



Robotics and the Future of Personal Transportation

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ARTICLE INFO	ABSTRACT
Published Online: 16 March 2026	The rapid evolution of robotics is reshaping the landscape of personal transportation, driving a paradigm shift toward safer, smarter, and more efficient mobility solutions. As autonomous systems become increasingly sophisticated, robots are transitioning from industrial and service environments into everyday transportation platforms. Autonomous vehicles, delivery robots, intelligent drones, and robotic personal mobility devices demonstrate how robotics can enhance convenience while reducing human error, a major cause of road accidents. Integration of advanced sensors, machine learning algorithms, and real-time decision-making capabilities enables robotic transportation systems to navigate complex environments with minimal human intervention. Moreover, robotics supports sustainable transportation by optimizing energy use, reducing congestion through coordinated traffic flow, and enabling compact mobility solutions such as self-balancing scooters and robotic wheelchairs. The rise of connected vehicle ecosystems further amplifies these benefits, allowing robots and vehicles to communicate seamlessly with infrastructure and one another. Despite these advancements, challenges remain—including regulatory frameworks, ethical considerations, cyber security risks, and the need for robust public acceptance of autonomous technologies. Looking ahead, the convergence of robotics with artificial intelligence, 5G connectivity, and smart city initiatives will accelerate the deployment of personalized, autonomous transportation options. These innovations promise not only improved mobility but also greater accessibility for individuals with disabilities, reduced environmental impact, and enhanced quality of urban life. Ultimately, robotics is poised to transform personal transportation into a more intelligent, adaptive, and sustainable system, redefining how people move within both urban and rural environments.
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GRAPHICAL ABSTRACT

It transports through automation, intelligence, and interconnected systems. At the centre of the diagram is a segmented circle representing the four core components of next-generation mobility: autonomous vehicles, service robots, artificial intelligence, and digital connectivity. Each segment illustrates a key element—self-driving cars equipped with sensors, delivery robots navigating urban paths, AI-driven decision-making, and device-to-device communication symbolized through wireless signals and interface icons. Surrounding this central structure are representations of real-world robotic technologies, including humanoid robots, personal mobility devices like self-balancing scooters, and aerial drones. These elements

showcase the diversity of robotic applications in transportation, from ground-based navigation to unmanned aerial systems. The interplay between these components



highlights how robotics enhances safety, efficiency, and user convenience by reducing human error, optimizing route

planning, and enabling autonomous operation in dynamic environments. The illustration also reflects the integration of robotics within smart city ecosystems, where vehicles, infrastructure, and digital platforms communicate seamlessly. This interconnected network supports intelligent mobility services, improved traffic flow, and personalized transportation options. The overall design emphasizes the shift from manual, human-controlled transportation to a highly automated, AI-enhanced mobility landscape that is adaptive, sustainable, and accessible to all users.

1. INTRODUCTION

The integration of robotics into personal transportation marks one of the most transformative technological shifts of the 21st century. As advancements in artificial intelligence, sensor technologies, embedded systems, and machine learning accelerate, transportation systems are evolving from manually controlled machines to intelligent, autonomous mobility platforms. Robotics plays a central role in this evolution by enabling vehicles to sense their environment, make decisions, and navigate with remarkable precision. What once existed only in science fiction — self-driving cars, autonomous delivery pods, personal mobility robots, and aerial transport drones — is quickly becoming a practical reality. This transformation is driven by a global need for safer, cleaner, and more efficient mobility. Human error accounts for the majority of road accidents, and robotic systems have strong potential to reduce it. Moreover, urban congestion continues to rise, and conventional transportation methods place increasing pressure on the environment. Robotic technologies promise solutions through autonomous navigation, real-time data analysis, and optimized route planning. Beyond safety and efficiency, robotics also holds the potential to provide more inclusive mobility, supporting the elderly, people with disabilities, and individuals in remote areas through personalized and assistive robotic transport systems. However, the emergence of robotic transportation also brings a set of challenges and responsibilities. Policymakers must adapt regulations to ensure safety and accountability. Society must grapple with ethical concerns related to data privacy, employment shifts, and decision-making algorithms. Autonomous vehicles collect massive amounts of behaviour and location data, raising legitimate worries about surveillance, data ownership, and misuse. Despite these complexities, the trajectory of innovation clearly indicates that robotics will redefine how people and goods move in the coming decades [1], [2]. In this rapidly changing landscape, understanding the role of robotics in personal transportation is crucial, as it provides insight into the technological progress shaping future mobility systems [3]. It not only highlights advancements in autonomous navigation, intelligent sensing, and connected infrastructure but also invites thoughtful consideration of the social, economic, and environmental implications associated with robotic mobility [4], [5]. As

robotics continues to influence next-generation transportation, it holds the promise of creating systems that are autonomous, sustainable, accessible, and seamlessly integrated into daily life, ensuring safer and more efficient mobility for diverse populations [6], [7].

1.1. Service and Assistance Robots

They are a rapidly growing category of intelligent robotic systems designed to support, guide, and enhance the travel experience of passengers by performing tasks that improve mobility, efficiency, comfort, and accessibility. Unlike autonomous vehicles, which primarily focus on driving functions, Service and Assistance Robots focus on human interaction, mobility assistance, information delivery, and logistical support across transportation environments such as airports, railway stations, bus terminals, parking areas, and pedestrian pathways[9].

1.2. Infrastructure Robotics

Infrastructure Robotics refers to robotic systems embedded within transportation infrastructure to support, manage, automate, and optimize the movement of vehicles and passengers. These robots work behind the scenes to make transportation systems more intelligent, safe, resilient, and efficient. Unlike autonomous vehicles or personal mobility robots, infrastructure robots are fixed or semi-mobile, integrated into roads, bridges, tunnels, stations, and smart city networks. They serve as the structural backbone for large-scale transportation automation. Infrastructure robotics combines the fields of robotics, civil engineering, urban planning, AI, and IoT. These systems allow infrastructure to act like a “living organism” capable of sensing, responding, and self-correcting[6]. They communicate with vehicles, humans, and other robots to maintain efficient transportation flow. Infrastructure robots monitor traffic patterns in real time. They analyse congestion levels and adjust signals



accordingly. They predict traffic surges using AI models. They support autonomous vehicles by providing external navigation cues. They extend the sensing capabilities of AVs in difficult environments. For example, robots embedded in roads can detect ice formation earlier than vehicle sensors. Smart parking robots help vehicles find or park efficiently. Tunnel and bridge robots continuously monitor structural integrity.

1.3. Micro-Mobility Robots

Micro-mobility robots represent a transformative class of compact, lightweight, and intelligent transportation systems designed for short-distance travel within urban and semi-urban environments. These systems include autonomous or semi-autonomous e-scooters, e-bikes, hover boards, robotic skateboards, and small self-driving pods. Equipped with sensors, GPS modules, machine vision, and AI-based navigation algorithms, micro-mobility robots can independently plan routes, avoid obstacles, and adapt to dynamic traffic conditions[14]. A key advantage of micro-mobility robots is their ability to operate efficiently in congested city areas where larger vehicles struggle. Their



compact size allows them to navigate narrow lanes, footpaths, and dedicated micro-mobility corridors. Many systems are integrated with IoT platforms that enable real-time monitoring, fleet management, remote diagnostics, and smart charging. Some advanced models use self-deployment and self-parking features, allowing them to autonomously return to charging stations or high-demand areas. These robots also contribute to environmental sustainability by reducing carbon emissions, fuel consumption, and noise pollution. They support first-mile and last-mile connectivity, bridging gaps between public transport stations and final destinations. In many cities, micro-mobility robots complement public transportation networks by providing flexible, cost-effective, and accessible mobility solutions[12]. Their future development is expected to integrate swarm intelligence, improved battery technologies, and enhanced safety systems.

2. RELATED WORK

Robotics has expanded rapidly over the past decade, driven by advances in autonomous systems, artificial intelligence, connectivity, and urban mobility paradigms. Much of the literature on autonomous vehicles (AVs) emphasizes perception, decision-making, and human-robot interaction, showing how multimodal sensor fusion (e.g., camera, LiDAR, radar) and deep learning underpin safe navigation in complex urban setting. Recent studies also examine the grand challenge of large-scale deployment of AVs, addressing safety validation, regulation frameworks, and public acceptance. Parallel to this, there is significant research on connected transportation infrastructure, where robotics and intelligent systems are embedded in smart

roads, automated traffic-control networks, and Vehicle-to-Everything (V2X) communication systems[9]. For instance, infrastructure sensor-based cooperative perception (like roadside LiDAR) can extend AV perception, improve traffic flow, and enable cooperative data sharing Taylor & Francis Online. A growing area is infrastructure robotics for maintenance: robotic road inspectors, tunnel-monitoring drones, and automated repair systems are being explored to enhance structural safety and efficiency[15]. Unmanned aerial vehicles (UAVs) have been proposed for autonomous inspection of tunnel-like infrastructures, using path-planning and vision/thermal sensors to efficiently detect defects MDPI. Self-reconfigurable ground robots, such as the “Panthera” robot, combine vision and deep neural networks to identify cracks and other pavement defects MDPI[7]. Moreover, autonomous crack-detection systems integrate robotic platforms, AI-based perception modules, and planning to enable continuous infrastructure health monitoring. Work on micro-mobility robotics examines the rise of autonomous e-scooters, smart bicycles, and small personal transport robots designed for first- and last-mile mobility. Studies discuss environmental benefits, fleet management algorithms, demand prediction models, and challenges related to sidewalk safety and urban design. Similarly, research on service and assistance robots in transportation hubs explores robotic guides, luggage carriers, and autonomous wheelchairs that enhance accessibility and support smooth passenger flow in airports, campuses, and large public spaces. Finally, literature on last-mile delivery and logistics robots intersects with personal transportation, highlighting how sidewalk robots and aerial drones reshape urban movement patterns. Across these domains, researchers consistently identify common challenges related to safety assurance, interoperability, ethical considerations, and the need for holistic mobility ecosystems that integrate robotic systems with public transportation and smart city infrastructure.

3. MATERIALS AND METHODS

This study adopts a structured, technology-oriented methodology to investigate the role of robotics in shaping the future of personal transportation. The analysis integrates four major robotic domains—Autonomous Vehicle (AV) Robotics, Personal Mobility Robotics, Last-Mile Delivery Robotics, and Infrastructure & Inspection Robotics—and evaluates them using a combination of hardware-software materials, sensing modules, computational frameworks, and simulation tools. Methods include a systematic literature review, functional classification of robotic types, simulation-based analysis, and performance modelling.

3.1. Materials

1) Robotic Platforms

The robotic platforms analysed include autonomous road vehicles, robotic wheelchairs and smart personal mobility devices, sidewalk delivery robots, and unmanned

aerial/ground systems for infrastructure inspection. Delivery robots are examined using stakeholder-driven evaluation frameworks that define their operational constraints, environmental requirements, and human acceptance levels [9]. For infrastructure robotics, unmanned ground vehicles (UGVs) and unmanned aerial vehicles (UAVs) are included based on their applicability in monitoring bridges, highways, and public-transport structures, as reported in recent studies on civil-infrastructure inspection robots [10].

2) Sensing and Perception Modules

Transportation robots rely heavily on multimodal sensing to navigate complex environments safely. The materials include LiDAR, radar, stereo and RGB cameras, GPS/GNSS units, IMUs, and short-range sensors such as ultrasonic modules. The importance of sensor fusion and redundancy for mission-critical AV perception is guided by prior surveys of multi sensor integration architectures [11]. Connectivity components such as V2V/V2I modules are also included to enable cooperative perception and extended situational awareness.

3) Computing and Ai Frameworks

Robots across all categories employ embedded CPUs, GPU-accelerated systems, and edge-cloud architectures for real-time reasoning. Deep learning models for object detection, mapping, tracking, and decision-making form the computational backbone. Advanced sensor-fusion strategies were evaluated using context-adaptive multimodal frameworks such as those proposed in Hydra Fusion, which improve robustness by adjusting fusion strategies based on situational context [12].

4) Simulation Platforms and Datasets

Simulation environments such as CARLA, Gazebo, and SUMO were considered essential materials for modelling traffic scenarios, pedestrian interactions, and mixed-robot ecosystems. Open datasets (e.g., KITTI, nu Scenes) were used as reference standards for evaluating perception reliability under diverse lighting and weather conditions, consistent with methodologies outlined in multi sensor fusion literature [11].

3.2. Methods

1) Systematic Literature Review

A detailed review of robotics, transportation engineering, and intelligent-systems literature was conducted. The review prioritized recent findings on delivery robots [9], inspection robotics [10], and perception systems for autonomous driving [11], ensuring the methodological alignment with contemporary research.

2) Functional Classification of Robotics Types

Robotic systems were classified into four categories based on sensing demands, motion dynamics, operational domain, and levels of autonomy. Delivery robots were assessed for routing behaviour, human interaction, and real-world deployment challenges following stakeholder frameworks [9]. Inspection robots were classified by locomotion (aerial

vs. ground) and sensing modality following established taxonomies in civil-infrastructure robotics [10].

3) Simulation-Based Evaluation and Performance Modelling

Simulations modelled interactions between AVs, delivery robots, smart infrastructure, and pedestrians. Performance metrics included perception accuracy, communication latency, navigation robustness, and failure-tolerance. Adaptive sensor-fusion mechanisms were studied using principles from context-aware fusion models, such as Hydra Fusion, to assess their suitability for transportation environments [12].

4) Operational and Human- Centered Assessment

User acceptance, safety perception, and regulatory constraints were examined using findings from delivery-robot evaluations [9]. Infrastructure readiness and facility-level deployment feasibility were assessed through methodologies described in inspection-robot frameworks [10].

4. METHODOLOGY

This study employs a structured research methodology combining a systematic literature review, functional classification of robotic systems, simulation-based evaluation, and assessment of human-robot interaction impacts. The methodology enables a comprehensive understanding of how robotics technologies—including autonomous vehicles, delivery robots, mobility-assistive robots, and infrastructure inspection robotics—shape the future of personal transportation.

4.1. Classification of Robotic Systems

Robotics in personal transportation was classified into four categories: Autonomous Vehicle (AV) Robotics: Systems integrating LiDAR, radar, cameras, and deep-learning perception modules for safe navigation under urban conditions, following the multi sensor-fusion models presented in [11]. Personal Mobility Robotics: Assistive robots, robotic wheelchairs, and autonomous pods designed to enhance accessibility for elderly and disabled users. Delivery and Service Robotics: Last-mile ground robots and aerial systems used for logistics and urban delivery, evaluated using stakeholder-informed criteria from [9]. Infrastructure Robotics: UAVs and UGVs used for inspection and maintenance of roads, tunnels, and bridges, based on robotic inspection techniques described in [10]. This classification enabled targeted analysis of functional requirements, autonomy levels, operating environments, and human interaction features.

4.2. Human-Centered Assessment

The societal implications of robotics were assessed using evidence from stakeholder studies and field evaluations. Delivery-robot acceptance and human-robot interaction challenges were examined based on frameworks in [9]. Infrastructure inspection robotics informed safety and risk

considerations for workers and urban populations [10]. By synthesizing these insights, the methodology considered human safety, mobility equity, privacy, and public trust alongside technical performance.

4.3. Synthesis and Reporting

Findings from literature, simulations, and impact assessment were integrated to derive conclusions on the future role of robotics in personal transportation. The final synthesis highlights cross-domain dependencies among AVs, infrastructure robotics, assistive mobility systems, and urban delivery robots, forming the basis for the study's recommendations and future research directions.

CONCLUSION

Robotics is reshaping the landscape of personal transportation by enabling systems that are safer, more efficient, and deeply integrated with intelligent infrastructure. Advancements in autonomous vehicles, robotic mobility platforms, and infrastructure-embedded robotic systems demonstrate a shift toward transportation networks that are capable of sensing, learning, predicting, and adapting to human needs. These technologies help reduce traffic congestion, enhance road safety, improve accessibility for elderly and disabled commuters, and support sustainable transportation models. Despite these benefits, significant challenges remain—ranging from cyber security risks and ethical issues to regulatory gaps and public acceptance. The success of future transportation robotics will depend on coordinated progress in engineering, policy, human-centered design, and large-scale deployment standards. Overall, robotics holds transformative potential to redefine personal mobility, moving societies toward more resilient, autonomous, and interconnected transportation ecosystems.

RECOMMENDATIONS

The advancement of robotics in personal transportation requires a structured approach to safety, infrastructure, ethics, and public acceptance. The following recommendations are proposed to guide future development and deployment of robotic mobility systems.

A. Strengthening Safety Standards and Regulatory Frameworks

Uniform global standards for autonomous robotic vehicles should be established to ensure consistent performance and safety across regions. Regulatory agencies must adopt certification procedures for sensing, control, fail-safe behavior, and cyber security as emphasized by several recent studies in autonomous system governance [13].

B. Investment in Smart Infrastructure

Governments should expand smart transportation infrastructure, including IoT-enabled roads, edge-computing networks, and 5G/6G connectivity to support real-time robotic decision-making. Integration of Vehicle-to-

Everything (V2X) systems will significantly enhance autonomous mobility performance and reliability [13], [14].

C. Enhancing Human–Robot Collaboration

User-centered design should guide the development of robotic interfaces for personal mobility devices. Explainable AI (XAI) is recommended to improve system transparency and trust, enabling smoother interaction between users and intelligent robotic platforms [13].

D. Promoting Sustainable and Energy-Efficient Robotics

Robotic mobility systems should prioritize energy efficiency through advanced batteries, lightweight materials, and green energy integration. Sustainable robotic transportation helps reduce carbon emissions and supports environmental goals outlined in recent mobility research [14], [16].

E. Strengthening Data Privacy and Ethical Governance

To protect users, strict guidelines must be implemented for data handling, algorithmic transparency, and bias mitigation. Ethical frameworks and privacy-preserving AI models are essential to maintaining trust in autonomous transportation ecosystems.

F. Advancing Multi-Modal Robotic Transportation Research

Future transportation networks should include autonomous ground vehicles, drones, and assistive robotic mobility devices. Pilot projects and testbeds will accelerate innovation and ensure interoperability among diverse robotic systems [13], [17].

G. Improving Accessibility and Inclusivity

Robotic transportation solutions must be designed for users with disabilities and elderly individuals. Accessible interfaces and subsidized deployment programs will support equitable access to future mobility technologies [16].

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