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AI and human-robot interaction: A review of recent advances and challenges

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Abstract

The integration of artificial intelligence (AI) into human-robot interaction (HRI) has witnessed significant advancements in recent years, revolutionizing the way humans and robots collaborate and coexist. This review provides a comprehensive overview of the latest breakthroughs in AI-driven HRI and identifies the challenges that lie ahead. Recent years have seen a surge in AI-driven capabilities that enhance human-robot interaction. Machine learning algorithms enable robots to adapt to user preferences and behaviors, creating personalized and intuitive interactions. Natural language processing (NLP) facilitates seamless communication between humans and robots, enabling voice commands and context-aware responses. Computer vision advancements empower robots with enhanced perception, enabling them to recognize and interpret human gestures, emotions, and facial expressions. Reinforcement learning has played a pivotal role in enabling robots to learn from human feedback and optimize their actions in real-time. Socially assistive robots leverage AI to provide emotional support and companionship, particularly in healthcare and elderly care settings. Despite these advancements, challenges persist in the field of AI-driven HRI. Ethical considerations, including privacy concerns and the responsible use of AI in influencing human behavior, demand careful attention. Ensuring the safety and security of AI-driven robotic systems remains paramount, requiring robust measures against malicious attacks and unintended consequences. Human-robot trust remains a critical challenge, necessitating transparent AI algorithms and effective communication strategies. Interdisciplinary collaboration between AI researchers, roboticists, psychologists, and ethicists is essential to address the complex socio-technical aspects of HRI. The fusion of AI and human-robot interaction holds immense potential to redefine various facets of our daily lives. This review highlights recent strides in AI-driven HRI, emphasizing the need for interdisciplinary efforts to address challenges and ensure the responsible development and deployment of AI-powered robotic systems. As researchers continue to innovate, the dynamic landscape of AI and human-robot interaction promises a future where seamless collaboration and coexistence between humans and robots become an integral part of our societal fabric.

Keywords: AI; Human-Robot; Interaction; Recent Advances; Challenges

1. Introduction

In recent years, the intersection of artificial intelligence (AI) and human-robot interaction (HRI) has emerged as a dynamic and rapidly evolving field, shaping the way humans and robots interact in various domains (Wamba *et al.*,

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2023). This introduction provides a brief overview of AI's role in HRI, highlights the growing importance of HRI in various sectors, and outlines the purpose of the review, which is to examine recent advances and challenges in AI-driven HRI. AI plays a pivotal role in enhancing human-robot interaction by enabling robots to perceive, understand, and respond to human cues and commands. Through AI-powered algorithms, robots can interpret natural language, recognize facial expressions, and adapt their behavior in real-time based on human feedback (Sharma *et al*., 2022). By leveraging techniques such as machine learning, computer vision, and natural language processing, AI empowers robots with cognitive capabilities, allowing them to interact with humans in more intuitive, intelligent, and human-like ways (Hashmi, 2023).

The importance of HRI has been steadily increasing across various sectors, including manufacturing, healthcare, retail, hospitality, and entertainment (Reis *et al*., 2020). In manufacturing, collaborative robots, or cobots, work alongside human workers to improve productivity, safety, and efficiency (Liu *et al*., 2022). In healthcare, robots assist with patient care, rehabilitation, and surgery, enhancing the capabilities of healthcare professionals and improving patient outcomes (Khan and Anwar, 2020). In retail, service robots provide assistance to customers, automate inventory management, and enhance the shopping experience (Song and Kim, 2022). In hospitality and entertainment, robots serve as companions, entertainers, and assistants, providing personalized services and enhancing customer satisfaction (Moriuchi and Murdy, 2024).

The purpose of this review is to provide a comprehensive analysis of recent advances and challenges in AI-driven HRI. By examining the latest research, developments, and applications in the field, this review aims to shed light on the current state-of-the-art in AI-driven HRI and identify key challenges and opportunities for future research and innovation. By addressing these challenges and leveraging the latest advancements in AI and robotics, we can unlock the full potential of human-robot interaction and pave the way for a future where humans and robots collaborate seamlessly to achieve common goals.

2. History of the advances and challenges of AI and human-Robot interaction

The history of advances and challenges in AI and Human-Robot Interaction (HRI) spans several decades, characterized by significant milestones, breakthroughs, and evolving challenges (Tong *et al*., 2024). From early attempts at creating intelligent machines to the development of sophisticated robotic systems capable of interacting with humans in various contexts, the journey of AI-driven HRI reflects the convergence of AI technologies, robotics, cognitive science, and human-computer interaction. This review explores the historical evolution of advances and challenges in AI and HRI, highlighting key developments, breakthroughs, and ongoing considerations.

The roots of AI and HRI can be traced back to the mid-20th century when pioneers in the field of artificial intelligence envisioned creating intelligent machines capable of reasoning, learning, and interacting with humans (Chakraborti, 2023). In the 1950s and 1960s, researchers such as Alan Turing, Marvin Minsky, and John McCarthy laid the groundwork for AI by developing theoretical frameworks, algorithms, and programming languages. The emergence of robotics in the 1960s marked a significant milestone in the history of HRI, with the development of the first industrial robots capable of performing repetitive tasks in manufacturing settings (ElMaraghy *et al*., 2021). These early robots were pre-programmed and operated independently of human input, lacking the ability to interact with or adapt to their environment.

In the 1970s and 1980s, researchers began exploring the concept of human-robot collaboration, envisioning robots that could work alongside humans in shared workspaces. However, the technological limitations of the time hindered progress in AI and HRI, with robots still relying primarily on pre-defined instructions and lacking the ability to perceive, interpret, or respond to human cues. The integration of AI technologies into robotics marked a turning point in the evolution of HRI, enabling robots to exhibit more intelligent behavior and interact with humans in more natural and intuitive ways (Zhong *et al*., 2021). In the 1990s and early 2000s, advancements in machine learning, computer vision, and natural language processing paved the way for more sophisticated AI-driven HRI systems.

One of the significant milestones in AI-driven HRI was the development of socially assistive robots, designed to interact with humans in socially appropriate and emotionally sensitive ways. Researchers explored the use of AI algorithms to imbue robots with emotional intelligence, empathy, and social skills, enabling them to provide companionship, support, and assistance to individuals in various contexts, including healthcare, education, and therapy (Lynch, 2021; George, 2023). Advancements in machine learning algorithms, particularly deep learning, revolutionized HRI by enabling robots to learn from large datasets and adapt their behavior based on experience. This led to the development of more autonomous and adaptive robots capable of perceiving, understanding, and responding to human gestures, facial expressions, and speech.

While AI-driven HRI has made significant progress, it also poses various challenges that must be addressed to ensure its responsible and ethical deployment. One of the primary challenges is ensuring the safety and reliability of AI-driven robots, particularly in safety-critical domains such as healthcare and transportation. Robots must be designed to operate safely in dynamic and unpredictable environments, minimizing the risk of accidents or injuries to humans. Ethical considerations are another significant challenge in AI-driven HRI, particularly concerning privacy, autonomy, and accountability. As robots become increasingly integrated into society, questions arise about the ethical implications of their use, including issues related to data privacy, consent, and the potential for bias or discrimination in decision-making (Wullenkord and Eyssel 2020).

Building trust between humans and robots is essential for successful HRI, but it can be challenging due to factors such as uncertainty, unpredictability, and cultural differences. Humans may be hesitant to trust AI-driven robots, particularly in critical situations where human lives are at stake (Tudorie, 2023). Addressing trust-related challenges requires designing robots that are transparent, reliable, and capable of explaining their actions and decisions to humans.

Despite the challenges, the future of AI-driven HRI holds immense promise for enhancing human-robot interactions in various domains. Advances in AI technologies, coupled with ongoing research and innovation, are expected to further improve the capabilities and effectiveness of robots in interacting with humans (Vrontis *et al*., 2022). From collaborative robots that work alongside humans in shared workspaces to socially assistive robots that provide support and companionship to individuals in need, AI-driven HRI has the potential to transform the way we live, work, and interact with technology. Interdisciplinary collaborations between researchers, engineers, designers, ethicists, policymakers, and other stakeholders will play a crucial role in shaping the future of AI-driven HRI. By addressing technical challenges, ethical considerations, and societal implications, we can unlock the full potential of AI-driven robots to enhance human well-being, productivity, and quality of life.

In conclusion, the history of advances and challenges in AI and HRI reflects the ongoing quest to create intelligent machines capable of interacting with humans in meaningful and socially acceptable ways. While significant progress has been made, numerous challenges remain, underscoring the need for continued research, innovation, and responsible deployment of AI-driven HRI systems (Alzubaidi *et al*., 2023). By leveraging emerging technologies and collaborative efforts, we can create a future where humans and robots coexist harmoniously, enriching our lives and advancing society as a whole.

3. Historical Context of HRI and AI Integration

The evolution of human-robot interaction (HRI) has been closely intertwined with advancements in robotics and artificial intelligence (AI). This historical context provides insights into the journey from early attempts at integrating AI into robot-human interactions to the current state of AI-driven HRI, highlighting key milestones, challenges, and opportunities along the way (Huang *et al*., 2021). The evolution of robotics can be traced back to ancient civilizations, where rudimentary automata and mechanical devices were developed for various purposes. However, significant advancements in robotics began in the 20th century with the emergence of modern computing and engineering technologies.

In the mid-20th century, pioneers such as George Devol and Joseph Engelberger developed the first industrial robots capable of performing repetitive tasks in manufacturing settings. These early robots were programmed using simple instructions and operated in controlled environments, laying the foundation for the field of robotics. The field of AI emerged in the 1950s with the goal of creating machines capable of exhibiting human-like intelligence (Natale and Ballatore, 2020.). Early AI research focused on symbolic reasoning, logic-based systems, and expert systems. However, progress was limited by the computational power and data availability of the time.

Early attempts at integrating AI into robot-human interactions were characterized by limited capabilities and functionality. Researchers explored various approaches to enable robots to perceive, understand, and respond to human cues and commands (Setchi *et al*., 2020; Mukherjee *et al*., 2022). In the 1960s and 1970s, researchers developed rule-based systems that relied on predefined rules and heuristics to guide robot behavior. These systems lacked flexibility and adaptability, as they could not learn or evolve over time. In the 1980s and 1990s, behavior-based robotics emerged as an alternative approach to AI-driven HRI. Instead of relying on explicit rules, behavior-based systems employed simple reactive behaviors that could be combined and coordinated to achieve complex tasks. While more robust and adaptable than rule-based systems, behavior-based approaches had limitations in handling uncertainty and ambiguity. The current state of AI-driven HRI is the result of significant advancements in robotics, AI, and human-computer interaction over the past few decades (Zhu *et al*., 2023). Several key milestones have contributed to the development of AI-driven HRI and shaped its evolution.

The advent of machine learning algorithms, particularly deep learning, has revolutionized AI-driven HRI by enabling robots to learn from data and improve their performance over time. Deep learning algorithms have been applied to various HRI tasks, including speech recognition, gesture recognition, and emotion detection, leading to more natural and intuitive interactions between humans and robots (Spezialetti *et al*., 2020). The development of social robots, designed to interact with humans in social and emotional ways, has expanded the scope of AI-driven HRI beyond traditional industrial settings. Social robots, such as Pepper and Jibo, are equipped with sensors, actuators, and AI algorithms that enable them to perceive human emotions, engage in natural language dialogue, and adapt their behavior based on social cues. These robots are used in various applications, including healthcare, education, and entertainment, to provide companionship, support, and assistance to humans (Ragno *et al*., 2023).

The integration of AI and cloud computing technologies has facilitated the development of intelligent robotic systems that can access vast amounts of data, compute-intensive algorithms, and computational resources in real-time. Cloud-based AI services, such as natural language processing, image recognition, and predictive analytics, enable robots to perform complex tasks, such as language translation, visual perception, and decision-making, with high accuracy and efficiency (Andronie *et al*., 2022). This integration has enabled new applications and capabilities in AI-driven HRI, such as remote monitoring, autonomous navigation, and collaborative problem-solving.

In conclusion, the historical context of HRI and AI integration provides valuable insights into the evolution of robotics, AI, and human-computer interaction. From early attempts at integrating AI into robot-human interactions to the current state of AI-driven HRI, significant advancements have been made, leading to more sophisticated and capable robotic systems. By understanding the milestones, challenges, and opportunities in AI-driven HRI, researchers and practitioners can continue to push the boundaries of technology and create innovative solutions that enhance human-robot interactions across diverse domains.

4. Recent Advances in AI-Enhanced Human-Robot Interaction

In recent years, significant advancements in artificial intelligence (AI) have revolutionized human-robot interaction (HRI), leading to more natural, intuitive, and adaptive interactions between humans and robots. This review examines recent advances in AI-enhanced HRI across various domains, including machine learning applications, natural language processing (NLP), computer vision technologies, reinforcement learning, and socially assistive robots. Machine learning (ML) algorithms have played a central role in enhancing HRI by enabling robots to personalize interactions and adapt their behavior based on user preferences and feedback. ML algorithms are used to analyze user data, such as past interactions, preferences, and behaviors, to personalize robot interactions. For example, robots can use reinforcement learning to adapt their behavior based on user feedback, ensuring that interactions are tailored to individual preferences and needs (Fabian *et al*., 2023). ML algorithms enable robots to learn and adapt their behavior over time through continuous interaction with users. For instance, robots can use supervised learning techniques to learn from human demonstrations and improve their performance in tasks such as object manipulation or navigation.

NLP technologies have advanced significantly, enabling robots to understand and respond to natural language commands and conversations more effectively. Recent advancements in voice recognition technology have improved the accuracy and reliability of speech recognition in HRI. Robots can now understand a wider range of accents, languages, and speech patterns, allowing for more seamless communication with users (Uchechukwu *et al*., 2023). NLP algorithms enable robots to understand the context of a conversation and generate appropriate responses accordingly. For example, robots can use context-aware language models to interpret ambiguous or incomplete commands and generate responses that are relevant to the current context of the interaction.

Computer vision technologies have advanced significantly, enabling robots to perceive and understand visual information more accurately and efficiently. Advances in object detection, recognition, and tracking algorithms have improved robots' ability to perceive and interact with objects in their environment. Robots can now recognize and manipulate objects with greater accuracy and precision, enabling them to perform complex tasks such as assembly or manipulation. Computer vision algorithms enable robots to recognize human gestures and expressions, allowing for more intuitive and natural interactions (Hassan *et al*., 2024). Robots can use gesture recognition and emotion analysis to infer user intentions and emotions, adapting their behavior accordingly to enhance the quality of the interaction.

Reinforcement learning techniques enable robots to learn from experience and optimize their behavior in real-time based on feedback from users and the environment. Robots can use reinforcement learning to adapt their behavior in real-time based on feedback from users and the environment. For example, robots can learn to navigate crowded environments or avoid obstacles by receiving rewards or penalties based on their actions. Reinforcement learning algorithms enable robots to learn from human feedback and improve their interactions over time (Balogun *et al*., 2024).

For instance, robots can use reinforcement learning to learn user preferences and adapt their behavior accordingly, leading to more personalized and satisfying interactions.

Socially assistive robots are designed to provide emotional support, companionship, and assistance to users, particularly in healthcare and other industries (Akindote *et al*., 2023). Socially assistive robots are equipped with AI algorithms that enable them to recognize and respond to human emotions. These robots can provide emotional support and companionship to users, helping to reduce loneliness and improve overall well-being. Socially assistive robots have a wide range of applications in healthcare, education, and other industries (Akindote *et al*., 2024). For example, robots can assist therapists in delivering therapy sessions to patients, provide companionship to elderly individuals in nursing homes, or help children with autism improve their social skills.

In conclusion, recent advances in AI-enhanced HRI have transformed the way humans and robots interact, enabling more natural, intuitive, and adaptive interactions across various domains. From machine learning applications to natural language processing, computer vision technologies, reinforcement learning, and socially assistive robots, these advancements have opened up new possibilities for improving the quality of human-robot interactions and unlocking the full potential of AI in HRI (Singh *et al*., 2021). However, challenges such as ethical considerations, safety concerns, and user acceptance remain, highlighting the need for further research and innovation in this exciting and rapidly evolving field.

5. Challenges in AI-Driven Human-Robot Interaction

As artificial intelligence (AI) continues to advance, the field of human-robot interaction (HRI) faces several challenges that must be addressed to ensure the responsible and ethical deployment of AI-driven systems (Pflanzer *et al*., 2023). This review explores key challenges in AI-driven HRI, including ethical considerations, safety and security challenges, building human-robot trust, and bias and fairness issues. Ethical considerations are paramount in AI-driven HRI, as these systems have the potential to impact human behavior and privacy in significant ways.

AI-driven systems often collect and analyze vast amounts of data from users to personalize interactions and improve performance. However, this raises concerns about privacy and data security, as users may be unaware of how their data is being used or shared. It is essential to establish clear guidelines and regulations for data collection, storage, and usage in AI-driven HRI to protect user privacy rights. AI algorithms have the power to influence human behavior through personalized recommendations and interventions (Sardianos *et al*., 2021). However, there is a risk of using AI in ways that may manipulate or exploit users' vulnerabilities. It is crucial to adopt ethical guidelines and principles for the responsible design and deployment of AI-driven systems to ensure they uphold human values and rights.

Ensuring the safety and security of AI-driven HRI systems is critical to prevent potential harm to humans and protect against malicious use of AI technologies. AI-driven robots interact closely with humans in various contexts, including healthcare, education, and entertainment. It is essential to design robust security mechanisms to prevent unauthorized access to robot systems and protect sensitive information shared during interactions. AI technologies can be exploited for malicious purposes, such as impersonation, fraud, or cyber-attacks. As AI-driven HRI systems become more prevalent, there is a need to develop safeguards and countermeasures to detect and mitigate potential threats, ensuring the safety and security of both humans and robots (Segate and Daly, 2023).

Building trust between humans and robots is essential for successful HRI, as trust influences user acceptance, engagement, and cooperation with AI-driven systems (Zhu *et al*., 2023). Transparency is crucial for building trust in AI-driven systems. Users should have visibility into how AI algorithms make decisions and recommendations to understand their rationale and limitations. Providing explanations and justifications for AI-driven actions can enhance user trust and confidence in HRI. Establishing trust in HRI requires proactive efforts to address user concerns and perceptions about AI-driven systems. Strategies such as clear communication, user education, and demonstration of reliability and competence can help build trust over time, fostering positive interactions and collaborations between humans and robots.

Bias and fairness issues in AI algorithms pose significant challenges to achieving equitable and non-discriminatory outcomes in HRI. (Babarinde *et al*., 2023) AI algorithms can inadvertently reflect biases present in training data, leading to discriminatory outcomes in HRI. It is essential to develop methods to identify and mitigate biases in AI models to ensure fairness and equality in human-robot interactions. AI-driven HRI systems must comply with anti-discrimination laws and ethical standards to prevent discriminatory practices and promote fairness and inclusivity. This requires ongoing monitoring and evaluation of AI algorithms to ensure they adhere to legal and ethical guidelines, promoting equal treatment and opportunities for all individuals.

In conclusion, addressing the challenges in AI-driven human-robot interaction requires a multi-faceted approach that encompasses ethical considerations, safety and security measures, trust-building strategies, and efforts to mitigate bias and promote fairness. By proactively addressing these challenges, researchers, developers, and policymakers can foster the responsible and ethical deployment of AI-driven HRI systems, ensuring they benefit society while minimizing potential risks and harms (Okoro *et al*., 2024).

6. Future Trends and Outlook

As artificial intelligence (AI) technologies continue to advance, the field of human-robot interaction (HRI) is poised for significant growth and innovation. This review explores future trends and outlooks in AI-driven HRI, highlighting emerging trends, collaborative interdisciplinary efforts to address challenges, and the importance of regulatory frameworks for responsible AI use in HRI. The future of AI-driven HRI is characterized by several emerging trends that have the potential to shape the way humans and robots interact in diverse domains. Future HRI systems will leverage advanced machine learning algorithms to personalize interactions and adapt robot behavior based on individual user preferences, behaviors, and contexts. This will enable robots to provide more tailored and effective assistance, support, and companionship to users across various applications, including healthcare, education, and entertainment (Ayo-Farai *et al*., 2023).

Future HRI systems will incorporate multi-modal interaction capabilities, allowing users to interact with robots using a combination of speech, gestures, facial expressions, and touch. This multi-modal approach will enable more natural and intuitive interactions between humans and robots, enhancing communication, engagement, and collaboration in diverse contexts (Ogundairo *et al*., 2023). Collaborative robotics, or cobots, will play an increasingly prominent role in future HRI systems, enabling humans and robots to work together seamlessly to achieve common goals. Cobots will be designed to complement human capabilities, assist with tasks that require physical strength, precision, or endurance, and adapt their behavior based on human feedback and preferences.

Future HRI systems will feature socially intelligent robots equipped with advanced AI algorithms that enable them to understand and respond to human emotions, intentions, and social cues. These robots will possess emotional intelligence, empathy, and social skills, enabling them to interact with humans in socially appropriate and emotionally sensitive ways (Orieno *et al*., 2024). Autonomous robots capable of proactive decision-making and autonomous behavior will become increasingly prevalent in future HRI systems. These robots will be able to anticipate user needs, preferences, and intentions, take initiative to assist with tasks, and adapt their behavior dynamically to changing environments and contexts.

Addressing the challenges in AI-driven HRI requires collaborative interdisciplinary efforts involving researchers, engineers, designers, psychologists, ethicists, policymakers, and other stakeholders. Collaborative research initiatives involving academia, industry, and government agencies will drive innovation in AI-driven HRI, enabling the development of more advanced and robust robotic systems (Stasevych and Zvarych, 2023). Interdisciplinary collaborations will facilitate knowledge sharing, technology transfer, and the integration of diverse expertise to address complex challenges and opportunities in HRI. Design thinking and user-centered approaches will be essential for creating AI-driven HRI systems that are intuitive, user-friendly, and socially acceptable. Interdisciplinary teams will work together to understand user needs, preferences, and behaviors, incorporating human-centered design principles into the development process to ensure that robots are designed with users in mind (Lindblom *et al*., 2020).

Collaborative efforts involving ethicists, social scientists, and policymakers will be essential for addressing the ethical and societal implications of AI-driven HRI (Boch *et al*., 2023). These efforts will focus on developing ethical guidelines, regulatory frameworks, and policy recommendations to ensure that AI-driven HRI systems are deployed responsibly, ethically, and in a manner that respects human rights and values. Regulatory frameworks and guidelines play a crucial role in ensuring the responsible and ethical use of AI in HRI, protecting user rights, safety, and well-being (Mantelero and Esposito, 2021). International organizations, professional associations, and industry consortia will develop ethical guidelines and principles for the responsible design, development, and deployment of AI-driven HRI systems. These guidelines will address issues such as privacy, transparency, accountability, fairness, and bias, providing guidance for researchers, developers, and policymakers to navigate ethical challenges in HRI (de Pagter, 2023).

Regulatory agencies and standards organizations will establish safety and security standards for AI-driven HRI systems to ensure that robots operate safely and securely in various environments and applications (Aditya *et al*., 2023). These standards will cover aspects such as robot design, performance, reliability, cybersecurity, and risk management, promoting the safe and responsible use of AI in HRI.mGovernments and regulatory bodies will enact laws, regulations, and policies to govern the use of AI in HRI and protect the rights and interests of users. These frameworks will address

issues such as liability, accountability, data protection, and human rights, establishing clear legal and ethical guidelines for the development and deployment of AI-driven HRI systems (Chang and Ke, 2023).

In conclusion, the future of AI-driven HRI holds great promise for enhancing human-robot interactions across diverse domains. By embracing emerging trends, fostering collaborative interdisciplinary efforts, and establishing regulatory frameworks for responsible AI use, we can unlock the full potential of AI-driven HRI to improve human well-being, productivity, and quality of life (Mouta *et al*., 2023; Licardo *et al*., 2024). However, addressing the challenges and ethical considerations associated with AI-driven HRI will require concerted efforts from stakeholders across academia, industry, government, and civil society to ensure that AI technologies are developed and deployed in a manner that benefits society while minimizing potential risks and harms.

7. Conclusion

The review of recent advances and challenges in AI and Human-Robot Interaction (HRI) underscores the transformative potential and pressing considerations within this rapidly evolving field. From personalized interactions driven by machine learning algorithms to the integration of natural language processing, computer vision, and reinforcement learning techniques, AI-driven HRI has made significant strides in enabling more intuitive, adaptive, and socially intelligent interactions between humans and robots. However, alongside these advancements come critical challenges that must be addressed to ensure the responsible and ethical deployment of AI in HRI.

Recent advances in AI-driven HRI have demonstrated the potential to revolutionize various domains, including healthcare, education, manufacturing, and service industries. The ability of robots to personalize interactions, understand natural language commands, interpret visual information, and learn from human feedback opens up new opportunities for enhancing productivity, efficiency, and user experience. Moreover, socially assistive robots equipped with emotional intelligence have the potential to provide companionship, support, and assistance to individuals in need, particularly in healthcare settings.

Despite the promise of AI-driven HRI, several challenges persist, ranging from ethical considerations and privacy concerns to safety and security issues, trust-building, and bias mitigation. Addressing these challenges requires collaborative interdisciplinary efforts involving researchers, engineers, designers, ethicists, policymakers, and other stakeholders. Ethical guidelines, regulatory frameworks, and standards play a crucial role in ensuring that AI-driven HRI systems are developed and deployed responsibly, respecting human rights, values, and dignity.

Looking ahead, the future of HRI with AI holds immense potential for enhancing human-robot interactions in diverse contexts. Advances in AI technologies, coupled with ongoing research and innovation, are expected to further improve the capabilities and effectiveness of robots in interacting with humans. However, it is essential to continue prioritizing research, responsible development, and ethical considerations in AI-HRI to address challenges, mitigate risks, and maximize the benefits of AI-driven interactions.

In conclusion, AI-driven HRI represents a promising frontier in robotics and AI research, with significant implications for various sectors and societal domains. By embracing recent advances, addressing challenges, and upholding ethical principles, we can pave the way for a future where humans and robots collaborate seamlessly, enriching our lives and shaping a more inclusive, equitable, and technologically advanced society.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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