Suitcase-Integrated Foldable Scooter for Micro-Mobility

A Hybrid Mobility Solution for Urban and Transit Use

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Abstract

The rapid growth of urban population and infrastructure has led to significant challenges in transportation systems, particularly in terms of traffic congestion, limited parking availability, and inefficient last-mile connectivity. Commuters frequently experience difficulty in covering short distances within transit environments such as airports, metro stations, and educational campuses, especially when handling personal luggage. This highlights the need for an integrated, compact, and efficient mobility solution.

This paper proposes a suitcase-integrated foldable scooter, a hybrid system that combines personal transportation with luggage functionality. The system is designed to enable seamless transition between walking and riding modes, thereby enhancing user convenience and reducing physical effort. The design incorporates a foldable scissor mechanism, a telescopic handlebar, and a compact electric drive system consisting of a BLDC hub motor powered by a lithium-ion battery.

The development process involves material selection, structural design, and CAD-based modeling to ensure optimal strength, durability, and portability. Analytical studies, including stress analysis and load distribution, were performed to evaluate the structural integrity of the system. Experimental testing was conducted to assess key performance

parameters such as folding time, ride stability, load capacity, and battery efficiency.

The results demonstrate that the proposed system effectively improves mobility in congested urban environments while reducing dependency on conventional transport methods. The integration of luggage and mobility into a single unit enhances space utilization and promotes sustainable transportation practices.

In conclusion, the suitcase-integrated foldable scooter represents a promising advancement in micro-mobility solutions. While certain limitations related to structural stability and weight optimization exist, further improvements in material technology and design can enhance its performance and usability. The system has strong potential for application in smart cities and modern transportation networks.

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1. Introduction

A literature review is a critical examination and assessment of previous research on a certain topic. It is an important component of academic research since it summarizes the present state of knowledge in a certain subject, identifies gaps in the literature, and helps to direct future study. This article will go over the significance of literature reviews as well as the stages required in performing one.

A literature review's goal is to identify major themes and topics in the literature, as well as gaps in the literature and possibilities for future research. It is also intended to assess and integrate previous studies in order to uncover trends and patterns. A well-conducted literature evaluation sets the framework for your research questions or hypotheses.

2. Literature Review

Conceptualizing Micromobility proposes a rigorous socio-technical definition of micromobility through a comprehensive literature review that highlights size, weight, energy usage, and speed criteria as core parameters for classification. The authors argue that consistent conceptual boundaries enable better regulation, infrastructure design, assessment frameworks, and vehicular standards. Their multi-dimensional framework includes human-powered, electrically assisted, and fully motorized devices with typical speeds below 25–45 km/h and vehicle weights under 350 kg.

This definitional clarity is directly relevant to the suitcase scooter project since it positions such a device within micromobility's low-energy, spatially efficient domain, aiding compliance, standardization, and positioning in sustainable transport discourse.[01]

Sociopsychological Factors Associated with the Adoption and Usage of Electric Micromobility synthesizes 67 empirical studies to evaluate electric micromobility adoption through functional (time, cost, convenience) and non-functional (environmental, social, identity) variables. The review finds that non-functional factors such as innovative self-identity, environmental concern, and social belonging significantly influence willingness to adopt micromobility, whereas hesitations relate to equity, safety, and usability concerns. The work suggests that policy, service design, and product engineering must address psychological and cultural dimensions rather than purely technical ones. This is relevant for the suitcase scooter concept because customer uptake will depend not only on engineering practicality but also on perceived innovation, personal safety, and socio-environmental value proposition.[02]

University Students' Perspectives on Micromobility: An Evaluation Based on E-Scooters investigates attitudes among university students using structured interviews and reveals reluctance due to unsafe road conditions, lack of regulation, and gender-linked harassment concerns. Findings emphasize that social safety (not just physical safety) plays a considerable role in adoption acceptance. The study shows how poorly structured infrastructure and ambiguous regulations discourage usage among young adults. For the suitcase scooter concept, this underscores the need to consider perceived safety, clarity of user context (sidewalk vs. bike lane), and potential gender-sensitive usability factors during both design and market positioning.[03]

Factors Affecting the Integration of Micromobility into Smart Cities and Effects on Urban Transport uses the DEMATEL method to analyse six main criteria and nine sub-criteria affecting deployment. The research finds that dedicated micromobility road infrastructure, integration with public transport, regulatory alignment, and safety lighting/signage are primary causal factors shaping performance and adoption. Secondary factors include environmental sustainability, accessibility, and fuel costs. These insights reinforce that the suitcase scooter's long-term usability depends not only on hardware quality but also on how urban systems accommodate lightweight electric vehicles through regulation and multimodal integration.[04]

Research gaps exist in integrating mobility with luggage systems. This study bridges that gap by combining both functionalities into a single compact design.

3. Methodology

The methodology of this research involves the design, development, and testing of a suitcase-integrated foldable scooter. The process begins with designing the system using CAD software to ensure proper structure, compactness, and ease of use. The design includes a foldable mechanism, telescopic handle, and integrated mobility components.

Suitable materials such as ABS plastic and aluminum are selected to achieve a balance between strength and lightweight construction. The system is powered by a BLDC hub motor and a lithium-ion battery, chosen based on efficiency and performance requirements.

A prototype is then developed by assembling all components, including the frame, motor, battery, and folding mechanism. After development, the system is tested for various parameters such as load capacity, stability, folding time, and battery performance.

Finally, the results obtained from testing are analyzed to evaluate the efficiency and usability of the system. This helps in identifying limitations and suggesting improvements for future development.

4. Components

The system consists of:

1	ABS suitcase shell
2	Telescopic handle
3	Foldable mechanism
4	BLDC motor
5	Battery pack
6	Wheels and braking system

5. Results and Discussion

The suitcase-integrated foldable scooter was tested to evaluate its performance and usability. The system showed good results in terms of portability, ease of use, and mobility. It can be quickly converted from suitcase mode to scooter mode, making it convenient for users in crowded areas.

The load capacity test confirmed that the system can support an average user along with luggage. The scooter provided smooth movement on flat surfaces, and the motor performed efficiently. The braking system also worked properly, ensuring safe operation.

The battery performance was satisfactory for short-distance travel, making the system suitable for urban use. However, minor issues such as slight instability at higher speeds and weight distribution were observed.

Overall, the system successfully improves mobility and reduces user effort in last-mile transportation.

However, limitations include load capacity and stability concerns. Further improvements are needed for durability and safety.

6. Conclusion

This research presents the design and development of a suitcase-integrated foldable scooter as an innovative solution to the problem of last-mile connectivity in urban transportation. The system successfully combines the functionality of a travel suitcase with a personal mobility device, providing convenience, portability, and efficiency in a single compact unit.

The study shows that the proposed system reduces physical effort, improves mobility, and enhances user experience, especially in crowded areas such as airports, railway stations,

and campuses. The use of lightweight materials, foldable mechanisms, and an electric drive system ensures smooth operation and easy handling.

The results obtained from testing indicate that the system performs effectively in terms of load capacity, stability, and battery efficiency. However, certain limitations such as balance at higher speeds and weight distribution need further improvement.

Overall, the project demonstrates strong potential for real-world applications in modern urban environments. Future work can focus on improving design optimization, adding smart features, and enhancing durability to make the system more efficient and user-friendly.

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