bridges and expressways.

This project addresses the archaic manual toll collection process for vehicles entering expressways and bridges. Cars arriving at a toll plaza must pay a specific toll amount based on their category and be provided with a printed receipt. This procedure is conducted by toll booth operators who depend on paperwork for calculations. Consequently, this manual process often leads to congestion at bridge entrances, diminishing overall operational efficiency. Moreover, the absence of proper records makes the system vulnerable to corruption, as there is no transparent means of tracking toll collections.

The primary objective of this project, known as TollKeeper.ai, is to transform the entire toll payment process digitally. This entails eliminating the need for printed receipts and physical cash transactions. Instead, digital payment methods such as credit cards, debit cards, and mobile financial services (MFS) will be employed. Furthermore, this innovation can greatly benefit transportation and courier service companies like Pathao, Shohag Paribahan, TruckLagbe, and SA Paribahan, allowing them to pay tolls directly from their offices as their vehicles traverse multiple toll points. This integration significantly enhances transparency throughout the toll collection process. We plan to launch TollKeeper.ai as an ML-trained Android app.

To realize our vision, we are adopting a two-pronged approach: we have tested and trained a Machine Learning Model to recognize the number plates of cars passing through the toll points. Then, we will develop a dedicated mobile app for toll payers, TollKeeper.ai. Through these platforms, users can make all toll payments via their mobile devices, revolutionizing the toll collection process in Bangladesh.

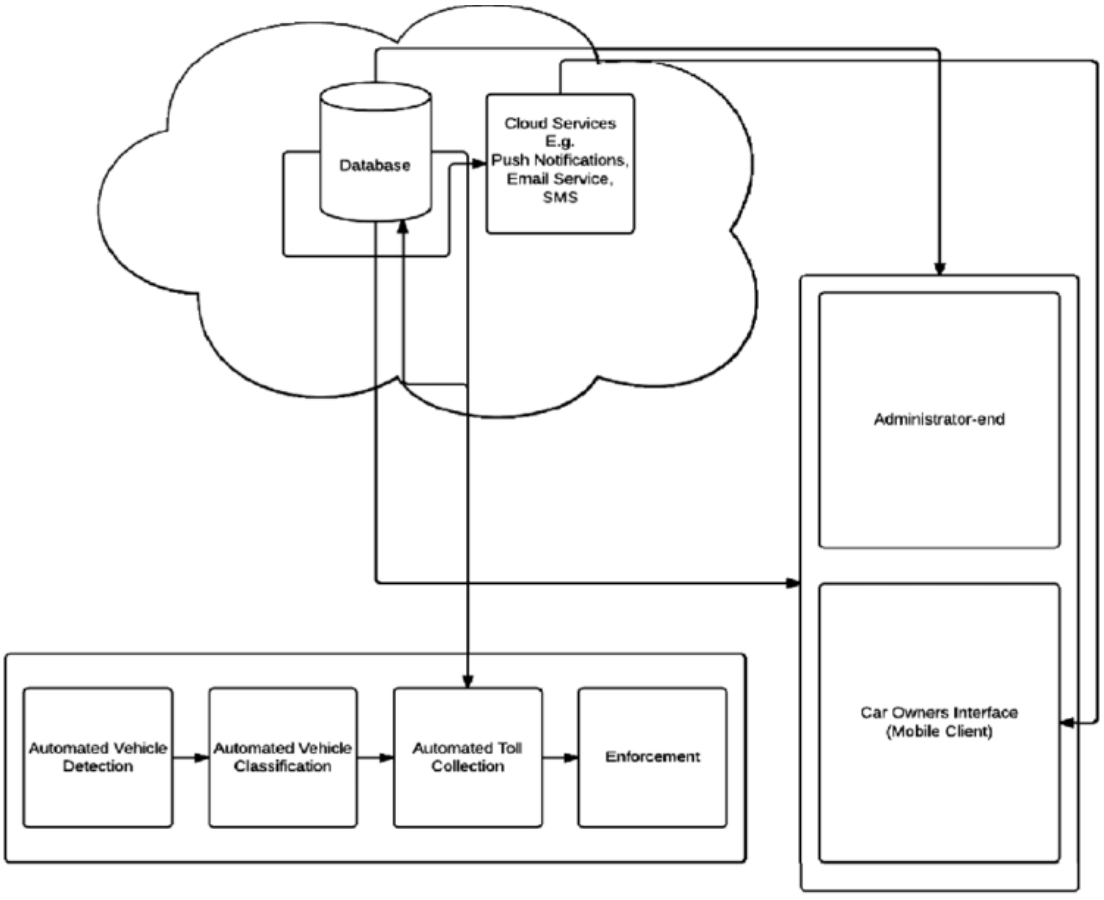
Research Literature Review

[1] The research paper titled "*Design and Implementation of an Automated Toll Collection System*" by Zhiwei Yang, Yangxiang Zhang, and Qiyuan Peng, presented at the 2012 CECNet conference, explores the development and deployment of an automated toll collection system. It addresses the limitations of manual toll collection, emphasizing the role of Radio-Frequency Identification (RFID) technology in enhancing efficiency and accuracy. The paper details the system's architecture, integration with existing infrastructure, and performance evaluation. It acknowledges challenges and proposes future enhancements. This research significantly advances automated toll collection, offering a comprehensive blueprint for more efficient and reliable transportation infrastructure management.

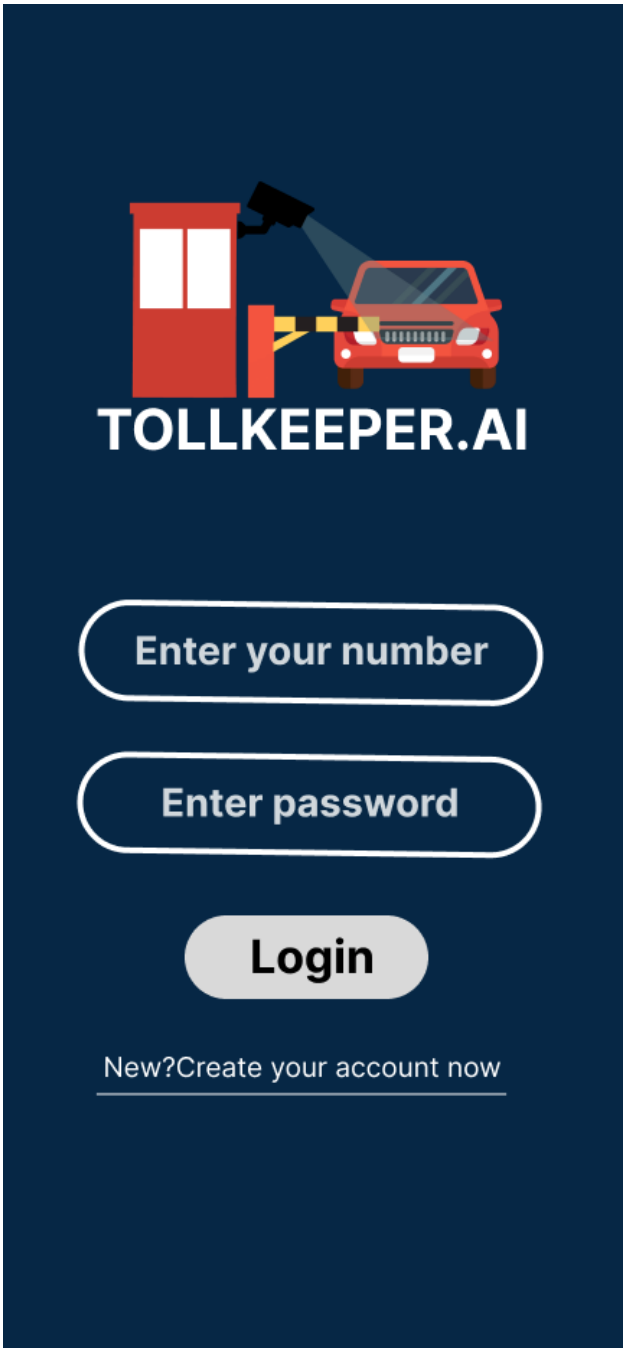
[2] The paper titled "*Evaluation of an Automatic Toll Collection System Using RFID Technology*" by Manoj M Nair, Anandakumar Haldorai, and anesh Kumar C., published in the International Journal of Emerging Technology and Advanced Engineering, assesses the efficiency and accuracy of an RFID-based automatic toll collection system. It examines the system's real-time performance, reliability in adverse conditions, and potential challenges. This research offers insights into improving toll collection processes and enhancing transportation infrastructure.

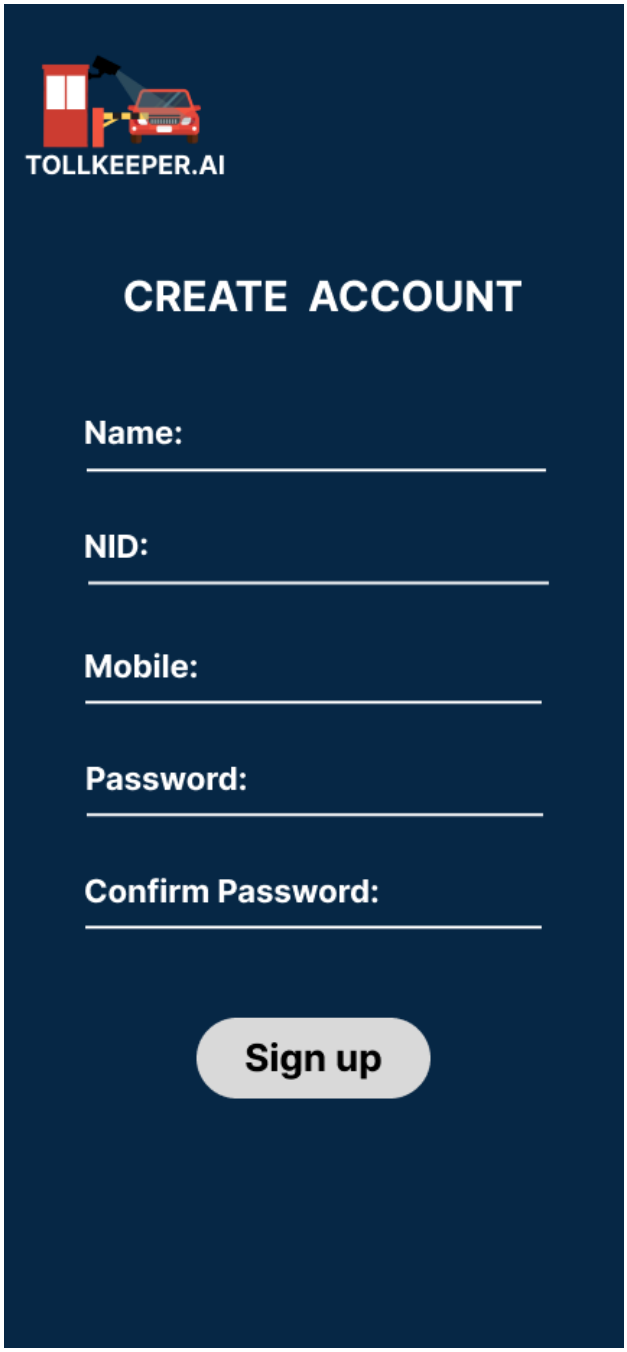
[3] The paper titled "*Intelligent Transportation Systems in India: Challenges and Opportunities in Electronic Toll Collection*" by aurav Raheja and Ajay Kumar, published in the Proceedings of the 2nd International Conference on Intelligent Transportation, sheds light on the complexities of introducing electronic toll collection systems within India's burgeoning intelligent transportation framework. It delves into the multifaceted challenges, including technology adoption, interoperability, and cybersecurity issues, while emphasizing the significant prospects for enhancing efficiency, reducing congestion, and optimizing revenue collection. This comprehensive review is a valuable resource for policymakers, researchers, and industry professionals aiming to navigate the intricate landscape of electronic toll collection in the Indian context.

System Design



UX Design


TOLLKEEPER.AI
Enter your number
Enter password
Login
New?Create your account now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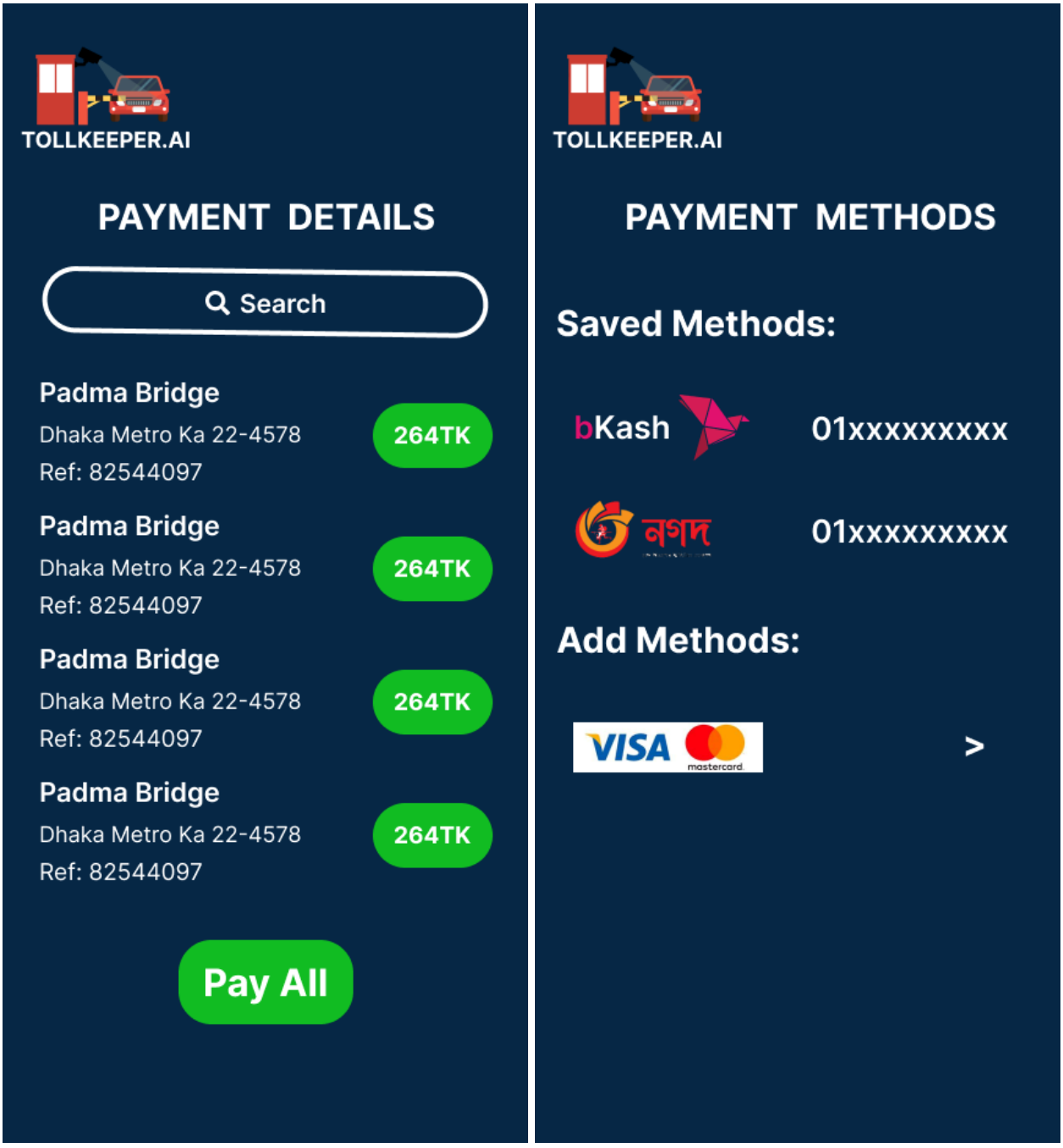
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PAYMENT DETAILS
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Impacts and Constraints

Business Viability of the Project

a. **Novelty:** The TollKeeper.ai project introduces a groundbreaking approach to Bangladesh's age-old manual toll collection system by leveraging digital technology, including mobile payment methods. This novel initiative sets it apart from conventional toll collection practices and is a pioneering step towards modernizing the country's transportation infrastructure.
b. **Market Segments:** TollKeeper.ai addresses a broad market segment encompassing Bridge and expressway authorities, individual vehicle owners, and transportation/courier service companies. This diverse market potential signifies a substantial user base for the platform.
c. **Competitor Analysis:** In Bangladesh, more direct competitors must offer a comprehensive digital toll-collection platform like TollKeeper.ai. While there are some fragmented digital payment solutions, they offer only some end-to-end toll payment and tracking capabilities envisioned in this project.
d. **Competitive Advantages:** TollKeeper.ai's competitive advantages lie in eliminating congestion at toll plazas, enhancing transparency, and providing a seamless and secure digital payment experience. These advantages position it as a game-changer in the toll collection industry.
e. Success Factors: Successful implementation of TollKeeper.ai necessitates the establishment of a secure, user-friendly web platform, followed by the development of a mobile app. Furthermore, securing partnerships with transportation companies is essential to facilitate widespread adoption. Expanding the platform's reach to include additional modes of transportation and integrating with government agencies for regulatory compliance would be advantageous. Success will be measured by the percentage reduction in toll booth congestion, the number of registered users, and the volume of digital toll payments.

Economic (Cost) Impact

Implementing TollKeeper.ai in Bangladesh carries significant economic implications about its cost and potential effects on the market. Two primary factors warrant attention:

- Tax Incentives for Environmental Sustainability: One aspect of considerable significance is the prospect of tax incentives aligned with environmental sustainability. TollKeeper.ai, as an eco-friendly digital toll collection system, dovetails with global endeavors to reduce carbon footprints. This alignment could render the project eligible for tax incentives tied to energy efficiency and environmental sustainability. The Bangladeshi government might extend tax benefits or rebates as part of its commitment to sustainable transportation solutions. This reflects an encouraging avenue for reducing costs and fostering environmental consciousness.

- Environmental Resource Availability: Resource availability constitutes another critical factor affecting the project's cost and viability. Precisely, the availability of crucial resources such as mobile network coverage, internet connectivity, and server infrastructure can wield a substantial influence on prices. In areas endowed with robust infrastructure, project setup expenses may be lower. TollKeeper.ai relies on a dependable network and data infrastructure, and regions with such infrastructure can enjoy a cost advantage. Conversely, in the resource-scarce areas, the cost of setting up the requisite infrastructure may be relatively higher, affecting the overall cost of the project.

The cost implications of the project are instrumental in shaping the pricing strategy. A higher project cost may lead to increased service fees, potentially rendering TollKeeper.ai less affordable for users and exposing it to market vulnerability if the pricing structure is uncompetitive.

Environmental Impact

The advent of TollKeeper.ai in Bangladesh bears significant environmental ramifications, focusing on emissions, consumption patterns, and resource reliance:

- Greenhouse Gas Emission Reduction: A primary environmental benefit of TollKeeper.ai is the potential reduction in greenhouse gas (GHG) emissions. By replacing the manual toll collection system with a digital counterpart, a substantial decrease in the carbon footprint is achievable. Fewer toll booth operators and reduced paperwork contribute to energy and resource savings, thereby contributing to a decline in GHG emissions. This resonance with global efforts to combat climate change underscores TollKeeper.ai's positive environmental impact.

- Positive Change in Consumption Patterns: TollKeeper.ai propels a positive shift in consumption patterns by significantly reducing paper usage. This constructive alteration aligns with environmental sustainability by curbing the demand for tree harvesting and paper production. Furthermore, transitioning to a digital platform could stimulate a broader transformation in the transportation and payment sectors toward more sustainable practices.

- Reliance on Abundant Resources: TollKeeper.ai predominantly hinges on readily available resources, including mobile networks, internet infrastructure, and server technology. This reliance on abundant resources is advantageous, ensuring the technology is deployable across Bangladesh without straining scarce or precious materials. This accessibility and affordability of the technology are pivotal for its successful environmental impact.

Thus, TollKeeper.ai reduces GHG emissions and augments positive changes in consumption patterns. Relying on abundant technological resources not only bolsters its environmental sustainability but also ensures the technology's availability and affordability across Bangladesh.

Social Impact

TollKeeper.ai is poised to bring about a positive transformation in the lives of individuals in Bangladesh. This positive social impact is characterized by the following:

- Positive Transformation: The introduction of TollKeeper.ai simplifies toll payment processes, reducing wait times and congestion at toll plazas. This contributes to a smoother and less stressful commuting experience, ultimately enhancing the overall quality of life for users.

- Addressing Community Needs: TollKeeper.ai directly addresses the need for enhanced mobility within the community. It streamlines toll collection, making travel more convenient and efficient for individual vehicle owners, transportation companies, and courier services. This, in turn, improves access to essential services and markets, which is particularly significant in densely populated regions like Bangladesh.

- Safety and Health Considerations: Reducing congestion by implementing TollKeeper.ai enhances safety. Fewer traffic jams and smoother traffic flow mitigate the risk of accidents and related health concerns, such as those caused by accidents or prolonged exposure to vehicular emissions.

- Regulatory Compliance and Environmental Concerns: TollKeeper.ai aligns with evolving government policies and addresses environmental concerns. By reducing the need for printed receipts and streamlining transactions, it actively contributes to diminishing paper consumption and its associated environmental impacts. It can also decrease air pollution through reduced waiting times at toll plazas.

Legal Considerations and Constraints

Implementing TollKeeper.ai in Bangladesh necessitates meticulous attention to legal considerations and constraints. These encompass standards that impact design choices and existing technology limitations. Specific examples include:

- Energy Efficiency Regulations: Bangladesh has regulations and standards regarding energy efficiency, which may influence the design and operation of the TollKeeper.ai system. These regulations often define energy consumption limits for electronic devices, including the TollKeeper.ai system, potentially mandating design modifications for compliance.

- Cybersecurity Laws: To global trends, Bangladesh has established cybersecurity laws. To ensure data security and user privacy, the TollKeeper.ai system must adhere to these laws. This could entail the implementation of robust data encryption and protection measures.

- Data Protection Standards: Critical standards concerning user data protection, encompassing both transmission and storage, must be strictly observed. Compliance with data protection laws, which may align with international standards such as GDPR, is imperative to fulfill legal prerequisites.

- Hardware and Network Standards: TollKeeper.ai relies on various hardware and network technologies, including mobile devices, Internet Protocol, and wireless communication protocols. Adherence to relevant standards is indispensable to guarantee compatibility, performance, and safety.

- Vehicle Identification Standards: The machine learning-based vehicle identification system employed by TollKeeper.ai must conform to recognized standards to ensure accurate and reliable number plate recognition.

- Payment and Financial Standards: TollKeeper.ai incorporates digital payments, necessitating strict adherence to financial standards and regulations pertinent to Bangladesh. This ensures the legal integrity and security of all financial transactions.

- Safety and Reliability Standards: The safety and reliability of the TollKeeper.ai system, including its machine learning algorithms and software, must meet recognized safety and reliability standards. This minimizes risks and potential legal liabilities.

Therefore, the implementation of TollKeeper.ai in Bangladesh mandates thorough consideration of various legal and regulatory factors. These range from energy efficiency and cybersecurity laws to data protection and hardware standards, pivotal for ensuring compliance with local regulations and establishing a secure and efficient toll collection solution.

Methodologies

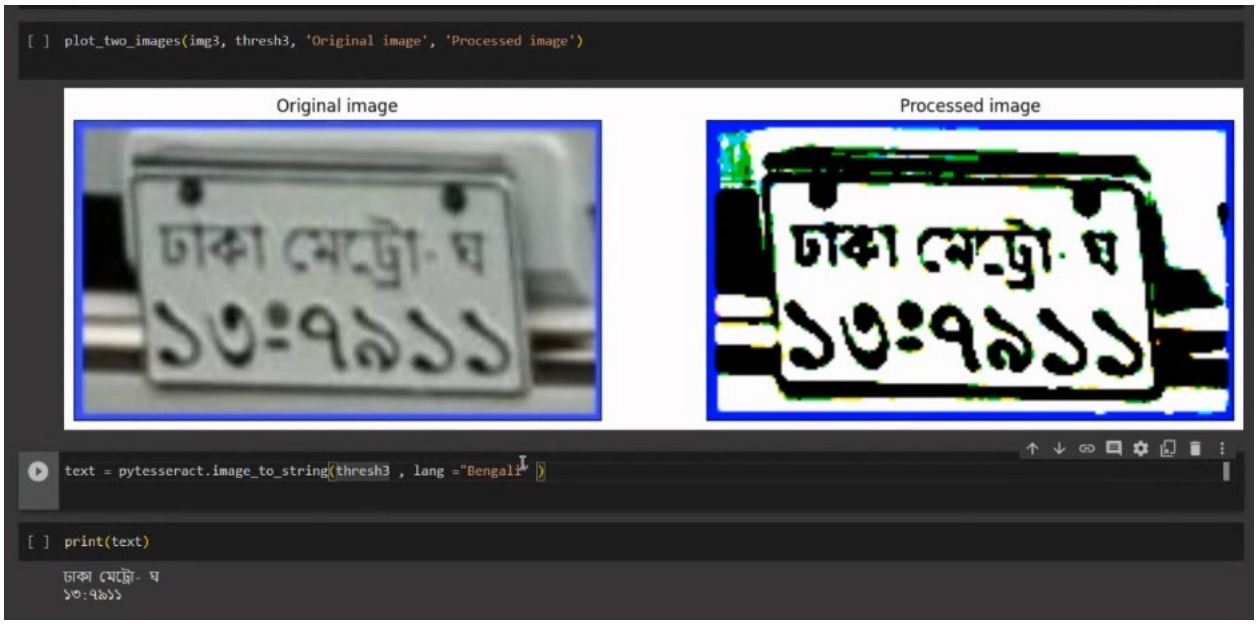
The software implementation included configuring the development environment and configuring numerous software components. We used the programming language Python. We then used Clodsa Augmentation and the YOLO v5 AI model to detect the number plates of the cars. During model training, we implemented through the M, L, and X models. After detection, to crop the detected number plate, we used Python's "tesseract.ocr" and Bengali training data to extract the text in the number plate. For this, we used the platform oogle Colab.

After that, in the next part, upon logging in, registered users can view their pending payment list of toll plazas with detailed information, enabling them to choose the tolls they wish to pay, add them to their virtual cart, and complete the payment process. Users will receive confirmation via SMS on their registered mobile numbers. On the administrative side, authorities can access a dashboard displaying payment details alongside vehicle information, offering insights into the number of vehicles passing through and total toll collections.

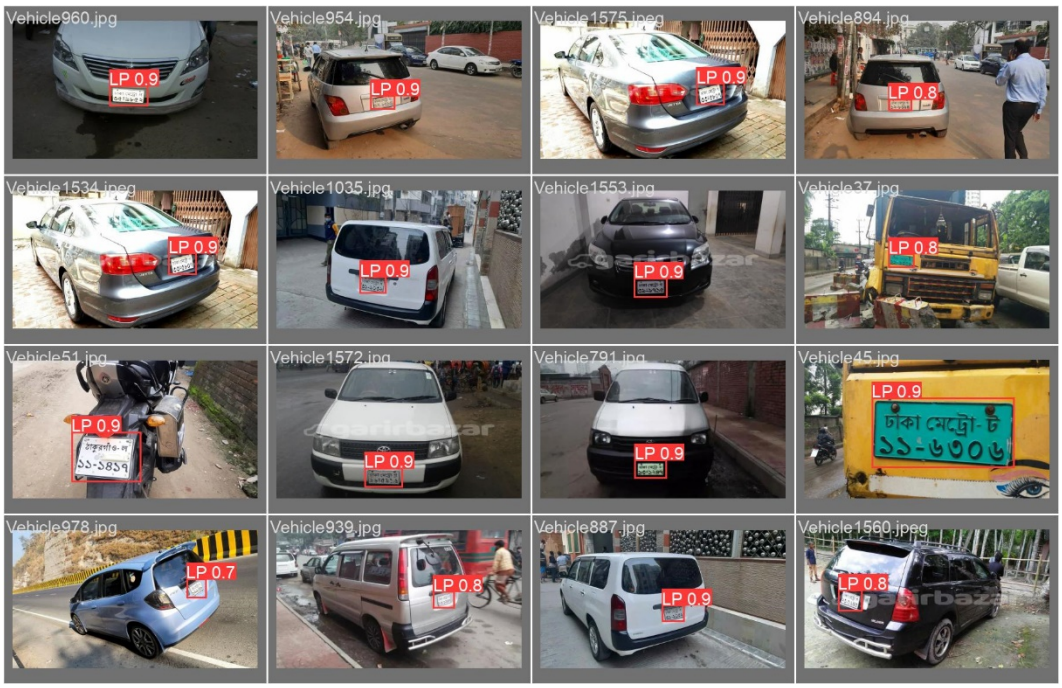
The automated toll payment system's technology implementation includes dataset preparation, augmentation, validation, model training, and Bengali text extraction. Combining all this results in an efficient method of automated toll payment system.

Result

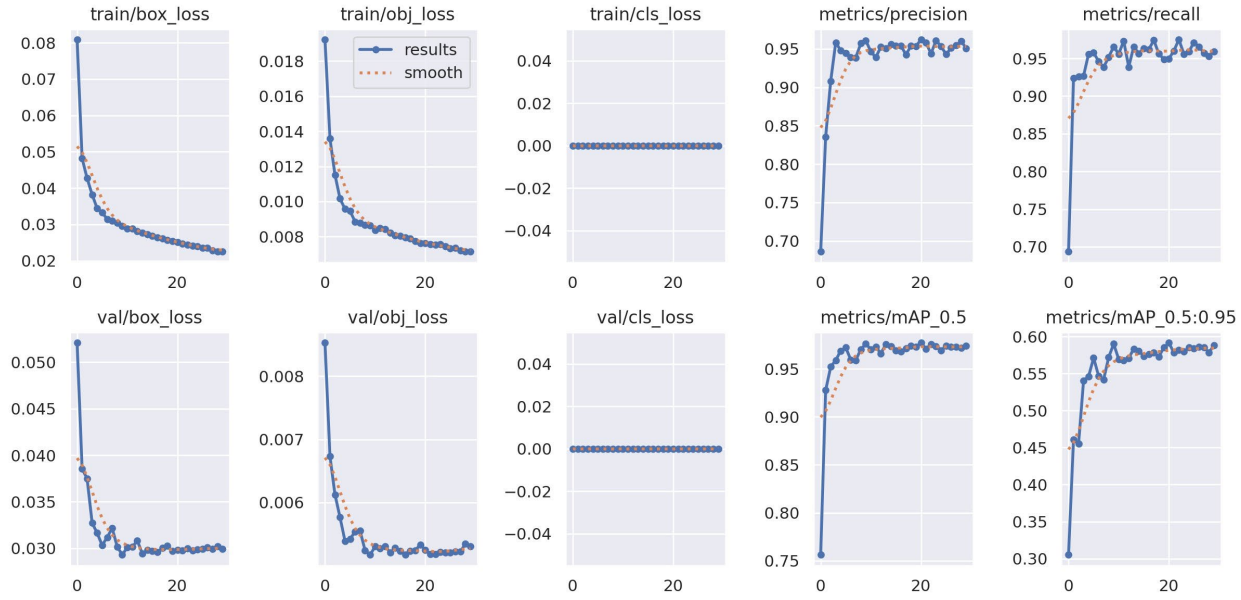
We have successfully extracted the Bangla text from the number plate through our Machine Learning model.



Before that, our model scanned real-time car images and detected the number plate in the car:



The graphs show that the losses are decreasing and the precision increases gradually after our tests and training.



Conclusion

Presently, within Bangladesh, the inauguration of the Dhaka-Mawa smart expressway has introduced an Intelligent Transport System under the supervision of the Road and Highways Department. This system incorporates various data collection mechanisms, including vehicle detection systems, surveillance cameras, automated number plate recognition cameras, speed detection devices, and variable messaging signs. However, this advanced system does not encompass automated toll payment capabilities. That's why the slow pace at expressway toll booths causes congestion while the road ahead is empty. Thus, it proves that it is high time that Bangladesh automates its toll payment system.

Through Tollkeeper.ai, we aim to solve this problem. However, the solution comes with certain limitations from our end, as there are some risk factors to be addressed:

- Security Concerns: Safeguarding user data and financial transactions will be paramount. Any data breaches or security lapses could harm the project's reputation.
- Regulatory Challenges: Adhering to existing regulatory frameworks and ensuring compliance with evolving government policies may pose challenges.
- Public Perception: Building trust in digital payment systems and overcoming skepticism about new technologies will be crucial for user adoption.
- Operational Issues: System failures or downtime could disrupt toll collection operations, leading to user dissatisfaction.

However, navigating these risk factors while achieving the outlined success factors will be critical to TollKeeper.ai's viability and impact on the toll collection industry of Bangladesh. That's why, continuing working on this project in CSE499B, we aim to build a full stack automated toll payment system. Further, we would like to approach the government through the Dhaka City Corporation and the Ministry of Road & Highways to sell our services and use them in the nation's toll plazas.

Reference

[1] Zhiwei Yang, Yangxiang Zhang, and Qiyuan Peng, “Design and Implementation of an Automated Toll Collection System" 2012, 2nd International Conference on Consumer Electronics, Communications and Networks (CECNet)

[2] Manoj M. Nair, Anandakumar Haldorai, and anesh Kumar C. , "Evaluation of an Automatic Toll Collection System Using RFID Technology," International Journal of Emerging Technology and Advanced Engineering

[3] aurav Raheja and Ajay Kumar , "Intelligent Transportation Systems in India: Challenges and Opportunities in Electronic Toll Collection"