



Autonomous Mobile Robots: Redefining Intelligent Mobility for the Future of Robotics

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Commentary

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Abstract

Autonomous Mobile Robots (AMRs) are rapidly transforming the robotics landscape by enabling intelligent, flexible, and autonomous navigation across dynamic environments. Unlike traditional mobile robotic platforms that rely on predefined routes, AMRs leverage artificial intelligence (AI), simultaneous localization and mapping (SLAM), computer vision, sensor fusion, and real-time decision-making to operate safely and efficiently with minimal human intervention. Their increasing adoption across manufacturing, logistics, healthcare, agriculture, and public services reflects a broader shift toward adaptive automation and Industry 5.0. This commentary discusses the growing importance of Autonomous Mobile Robots, highlights recent technological advancements, examines current challenges, and considers their evolving role in shaping intelligent, human-centered robotic ecosystems.

Keywords: Autonomous Mobile Robots; Intelligent navigation; SLAM; Industry 5.0; Smart manufacturing

Abbreviations

AMRs: Autonomous Mobile Robots; AI: Artificial Intelligence; SLAM: Simultaneous Localization and Mapping; AGVs: Automated Guided Vehicles.

Introduction

Autonomous Mobile Robots have emerged as one of the most influential innovations in modern robotics, fundamentally changing how robotic systems interact with dynamic environments. Advances in artificial intelligence, machine learning, computer vision, and autonomous navigation have enabled robots to move beyond fixed-path automation toward intelligent decision-making and adaptive mobility. Unlike Automated Guided Vehicles (AGVs), which require dedicated infrastructure such as magnetic strips or guide rails, AMRs continuously perceive their surroundings,

generate environmental maps, and optimize their navigation routes in real time.

The rapid growth of e-commerce, smart manufacturing, healthcare automation, and intelligent logistics has accelerated the demand for robotic systems capable of operating safely alongside human workers. As industries increasingly pursue flexible production systems and resilient supply chains, AMRs have become essential tools for improving efficiency, reducing operational costs, and enhancing workplace safety.

The Rise of Intelligent Mobile Robotics

Recent advances in robotics have transformed AMRs into highly intelligent systems capable of performing increasingly complex tasks. Modern AMRs integrate LiDAR, RGB-D cameras, inertial measurement units, global navigation

technologies, and sophisticated AI algorithms to perceive and interpret complex environments [1]. Through SLAM and real-time path planning, these robots can safely navigate crowded facilities, avoid obstacles, and continuously adapt to changing workplace conditions.

Cloud robotics, edge computing, and Industrial Internet of Things (IIoT) platforms further enhance the capabilities of AMRs by enabling predictive maintenance, fleet coordination, and data-driven optimization. These developments are accelerating the deployment of autonomous mobile platforms in manufacturing plants, warehouses, hospitals, airports, and research facilities.

Expanding Applications Beyond Manufacturing

Although manufacturing remains a major application area, the influence of Autonomous Mobile Robots extends far beyond industrial production. Healthcare facilities increasingly rely on AMRs to transport medications, laboratory samples, and medical equipment while reducing staff workload and minimizing infection risks. Warehouses employ autonomous robots for inventory management, order fulfillment, and internal logistics, significantly improving operational efficiency [2].

Agricultural robots equipped with autonomous navigation systems support precision farming by monitoring crops, collecting field data, and assisting harvesting operations [1,2]. Similarly, AMRs contribute to infrastructure inspection, environmental monitoring, disaster response, and public service applications where human access may be difficult or hazardous.

These expanding applications demonstrate that AMRs are becoming versatile robotic assistants capable of supporting diverse sectors while addressing labor shortages and improving operational resilience.

Challenges that require Continued Attention

Despite remarkable technological progress, several challenges continue to influence the widespread adoption of Autonomous Mobile Robots [3]. Reliable navigation in highly dynamic environments remains difficult when robots encounter unexpected obstacles, changing layouts, or unpredictable human behavior. Robust perception under varying lighting and weather conditions also requires continuous improvement.

Cybersecurity has become another major concern as increasing connectivity exposes robotic systems to potential cyber threats. Protecting operational data, ensuring

secure communication, and maintaining system integrity are essential for safe deployment. Furthermore, ethical considerations regarding autonomous decision-making, accountability, data privacy, and regulatory compliance must evolve alongside technological innovation [4].

Workforce adaptation also deserves attention. Successful integration of AMRs requires training programs that prepare employees to collaborate effectively with intelligent robotic systems rather than viewing automation solely as a replacement for human labor.

Future Perspective

The future of Autonomous Mobile Robots will likely be shaped by closer integration with foundation AI models, multimodal perception, digital twins, cloud-edge computing, and next-generation wireless communication technologies [5]. These advances will allow robots to interpret more complex environments, collaborate with other autonomous systems, and perform increasingly sophisticated tasks with greater efficiency.

Industry 5.0 provides an important framework for this evolution by emphasizing human-centered automation. Future AMRs are expected to function as collaborative partners that augment human capabilities, improve workplace safety, and contribute to sustainable industrial development [3,4]. Explainable AI, energy-efficient robotic platforms, and standardized safety frameworks will become increasingly important as robots operate within more complex and socially integrated environments.

Continued interdisciplinary collaboration among roboticists, AI researchers, policymakers, manufacturers, and healthcare professionals will be essential to ensure that technological innovation remains aligned with societal needs [6].

Conclusion

Autonomous Mobile Robots are redefining intelligent mobility by combining advanced perception, autonomous navigation, and adaptive decision-making within dynamic operational environments. Their expanding role across manufacturing, healthcare, logistics, agriculture, and public services highlights their growing importance in modern robotics. While challenges related to safety, cybersecurity, interoperability, and ethical governance remain, ongoing advances in artificial intelligence and intelligent sensing continue to expand the capabilities of AMRs. As robotics enters the Industry 5.0 era, Autonomous Mobile Robots are expected to become indispensable partners that enhance human productivity, strengthen operational resilience, and

drive the next generation of intelligent automation.

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