Using Predictive Analysis in Logistics Industry to Associate Tolls and Damages to Customers

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ABSTRACT

This study develops a predictive system integrating telematics and images from trailer activities to enhance cost attribution and damage tracking in the logistics business model. Our goal is to automate trailer toll data attribution and enhance damage detection by leveraging telematics data and applying image classification with deep learning. Our results will help automate damage identification and severity assessment, aggregate tolls with the corresponding trip, and ensure proper attribution to the correct parties in the freight chain.

INTRODUCTION

Traditional 3PL logistics business models face challenges in balancing capacity and efficiency. Directly owning trailer assets requires a huge initial investment and ongoing maintenance costs, making capacity highly inflexible and leading to potential losses due to asset downtime. A **subscription-based trailer access model** offers a flexible solution to this challenge. Companies subscribe to trailer capacity, while the provider handles maintenance. This approach addresses the pain points of inflexible, seasonal capacity and high capital investment, expanding opportunities not only for 3PLs but also for brokers and carriers.

Under this trailer leasing model, the logistics industry faces challenges in cost attribution and damage tracking due to unknown parties in the freight chain, leading to inefficiencies and billing disputes. This study develops an analytics solution leveraging AI and telematics data to improve cost attribution and automate damage detection with limited data from logistics customers.

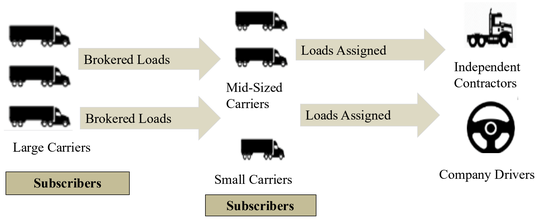

Fig 1. Complexity of Freight Logistics

Our approach enhances transparency with an interpretable model, reduces disputes, and streamlines operations for subscription-based trailer access model providers and customers.

Fig 2. Using Trailer telematics Data and Machine Learning for right attribution to win customer trust

RESEARCH OBJECTIVES

1. Identify predictive modeling approaches and data analytics systems that can improve the accuracy and efficiency of toll attribution in a subscription-based trailer access model.
2. Establish methods that enhance trailer damage monitoring together with attribution processes despite existing inspection irregularities and trailer exchange frequency.

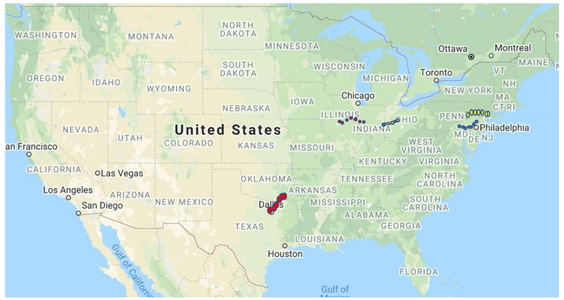

Fig 3. Linking trip information by mapping telematics data

LITERATURE REVIEW

Cost allocation in logistics remains a challenge due to data inconsistencies and operational complexities. Prior research, such as Sheng Xu et al. (2020), introduced a Time-Driven-Activity-Based (TDABC) model integrated with shared logistics platforms to enhance real-time cost attribution. In parallel, damage detection research has explored the effectiveness of **MobileNetV2** for classifying multiple damage types in large-scale inspections (Wang et al., 2021; Cimili et al., 2022). These studies emphasize the **strength of transfer learning** but highlight gaps in quantifying damage severity for intelligent decision-making. Our work builds upon these foundations by integrating **geospatial toll attribution with damage classification and severity labeling**, ensuring accurate cost allocation and responsibility tracking in a subscription-based trailer access model.

Study	Paper Aspect					
	Tolls		Damage			
	TDABC model	Shared Logistics Platform	MobileNet V2	Semi-Supervised Learning	MultipleType damage classification	Model Enhancement
(Sheng Xu et al., 2020)	✓	✓				
(Pavel Cimili, et al., 2022)			✓	✓		
(Jiahao Chen et al., *n.d.)*					✓	✓
(Zixin Wang et al., 2021)			✓		✓	
Our Study	✓		✓	✓		

Table 1. Literature Summary

METHODOLOGY

TOLL

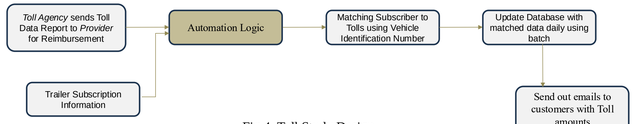

Fig 4. Toll Study Design

DAMAGE

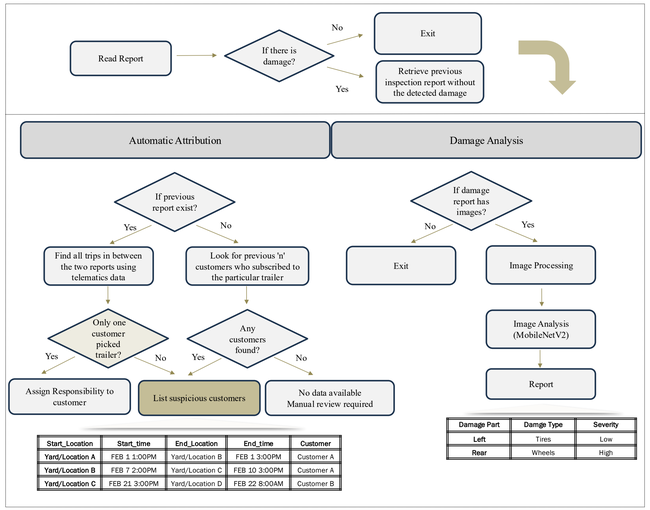

Fig 5. Damage Study Design

ASSUMPTIONS

- Data Integrity: Assumes accuracy and completeness of all input data, including toll reports, subscription information, inspection reports, and telematics data.
- System Functionality: Assumes proper functioning of automated logic and database systems.

LIMITATIONS

- Data Latency: Delays in data acquisition (toll data, telematics) can impact the timeliness and accuracy of results.
- Manual Intervention: Some cases require manual review, limiting full automation.
- Scope Limitations: Methodologies address specific aspects (toll assignment, damage assessment) but may not cover all related processes (e.g., dispute resolution, fraud detection).

EXPECTED IMPACT

Tolls, damages and maintenance together contribute to about 10% of the total costs of a trip. The hours spent on manually reviewing the reports and matching the drivers can be saved. The solution can increase the accuracy of attribution to drivers.
We arrived at this estimate based on the following assumptions: there are ~1000 trailers in operation, each trailer completes an average of four trips per week, it takes two minutes to review a report, the cost of labor is $15 per hour, and each trip incurs one toll charge.

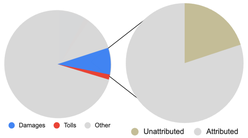

Fig 6. 20% of the damages, maintenance and tolls remain unattributed, leading to host company eating the cost

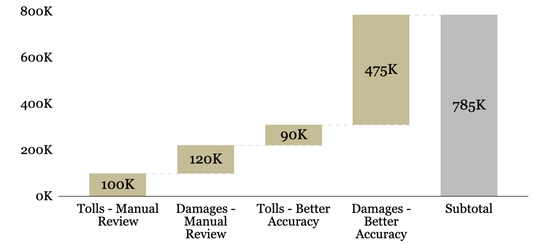

Fig 7. The timely and accurate attribution can result in **Annual** savings close to **USD 0.8 Million**

By implementing automated cost attribution, the company stands to gain substantial financial and operational benefits. The solution not only enhances transparency but also drives cost efficiency, ultimately leading to better resource management and increased profitability.

CONCLUSIONS

Before automation, toll and damage attribution, as well as image comparison, were performed manually, leading to longer processing times and a higher risk of human error. By implementing an automated process, we were able to significantly reduce processing time by ~2-3 FTEs and cut costs by close 0.5 Million USD annually. Additionally, automation minimized manual errors, enhancing the accuracy and reliability of the attribution process.

Considering the industry's payment cycle, timely and accurate attribution is critical. The automation of toll and damage identification ensures faster invoicing of carriers and accelerates insurance claims and settlement processes. Ultimately, this enhances cash flow management, improves operational efficiency, and strengthens compliance with industry standards.

ACKNOWLEDGEMENTS

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