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Biometrics for Secure and Sustainable Public Transportation

Nisbet Bhunia*

Department of Sociology and Social Studies, University of Regina, Regina, SK, Canada

Introduction

As urban populations continue to grow and cities strive to reduce their environmental impact, public transportation has emerged as a cornerstone of sustainable urban development. Efficient, accessible, and eco-friendly transport systems are essential for reducing greenhouse gas emissions, decreasing traffic congestion, and promoting healthier lifestyles. However, alongside these sustainability goals, modern public transit systems must also address rising concerns around security, efficiency, and user experience. In this context, biometric technology systems that identify individuals based on physical or behavioural characteristics such as fingerprints, facial recognition, or iris scans has emerged as a powerful tool for revolutionizing public transportation. Biometrics offer a secure, seamless, and user-friendly approach to identity verification, replacing traditional methods like tickets, passes, or cards with personalized, touch less authentication. This paper explores how biometric breakthroughs are transforming public transportation systems worldwide, enhancing both security and sustainability. It discusses the potential of biometric identification to streamline transit access, reduce fraud, improve operational efficiency, and support contactless travel an increasingly important feature in the post-pandemic world [1].

Description

Biometric technologies are reshaping the way people access and interact with public transportation systems, offering numerous benefits that align with both security enhancement and sustainable development. Traditionally, passengers have relied on physical tickets, smart cards, or mobile devices to access transit networks, but these methods come with inherent inefficiencies, such as the potential for loss, theft, misuse, or long queues during peak hours. In contrast, biometric systems enable fast, contactless, an d highly secure authentication, significantly improving the overall passenger experience. For example, facial recognition at turnstiles or iris scanners integrated into fare gates can verify a commuter's identity in seconds, allowing for uninterrupted flow and reducing bottlenecks. This not only minimizes waiting times but also contributes to energy efficiency by optimizing station operations and reducing the reliance on printed or plastic fare media. From a sustainability standpoint, the move toward digital identity systems reduces the need for physical infrastructure and disposable materials, contributing to lower environmental footprints for transport authorities [2].

Furthermore, biometric authentication can play a critical role in improving security and reducing fare evasion. In many major cities, transit systems face revenue loss due to fraudulent ticketing or unauthorized access. With biometric verification, transit agencies can establish a secure link between a person and their access rights, making it nearly impossible to duplicate or misuse credentials. Moreover, the integration of biometrics into a unified smart city framework allows for better tracking of transit patterns, enabling data-driven decisions on route planning, capacity management, and energy usage all key factors in building sustainable transport ecosystems. Some cities, such as Shenzhen, Dubai, and Tokyo, are already piloting or deploying biometric systems across metro, bus, and airport links, demonstrating how the technology can support urban mobility goals while enhancing passenger safety. Additionally, in the wake of the COVID-19 pandemic, biometric systems have gained traction due to their contactless nature, reducing the risk of viral transmission by eliminating the need for physical touch points. This has led to an increased public and governmental push for hygienic and efficient transit solutions [3].

However, despite these advancements, the integration of biometric systems into public transportation is not without its challenges. Chief among them are concerns related to privacy, data protection, and ethical surveillance. The storage and use of sensitive biometric data raise significant questions about user consent, potential misuse, and the risk of data breaches. While biometric identifiers are unique and difficult to replicate, their permanence also means that, if compromised, individuals cannot simply "reset" their face or fingerprint like a password. At the same time, it critically examines the challenges posed by these technologies, including privacy concerns, data protection, and equitable access. As biometric systems continue to advance, their integration into public transit holds the promise of smarter, safer, and greener mobility solutions for the future.

This calls for robust data governance frameworks, encryption standards, and transparent policies to ensure that biometric data is handled responsibly. Additionally, equity remains a pressing concern. In order for biometric-based systems to be truly sustainable and inclusive, they must accommodate people from all walks of life, including the elderly, individuals with disabilities, and those who may be uncomfortable with or lack access to digital technologies. Addressing issues of algorithmic bias where certain demographic groups may be misidentified or excluded is also vital to prevent discrimination and ensure that the benefits of biometrics are equitably distributed. Lastly, the cost of implementation can be a barrier for low-income cities or regions, requiring careful planning and public-private partnerships to deploy the technology in a scalable, fair, and accessible manner [4].

Biometric identification systems are being increasingly adopted across the transportation sector for their ability to offer both secure and user-friendly solutions to long-standing problems. Traditional public transportation access methods paper tickets, travel cards, or even mobile-based QR codes require physical interaction and are susceptible to loss, theft, duplication, and misuse. In contrast, biometric systems, such as facial recognition turnstiles or fingerprint readers, offer non-transferable, accurate, and rapid authentication that can enhance both security and convenience for commuters. These systems enable contactless travel experiences, which have become highly valuable in the wake of global health concerns like COVID-19, where minimizing physical contact is essential. From a sustainability perspective, replacing disposable paper tickets and plastic smart cards with biometric solutions significantly reduces waste and operational costs. Transit authorities no longer need to print millions of tickets or maintain a complex infrastructure for issuing and managing fare cards. Instead, passengers can register once and gain seamless access to multiple transit services across bus, metro, and train networks [5].

Conclusion

In conclusion, biometric technologies hold transformative potential for public transportation systems, offering innovative pathways toward greater security, operational efficiency, and environmental sustainability. By replacing traditional fare media with touch less, personalized authentication, biometrics

***Address for Correspondence:** Nisbet Bhunia, Department of Sociology and Social Studies, University of Regina, Regina, SK, Canada; E-mail: nisbet@bhunia.ca*

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can streamline access, enhance safety, reduce physical infrastructure needs, and provide valuable data for smarter transit planning. These improvements support broader goals of sustainable urban mobility, particularly as cities aim to reduce emissions, enhance user experience, and adapt to the health-conscious demands of a post-pandemic society. However, the widespread adoption of biometrics must be approached thoughtfully, with strong safeguards to protect individual privacy and data integrity. Clear regulations, ethical standards, and inclusive design practices are essential to ensure that biometric systems are not only technologically advanced but also socially responsible. As biometric breakthroughs continue to evolve, their integration into public transportation can be a key driver of innovation shaping a future where travel is not only more secure and efficient but also more sustainable and equitable for all.

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Conflict of Interest

There are no conflicts of interest by author.

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