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Artificial Intelligence and Robotics: An Overview of Technological Synergy, Core Application Scenarios, and Future Trends

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Abstract. With the rapid development of technology, the collaborative advancement of artificial intelligence and robotics is reshaping the global landscape and making significant, continuous changes to people's lives. The development of artificial intelligence has led to major breakthroughs in the field of robotics. This paper focuses on the progress in various daily application scenarios, such as industrial automation, medical surgery, service robots, and driverless vehicles. At the same time, it explores the current technical bottlenecks, including the integration of the two technologies, the autonomous learning of artificial intelligence, the key to technological breakthroughs, and the safety of robots under artificial intelligence. Finally, based on the trend of technological development and social needs, this paper further looks forward to future development directions, including the application of general artificial intelligence in robots, the development of human-robot interaction, the cooperation and communication of swarm robots, and the construction of an ethical governance framework. These explorations not only provide theoretical support for the academic community but also offer forward-looking references for the industrial sector and policymakers.

Keywords: Artificial intelligence, robotics, the integration of the two technologies, social needs

1. Introduction

The world today is undergoing a profound transformation driven by technology, where the integration and synergistic development of artificial intelligence (AI) and robotics undoubtedly form the central theme of this revolution. No longer isolated islands advancing independently, these two fields now demonstrate a mutually reinforcing and complementary trajectory, reshaping the global industrial landscape while profoundly impacting human daily life at every moment. The rapid advancement of artificial intelligence provides robots with a powerful core and a remarkable soul, transforming them from mechanical arms performing repetitive tasks into intelligent entities capable of perceiving their surroundings and engaging in autonomous learning and decision-making. Against this backdrop, breakthroughs have been achieved in fields such as industrial automation, medical surgery, service robots, and autonomous driving.

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Despite this, we still face a series of formidable challenges: achieving deeper integration between AI and robotics, applying them more effectively, overcoming existing technical barriers, and eliminating potential risks. These have become key constraints on advancing toward greater heights. Based on this, this paper will systematically outline the coordination, application scenarios, challenges faced, and future prospects of artificial intelligence and robotics technology, integrating technological R&D with societal demands. This study is based on literature retrieval from the CNKI platform, using keywords such as “artificial intelligence” and “robotics,” with a time range spanning from 2012 to 2025. This technology has the potential to reshape future development patterns, address numerous global challenges, and significantly enhance the convenience of people's lives.

2. Technological synergy mechanisms between artificial intelligence and robotics

2.1. The core role of artificial intelligence technology in robotic systems

AI technology has become the core force driving robot systems toward intelligence, far surpassing traditional programming and procedural control. It endows robots with the capabilities to perceive, think, make decisions, and learn.

First, AI is the key to a robot's perception and understanding of its environment. Technologies such as sensors, computer vision, and language recognition enable robots to comprehend commands like humans and adapt to challenges they encounter. Second, AI serves as the intelligent hub for a robot's decision-making and planning. Algorithms based on deep learning and autonomous learning allow robots to analyze perceived information in real time, generate optimal responses, and produce precise control commands, enabling them to complete tasks ranging from simple to complex. Moreover, AI is pivotal for enabling robots' autonomous evolution and learning. Through imitation and online learning, robots accumulate experience from real-world interactions, continuously optimizing their behavior. They acquire the ability to solve unknown problems, transforming from mere task-executing tools into autonomous, collaborative intelligent agents (see Figure 1). Furthermore, AI implementation in intelligent robotics enhances data management and application [1]. In summary, artificial intelligence technologies are demonstrably applied across all aspects of robotic systems, propelling them from automation toward autonomy and from clumsy, rigid machinery toward agile, sophisticated machines.

Figure 1. Collaborative mechanism of artificial intelligence and robotics

2.2. Robotics' feedback and promotion of artificial intelligence development

Robots serve as crucial “physical testing platforms” for artificial intelligence, exerting an undeniable influence on AI development and propelling its advancement. During operation, robots generate vast

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amounts of real-world data far exceeding what virtual environments can capture, providing invaluable “fuel” for training more powerful and robust AI models. Simultaneously, the need for complex physical interactions in robotics has created an urgent demand for new algorithms, significantly accelerating breakthroughs in cutting-edge fields such as reinforcement learning, imitation learning, and embodied intelligence. Ultimately, robotics has introduced the “embodiment challenge,” compelling AI to address the integration of perception, decision-making, and execution. This forces AI to progress from theoretical frameworks to practical applications, driving the advancement and maturation of AI technology.

2.3. Current status of key technology integration

Currently, the integration of artificial intelligence and robotics technology is accelerating. Large models have enabled robots to achieve breakthroughs in autonomous decision-making capabilities, primarily in industrial settings. While China's supply chain holds a prominent global share, it remains somewhat dependent on external sources for core components. Humanoid robots, such as those developed by Yushu Technology and Tesla, have entered the commercial exploration phase. Nevertheless, they face several challenges: First, simulation data demands extremely high hardware stability, yet the industry lacks unified standards. Second, companies are pursuing divergent development paths, and algorithms have not yet converged [2]. Third, the form and performance of robots remain unstable. Additionally, excessive costs and safety concerns are significant issues that cannot be overlooked.

3. Analysis of application scenarios for artificial intelligence and robotics

3.1. Industrial automation production

Industrial production robots are now commonplace in modern society, appearing everywhere from low-level production workshops to high-end precision instrument manufacturing plants. As the core equipment of automated production lines, industrial robots primarily consist of a control center, mechanical body structure, and drive system. Currently, precise control of industrial robots is mainly achieved through programming [3]. Industrial production robots significantly reduce labor requirements and, under programmed control, deliver continuous productivity with consistent quality assurance. For instance, automotive manufacturers like BMW and Mercedes-Benz, as well as machinery producers such as Omron and Nanjing Estun, have extensively integrated robots into their production processes.

3.2. Medical robots and surgical assistance systems

Medicine was once considered the field least amenable to technological replacement, yet with the advancement and experimentation of artificial intelligence and robotics, their presence is increasingly visible in healthcare [4]. The emergence of surgical robots, rehabilitation care robots, telemedicine assistance, and medical AI has ushered in a new chapter for modern medicine. Surgical robots can mitigate tremors in surgeons' hands, reducing the risk of accidents; medical AI is gradually becoming commercialized, with diverse computer-aided diagnostic tools proliferating.

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3.3. Service robots and their applications in daily life

With the advancement of artificial intelligence, robots are gradually integrating into people's daily lives. A wide variety of household robots are now hot sellers in home appliance stores, with floor-mopping and dishwashing robots appearing in homes across the country. These robots primarily provide services in cleaning, health care, and household assistance. Moreover, this industry boasts broad market prospects and tremendous growth potential [5].

3.4. Driverless and driver assistance systems

In the field of autonomous driving, artificial intelligence and robotics are ubiquitous, with technological advancements progressing rapidly. Leading companies such as Tesla, BYD, and Huawei HarmonyOS are pioneers in autonomous and assisted driving, blazing a trail where none existed before. They predominantly employ multiple technologies, including deep learning-based pedestrian detection, stereo matching, multi-sensor fusion, and end-to-end control [6]. According to a report on vehicle ownership released by the Ministry of Public Security, by the end of 2016, the national motor vehicle fleet reached 290 million units, including 194 million passenger cars. There were 360 million licensed motor vehicle drivers, with over 310 million holding passenger car licenses. Private car ownership totaled 146 million vehicles, averaging 36 private cars per 100 households. Compared to 2015, private car ownership increased by 22.08 million vehicles, representing a 15.8% growth. The continuous growth in motor vehicle numbers has placed unprecedented pressure on road traffic conditions while leading to frequent traffic accidents. The emergence of autonomous driving technology offers hope for addressing these challenges [7]. With the assistance of driverless and driver-assist technologies, the number of traffic accidents in society has significantly decreased, simultaneously bringing substantial convenience to people's lives.

3.5. Artificial intelligence in agriculture

Artificial intelligence and robotics have strong applications not only in high-tech fields such as industry and healthcare, but also in agriculture. AI is deeply integrating into every stage of agricultural production, driving the emergence of new smart farming models. By combining IoT with AI algorithms, precise monitoring of air humidity, soil fertility, meteorological data, and crop growth can be achieved, providing robust scientific basis for irrigation, fertilization, and other agricultural practices. Moreover, computer vision technology efficiently identifies pest characteristics, enabling early prevention and targeted treatment for crops. The United States' status as a global agricultural powerhouse is inextricably linked to its AI capabilities. Agricultural big data is systematically produced, collected, transmitted, and processed, becoming a crucial new form of labor object. Multi-source heterogeneous data serves as the core factor in reshaping the qualitative state of agricultural productivity. It rapidly integrates into production, distribution, exchange, and consumption processes, guiding technological flows, capital flows, talent flows, and material flows through data streams. Ultimately, this achieves precise guidance for agricultural production, management, operations, and services [8].

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4. Current technical bottlenecks and challenges

4.1. Barriers to the deep integration of artificial intelligence and robotics

The deep integration of artificial intelligence and robotics still faces multiple obstacles. On the technological front, AI's perception and adaptability capabilities require further enhancement, which in turn limits the reliability of robotic systems. Insufficient data and computational power constraints also hinder the evolution of large-scale AI models. Regarding costs, investments do not necessarily yield proportional returns, while commercial production and gaining public acceptance remain significant challenges.

4.2. Safety and ethical challenges

Safety and ethical issues remain prominent. For instance, in human-robot collaboration, the delineation of responsibility in the event of accidents and the protection of individuals' privacy still face ambiguous boundaries. These challenges constitute a major obstacle to the current development of artificial intelligence and robotics [9]. As AI applications in robotics increase the frequency of robots in daily life, significant challenges to social safety and ethics emerge. These necessitate constraints through societal laws and individual moral standards.

4.3. Technical standardization and system compatibility

Technical standards and system compatibility serve as essential bridges for the coordinated development of artificial intelligence and robotics. However, the distinctiveness of their respective technological frameworks and differences in data interface protocols create a series of obstacles to their advancement. “Standardization provides a universal framework and standardized processes for technological research and development” [10]. The standardization of artificial intelligence plays a pivotal role in industrial development, not only regulating the market but also driving technological progress.

5. Conclusion

Despite the relatively sluggish global economy, the mobile robotics market continues to grow. Research achievements in artificial intelligence-related fields have been widely applied across various sectors including daily life, industrial production, and national defense. In the era of information networks and knowledge-based economies, artificial intelligence technology is receiving increasing attention and will undoubtedly play a greater role in driving technological progress and industrial development. This paper analyzes the impact of AI-robot integration on contemporary society from multiple perspectives, though it lacks technical-level examination. Future research should focus on harmonizing robotics and AI through unified technical standards and system compatibility, thereby accelerating their joint advancement. Scientific research and development remain a long and arduous journey, where every breakthrough is as difficult as scaling the heavens. This challenge stems not only from technical constraints but also from societal skepticism regarding the widespread adoption of such technologies and the feasibility of integrating robots and AI more extensively into daily life. Nevertheless, globally, we can clearly observe how AI and robotics are subtly serving us and transforming our lives. Leading tech companies in this field, such as OpenAI, Google, Microsoft, Apple, and Boston Dynamics, represent the vanguard of this industry, guiding us toward higher levels of advancement. Future development can focus on

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breakthroughs at the technological level, such as cognitive leaps in artificial intelligence and revolutionary advancements in robotic body technology. Simultaneously, efforts can concentrate on vertical industry applications, including the practical implementation of AI and robotics in agriculture, industry, high-precision manufacturing, or enabling AI robots themselves to conduct research and development in scientific fields.

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