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Robotics in Modern Industrial Processes: A Review of USA and African Practices

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Abstract

This paper provides a concise overview of the current state and practices of robotics in modern industrial processes, drawing a comparative analysis between the United States of America (USA) and various African nations. The adoption of robotics in industrial settings has revolutionized manufacturing, enhancing efficiency, precision, and overall productivity. This review aims to shed light on the divergent paths taken by these two regions in embracing robotic technologies and their impact on industrial landscapes. In the USA, a global leader in technological innovation, the integration of robotics into industrial processes has reached advanced levels. Automation and smart manufacturing have become key components of the industrial ecosystem, with widespread adoption in sectors such as automotive, electronics, and aerospace. The USA's emphasis on research and development, coupled with a robust infrastructure, has enabled the implementation of cutting-edge robotic systems, leading to increased competitiveness on the global stage. Contrastingly, the African continent presents a diverse landscape with varying levels of technological adoption. While some nations have made significant strides in embracing robotics, others face challenges related to infrastructure, education, and economic constraints. This review explores the factors influencing the adoption of robotics in different African countries, highlighting success stories and identifying areas for improvement. Initiatives promoting technology transfer, skill development, and collaborative efforts with international partners are discussed as potential pathways to overcome existing challenges. Despite the disparities, both the USA and Africa share common aspirations for leveraging robotics to address industrial demands. The review emphasizes the need for knowledge exchange, capacity building, and policy frameworks that encourage the integration of robotics into African industries. Furthermore, it underscores the importance of fostering a supportive ecosystem that nurtures innovation, entrepreneurship, and collaboration between government, academia, and the private sector. This review provides insights into the contrasting landscapes of robotics in modern industrial processes between the USA and Africa. By understanding the challenges and opportunities each region faces, stakeholders can work towards fostering a global environment where technological advancements benefit industries across diverse socioeconomic contexts.

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1. Introduction

Robotics has become increasingly significant in modern industrial processes, with China emerging as the world's largest user of

industrial robots (Cheng *et al*., 2019). The adoption of robotics has led to concerns about job displacement, as evidenced by worker-level evidence indicating that the loss of manufacturing jobs is driven by fewer new jobs for young labor market entrants (Dauth *et al*., 2018). This concern is not limited to the USA but is a global phenomenon, as seen in the substantial increase in the adoption of robotic technology in the USA (Gunadi & Ryu, 2023). Furthermore, the global adoption of robotic technology extends beyond industrial processes, with applications in neurosurgical practice and research (Stumpo *et al*., 2020).

The purpose of this review is to compare and contrast the adoption of robotics in the USA and Africa. This is crucial due to the varying responses to the rise of robots in different regions, as evidenced by the substantial adoption in the USA Gunadi & Ryu (2023) and the emergence of China as the largest user of industrial robots (Cheng *et al*., 2019). Understanding these global variations is important for policymakers and industry stakeholders to comprehend the impact of robotics adoption on employment and to develop strategies to address potential job displacement concerns (Dauth *et al*., 2018). Additionally, the review aims to shed light on the potential opportunities and challenges associated with the adoption of robotic technology in African industrial processes, considering the global significance of robotics in modern industrial practices.

The review of USA and African practices in adopting robotics is essential to gain insights into the global variations in robotics adoption, understand the impact on employment, and identify opportunities and challenges associated with the adoption of robotic technology in African industrial processes.

2. Robotics in Modern Industrial Process

Robotics has indeed become an integral part of modern industrial processes, revolutionizing the way tasks are performed in manufacturing and automation. The evolution of industrial robotics has been closely linked to advancements in communication systems, enabling the seamless integration of robots into industrial processes (Grau *et al*., 2017). Modern industrial robots are equipped with machine vision, sensors, and advanced algorithms, significantly reducing human labor costs and enhancing production efficiency (Long, 2023). Additionally, the scheduling of robotic processes has been optimized through lean robotics approaches, streamlining adhesive dispensing and other manufacturing tasks (Sobaszek, 2022).

In line with the fourth industrial revolution, robotics has gained prominence in facilitating automation, ensuring the safety and consistency of manufacturing processes (Guma & Akporhuarho, 2021; Adeleke *et al*., 2019). The application of industrial robots extends to various tasks such as assembly, polishing, and even anomaly detection in highly automated production systems (Mohsin *et al*., 2019; Nentwich & Reinhart, 2021). Furthermore, the use of multiple robots working cooperatively has been explored to increase production speed, highlighting the potential of multi-robot systems in manufacturing applications (Ohenhen *et al*., 2024; Tereshchuk *et al*., 2019).

The versatility of modern industrial robots is evident in their application across diverse industries, including aviation, aerospace, and marine engineering, where robotized intelligent manufacturing is becoming increasingly prevalent (Tao *et al*., 2023). Moreover, the integration of robots in the metal industry has been a subject of extensive analysis, showcasing the widespread adoption of industrial robots in different manufacturing processes (Karabegović *et al*., 2012). As the complexity of robot systems continues to grow, the selection of the most suitable robotic system for specific industrial applications has become a challenging task for production firms (Babatunde *et al*., 2021; Wang *et al*., 2018). However, the increasing demand for robotics solutions is evident, as they align with the concept of the fourth industrial revolution, characterized by smart machines and dynamic engineering processes (Ezeigweneme *et al*., 2024; Moura & Silva, 2018).

In conclusion, modern industrial robotics has significantly transformed manufacturing and automation processes, offering enhanced efficiency, safety, and adaptability across various industries. The integration of advanced technologies such as machine vision, sensors, and intelligent algorithms has propelled industrial robots to become indispensable assets in the era of the fourth industrial revolution.

2.1. Robotics in the USA

The state of robotics in the United States is characterized by significant advancements and widespread adoption across various sectors. The country has been at the forefront of research, development, and innovation in robotics, contributing significantly to the global landscape. The adoption of robotic technology in the United States has been particularly notable in the fields of medicine, including surgical procedures such as laparoscopy and adrenalectomy (Sheetz *et al*., 2020; Grogan, 2020; Maynou *et al*., 2021; Fatehchehr *et al*., 2014; Borahay *et al*., 2013). Additionally, the automotive, electronics, and aerospace industries have also been key sectors leading in the integration of robotic systems, reflecting the diverse applications of robotics in the country (Rawashdeh *et al*., 2023; Kapusi *et al*., 2022; Doyle-Lindrud, 2015).

The emphasis on research and development in the United States is evident in the substantial contribution to the field of robotics, as reflected in the high number of published articles and citations in robotics-related research (Rawashdeh *et al*., 2023). Furthermore, the country has demonstrated a strong focus on innovation, with the deployment of advanced technologies such as deep learning for real-time object detection in industrial settings (Kapusi *et al*., 2022). The infrastructure supporting robotics research and development in the United States is robust, with a significant number of startups dedicated to service robots, highlighting the entrepreneurial and innovative landscape in the country (Orieno *et al*., 2024; Gonzalez-Aguirre *et al*., 2021).

The achievements and advancements in the integration of robotic systems in the United States have been driven by a combination of factors, including the rapid adoption of robotic surgery, the development of modular and reconfigurable robotics, and the deployment of humanoid robots for various applications (Sheetz *et al*., 2020; Grogan, 2020; Rawashdeh *et al*., 2023; Kapusi *et al*., 2022; Ficht *et al*., 2018; Saeedvand *et al*., 2019). These advancements have not only revolutionized surgical procedures but have also contributed to the development of autonomous and modular robotic systems for diverse industrial and service applications.

The global competitiveness of the United States in the field of robotics has had a profound impact on the industrial

landscape, with the country leading in the adoption and development of robotic technologies. The rapid adoption of robot-assisted procedures and the significant contribution to robotics research and development have positioned the United States as a global leader in the field, influencing the industrial landscape both domestically and internationally (Sheetz *et al*., 2020; Rawashdeh *et al*., 2023; Kapusi *et al*., 2022; Doyle-Lindrud, 2015).

2.2. Robotics in Africa

Africa, a continent rich in cultural diversity and resources, presents a complex and diverse landscape when it comes to the adoption of robotics in modern industrial processes. From the bustling tech hubs of South Africa to the rural areas where traditional agriculture persists, the levels of technological adoption vary significantly. Different nations are at different stages of integrating robotics into their industries, contributing to a diverse and evolving panorama.

Several factors influence the adoption of robotics across African nations. Infrastructure, or the lack thereof, plays a pivotal role. Countries with robust infrastructure are more likely to adopt robotics seamlessly, while others face challenges due to inadequate transportation, energy, and communication networks. Education is another critical factor. Access to quality education and training in robotics and automation directly impacts a nation's ability to incorporate these technologies into its industries. Economic constraints also pose challenges, as the initial costs of implementing robotic systems can be substantial. Governments and industries must navigate these hurdles to create an environment conducive to the widespread adoption of robotics.

The adoption of robotics in Africa is influenced by various factors such as infrastructure, education, and economic constraints (Augustine *et al*., 2018). Success stories in African countries, like Botswana, demonstrate the positive impact of economic stability on technology adoption (Acemoglu *et al*., 2001). However, challenges persist in countries with slower adoption rates, including limited infrastructure and economic constraints (Augustine *et al*., 2018). Initiatives and programs addressing the integration of robotics in African industries are essential for overcoming these challenges and promoting technological advancement (Nsikani *et al*., 2022).

Amidst the challenges, several African countries have successfully embraced robotics, showcasing the potential for transformative change. South Africa, for instance, stands out as a regional leader in adopting robotic technologies. With a well-established industrial base, South Africa has integrated robotics into manufacturing, mining, and automotive sectors, boosting efficiency and competitiveness. Nigeria, the continent's most populous nation, has seen advancements in the use of robotics in agriculture, contributing to increased yields and sustainable farming practices. Additionally, countries like Kenya and Rwanda have focused on technology hubs and innovation centers, fostering an environment for start-ups and entrepreneurs to develop and implement robotic solutions. These success stories not only demonstrate the adaptability of African nations but also serve as models for others to follow in integrating robotics into their industrial processes.

While success stories abound, many African nations face challenges that hinder the widespread adoption of robotics. Limited access to quality education and training programs in robotics is a common hurdle. The lack of skilled professionals proficient in designing, programming, and maintaining robotic systems slows down the pace of adoption. Economic constraints, including limited financial resources, also impede progress, making it difficult for industries to invest in expensive robotic solutions.

Moreover, some countries face resistance to change from traditional industries and a fear of job displacement. Addressing these challenges requires a holistic approach, involving collaboration between governments, educational institutions, and industries to develop tailored solutions that account for the unique circumstances of each nation.

Recognizing the potential benefits of robotics in advancing economic development, various initiatives and programs have emerged across Africa to address the challenges and promote integration. Collaborations with international organizations, governments, and private sectors have played a crucial role in supporting these initiatives.

For example, partnerships between African nations and established technology companies have led to knowledge transfer programs, enabling local engineers and technicians to acquire skills in robotics. Educational institutions are establishing specialized courses and training programs to cultivate a workforce equipped with the skills needed for the evolving job market. Governments are also implementing policies to incentivize industries to invest in automation and robotics, promoting innovation and efficiency.

In conclusion, robotics in Africa represents a dynamic landscape with both challenges and opportunities. While the continent faces diverse hurdles, success stories and initiatives demonstrate a growing awareness of the transformative potential of robotics. As African nations continue to navigate these challenges and invest in educational and technological infrastructure, they are poised to unlock the full potential of robotics, contributing to sustainable economic growth and competitiveness on the global stage.

2.3. Comparative Analysis of Robotics in Modern Industrial Processes

The adoption of robotics in modern industrial processes varies significantly between the USA and Africa. In the USA, there is evidence of a positive correlation between the increase in the use of industrial robots and employment (Acemoğlu & Restrepo, 2020). This suggests that robots and labor are grossly complementary in the production process, leading to an increase in employment. On the other hand, in Japan, the decline of robot prices increased the number of robots as well as employment, indicating a similar trend to that of the USA (Adachi *et al*., 2022). In contrast, China has shown empirical evidence that the use of industrial robots can promote the transformation of export trade modes, indicating a positive impact on trade and economic growth (Wang & Li, 2022). These findings highlight the contrasting approaches to robotics adoption in these regions, with the USA and Japan experiencing positive employment impacts, while China is leveraging robotics for trade transformation.

Despite the differences in adoption, there are common aspirations and shared challenges. The metal industry globally has seen a trend in the application of industrial robots, indicating a shared aspiration for automation and efficiency improvement (Karabegović *et al*., 2012). This suggests that both the USA and Africa share the aspiration for increased productivity and automation in industrial processes. However, the challenges of integrating robotics

into industrial processes are also shared. The need for adjustment of labor markets to robots is a common challenge, as evidenced by the need for workers to transition into better jobs within their original plants (Acemoğlu & Restrepo, 2020). This adjustment is crucial for both regions to ensure a smooth transition to a more automated industrial landscape.

The impact of robotics on industrial processes in both regions is significant. The USA and Japan have experienced a positive impact on employment, indicating that robotics has contributed to the growth of the labor market (Acemoğlu & Restrepo, 2020; Adachi *et al*., 2022). In contrast, China has seen a transformation in export trade modes due to the use of industrial robots, indicating a positive impact on trade and economic growth (Wang & Li, 2022). These impacts highlight the potential for robotics to drive economic and industrial development in both regions.

Lessons learned from the USA that could be applied to African contexts include the importance of understanding the complementary nature of robots and labor in the production process, as well as the need for labor market adjustments to accommodate the integration of robots (Acemoğlu & Restrepo, 2020). Additionally, the shared aspiration for automation and efficiency improvement in the metal industry presents an opportunity for African contexts to learn from the experiences of the USA and other regions in leveraging robotics for industrial advancement (Karabegović *et al*., 2012).

In conclusion, the adoption of robotics in modern industrial processes varies between the USA and Africa, with contrasting approaches and impacts. However, there are common aspirations, shared challenges, and valuable lessons that can be learned from the experiences of the USA and other regions to drive the effective integration of robotics into African industrial processes.

2.4. Collaboration and Knowledge Exchange

International collaboration in robotics research and development is crucial for advancing the field. emphasized the significance of global cooperation and collaboration in robotics, highlighting that it is through such collaboration that a true difference in the societal value of robotics can be achieved (Yang *et al*., 2020). This underscores the need for partnerships and knowledge exchange on a global scale to drive innovation and progress in robotics.

In the context of Africa, there are opportunities for technology transfer and skill development. Reference to the work by Wang (2022), which discusses the application status and development trend of industrial robots, suggests that with the development of artificial intelligence technology, industrial robots are gradually approaching production workshops, presenting an opportunity for technology transfer and skill development in regions like Africa (Wang, 2022). This indicates that Africa can benefit from the transfer of robotic technology and the development of skills in this domain to enhance its industrial capabilities.

Furthermore, successful collaborations between the USA and African nations can serve as case studies. For instance, the work by on USARSim, a simulation for the study of human-robot interaction, provides a platform for collaboration and sharing results in the field of human-robot interaction, which can be leveraged by the USA and African nations to foster successful collaborations in robotics research and development (Lewis *et al*., 2007). This demonstrates the potential for utilizing simulation platforms to facilitate collaborative research efforts between the USA and African countries.

2.5. Policy Implications

To foster the integration of robotics in modern industrial processes, government policies play a crucial role (Stam, 2015). emphasizes the significance of entrepreneurial ecosystems and regional policies in promoting innovation and entrepreneurship, which are essential for the successful integration of robotics (Stam, 2015; Langman *et al*., 2021). further highlight the changing industrial landscape due to the implementation of automated intelligent systems, indicating the need for supportive policies to accommodate these advancements (Langman *et al*., 2021). Additionally, Beliaeva *et al*. (2019) stress the importance of strategic partners in the innovation ecosystem, which can be facilitated through government policies to encourage digital entrepreneurship and technological transformation (Beliaeva *et al*., 2019).

Creating a supportive ecosystem for innovation, entrepreneurship, and research is vital for the successful adoption of robotics in Africa (Pagter, 2023). points out the uncertainties surrounding the future impact of robotics, highlighting the need for effective implementation of policies drawing on the ethics narrative (Pagter, 2023). Furthermore, Owolabi *et al*. (2022) discuss the readiness of academic librarians towards the use of robotic technologies, emphasizing the importance of policy and procedure documents to support the integration of robotics in educational and research settings (Owolabi *et al*., 2022; Kansheba, 2020). also reveals the mixed influence of eco-factors such as government support on productive entrepreneurship, suggesting the need for tailored policies to create a conducive environment for innovation and entrepreneurship (Kansheba, 2020).

Recommendations for policy frameworks that encourage robotics adoption in Africa should consider the findings of (Luyt & Swartz, 2022), who emphasize the impact of complex organizational behavior on policy implementation, highlighting the need for a robust policy framework to support technological adoption (Luyt & Swartz, 2022). Additionally, Yang (2022) stresses the importance of clarifying the relationship between the system and the influence of various elements on the effect of entrepreneurship education, indicating the need for targeted policies to enhance technological education and adoption (Yang, 2022). Moreover, Ibeneme *et al*. (2020) emphasize the need for frameworks that foster linkages and interconnections to strengthen health systems, providing insights into the holistic approach required for policy frameworks in the context of robotics adoption (Ibeneme *et al*., 2020).

2.6 Case Study of Robotics in Modern Industrial Processes in the USA and Africa

The integration of robotics in modern industrial processes has significantly transformed manufacturing and production systems in both the USA and Africa. In the USA, the automotive industry has witnessed the development and performance analysis of assembly systems based on industrial robots with integrated vision sensing systems for various applications (Ságа *et al*., 2020). These advancements have led to improved efficiency, safety, and cost-effectiveness in the construction industry (Eze *et al*., 2023). Additionally, the use of robotics in fruit sorting has alleviated

the challenges associated with sorting a large variety of fruits and vegetables, contributing to enhanced productivity and quality (Yu *et al*., 2021). Furthermore, the application of robotics in welding has not only increased flexibility but also improved the quality of weld joints, thereby enhancing the overall constructional strength and product quality in modern manufacturing industries (Kafi & Kovács, 2020).

In Africa, the adoption of robotics in manufacturing processes has also been evident. For instance, the integration of robotic arms, 2D-vision, and conveyor systems has been aimed at improving product quality and increasing productivity in manufacturing lines (Alghamdi *et al*., 2017). Moreover, the impact of robotization has been observed in the agricultural sector, particularly in the domestication of cows. Rather than viewing robots as mere technological resources causing industrialization, it is essential to consider the uses, configurations, and relations that robots establish in the technical process of domesticating cows (Deturche, 2019).

The use of robotics in modern industrial processes has not only revolutionized manufacturing but has also presented recurrent challenges in robotics software engineering. The practices applied by robotics industrial and academic practitioners, including processes, paradigms, languages, tools, frameworks, and reuse practices, have been crucial in addressing these challenges and improving the performance of robotics systems (Garcia *et al*., 2020). Additionally, the application of lean robotics approaches has been instrumental in the scheduling of robotic processes, contributing to enhanced efficiency and task management in industrial settings (Sobaszek, 2022).

In conclusion, the integration of robotics in modern industrial processes has had a profound impact on manufacturing and production systems in both the USA and Africa. These advancements have led to improved efficiency, productivity, and product quality, while also presenting challenges that have been addressed through innovative practices in robotics software engineering and lean robotics approaches.

2.7. Future Outlook

The future of robotics in modern industrial processes is poised for significant advancements and innovations, with the potential to revolutionize industries in both the USA and Africa. The integration of emerging technologies is expected to play a pivotal role in shaping this future landscape. As highlighted by , robotic systems are an essential part of modern industrial revolution 4.0 manufacturing (Galan-Uribe *et al*., 2023). This signifies the increasing reliance on robotics in industrial processes, indicating a shift towards more automated and technologically advanced production systems. Furthermore, the study by emphasizes the state of the field of large-area tactile sensing in robotics and prosthetics, particularly focusing on neural-like tactile data handling, energy autonomy, and advanced manufacturing based on printed electronics (Dahiya *et al*., 2019). This underscores the role of emerging technologies in enhancing the capabilities of robotics, making them more adaptable and efficient in industrial applications.

Advancements and innovations on the horizon encompass a wide array of areas. For instance, the study by highlights the scheduling of the process of robot welding of thin-walled steel sheet structures under constraint, resulting in increased time savings throughout the entire production process (Sobaszek & Świć, 2021). This indicates a potential for improved efficiency and productivity in industrial processes through the application of robotics. Additionally, the research by demonstrates a considerable improvement in polishing processes through robotic path planning under force control, achieving a 90% improvement in average roughness (Mohsin *et al*., 2019). Such advancements signify the potential for robotics to enhance the quality and precision of industrial processes, leading to superior end products.

In both the USA and Africa, the role of robotics in modern industrial processes is expected to be influenced by the adoption of innovative technologies. As highlighted by , a function as a service based fog robotic (FaaS-FR) for cognitive robots is proposed, indicating the integration of cognitive capabilities into robotic systems (Ahn, 2019). This suggests that emerging technologies such as fog computing and cognitive computing will shape the future capabilities of robotics in industrial processes, enabling them to make autonomous decisions and adapt to dynamic environments. Therefore, the future outlook for robotics in modern industrial processes is characterized by technological advancements that enhance efficiency, precision, and adaptability, ultimately transforming the industrial landscape in both regions.

2.8 Emerging 2025 Insights on Robotics Adoption in US and African Industries

Recent scholarship in 2025 has provided fresh perspectives on the evolving role of robotics in industrial processes across both the United States and Africa. Urrea and Kern (2025) offer a comprehensive synthesis of technological advancements in industrial robotics, emphasizing emerging applications and integration trends in leading economies, including the US. Complementing this, Phokoye *et al*. (2025) explore robotics adoption within higher education, drawing parallels to the industrial sector and revealing persistent disparities between US and African capabilities in technology-driven operations. Calitz, Poisat, and Cullen (2025) focus on collaborative robots in African manufacturing, presenting insights into workforce adaptation and cultural considerations that influence successful implementation. Similarly, Bongomin, Nganyi, and Abswaidi (2025) examine Industry 4.0 strategies within the East African Community, positioning robotics as a core driver of sustainable competitiveness and comparing these approaches with those in US industries. Together, these studies highlight a growing body of comparative evidence, reinforcing the need for adaptive, region-specific robotics strategies in modern industrial practices.

3. Recommendation and Conclusion

The review of robotics in modern industrial processes across the USA and Africa has uncovered a spectrum of insights, highlighting both successes and challenges. In the United States, a global leader in technological innovation, the integration of robotics has reached advanced levels, contributing to increased efficiency and competitiveness in various sectors. Conversely, African nations display a diverse landscape with varying levels of technological adoption, influenced by factors such as infrastructure, education, and economic constraints.

Key findings include the pivotal role of research and development, infrastructure, and education in the successful adoption of robotics. African success stories, such as South Africa's advancements in manufacturing and Nigeria's

innovations in agriculture, underscore the continent's potential for transformative change. However, challenges, such as limited access to education and economic constraints, remain prevalent in countries with slower adoption rates.

The comparative analysis highlights the importance of adopting a global perspective on robotics adoption. While the USA showcases advanced practices, collaboration and knowledge exchange with African nations can provide valuable insights and foster a more inclusive approach. The review emphasizes that a one-size-fits-all model is insufficient given the diverse challenges and opportunities present in different regions.

A global approach to robotics adoption involves acknowledging and addressing the unique circumstances of each nation. It requires international collaboration to share best practices, promote technology transfer, and facilitate skill development. Recognizing the interconnectedness of the global economy, a collective effort is necessary to ensure that the benefits of robotics and automation are accessible to all nations, contributing to sustainable and inclusive industrial development.

As the review concludes, it is imperative to encourage and prioritize ongoing research, collaboration, and knowledge exchange between the USA and African nations in the field of robotics. The dynamic landscape of robotics necessitates continuous exploration of emerging technologies, innovative solutions, and effective strategies for implementation.

To facilitate collaboration, joint research initiatives, and technology transfer programs can be established between institutions, industries, and governments. Educational and training programs should be designed to equip individuals with the skills needed for the evolving job market, fostering a workforce capable of driving the integration of robotics. Furthermore, platforms for continuous knowledge exchange and dialogue should be established to create a vibrant ecosystem where ideas and experiences can be shared. Initiatives promoting mentorship, networking, and joint projects between the USA and Africa can accelerate the pace of technological adoption and contribute to the overall advancement of global industries.

In conclusion, the review underscores the importance of a nuanced and inclusive approach to robotics adoption, recognizing the diversity of challenges and opportunities faced by nations across the globe. By emphasizing collaboration, knowledge exchange, and ongoing research, the USA and African nations can collectively shape a future where the transformative potential of robotics contributes to sustainable industrial development on a global scale.

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