Human-Robot Collaboration in Healthcare

Ishwari Jigajinni
23707865

Aswathy Unnikrishnan
23727733

Yadu Krishna
23673551

Mohammed Anas
23677645

Abstract

A revolutionary change in patient care, efficiency, and personnel shortages is represented by the introduction of robots into the healthcare industry. This study analyses the problems and solutions that are now being faced by academics and business as it looks at the cooperative roles that humans and robots can play in medical settings. The advantages and drawbacks of cutting-edge technologies are explored, including robotic surgery aids, telepresence robots, and automated medication dispensers. It is suggested that these systems be optimised in the future for better results. Reflections on the development of human-robot collaboration in healthcare and its potential to completely transform the sector are included in the report's conclusion.

1. Introduction

New paradigms of efficiency, accuracy, and support in medical practices have been brought about using robotics in healthcare. Healthcare professionals are finding that robots are an invaluable ally, helping with everything from surgical support to patient care and logistics. This human-robot partnership seeks to enhance the capacities of healthcare professionals, improve patient outcomes, and tackle pressing issues, including a lack of workers and escalating healthcare expenses. The numerous applications of robots in healthcare are examined in this paper, together with the state-of-the-art approaches, obstacles, and potential future paths in this exciting area.

2. The Challenges of Human-Robot Collaboration in Healthcare

Despite the intriguing possibilities, there are several obstacles facing both academia and industry when it comes to incorporating robots into healthcare:

i. Technical Limitations

The dexterity, sensory perception, and flexibility of current robotic systems are frequently limited, which reduces their effectiveness in complex and unpredictable contexts. For instance, care robots might not yet be able to fully understand and respond

to subtle patient demands, and surgical robots might have trouble providing the tactile input required for some delicate procedures. (Nejat, Wong and Mihailidis, 2015)

ii. **Cost**

For smaller healthcare facilities or those in low-resource areas, the high initial investment and maintenance costs associated with robotic systems may be prohibitive. This financial barrier prevents widespread adoption and could be a factor in the discrepancies in access to and quality of healthcare. (L. Ragno, A. Borboni et al., 2023)

iii. **Interoperability**

One major obstacle that has to be overcome is ensuring smooth communication and operation between robotic systems and current medical devices and IT infrastructure. It can be difficult to integrate many technologies into a coherent system without standardised protocols and interfaces, which could result in mistakes and inefficiencies. (Weerarathna et al., 2023)

iv. **Ethical and Regulatory Concerns**

Carefully managing ethical concerns, including patient privacy and consent, as well as navigating the regulatory environment, are important hurdles. Accountability is a concern when using robots for patient care, particularly when there are malfunctions or unfavourable outcomes. (M. Kyrarini, F. Lygerakis et al., 2021)

v. **Training and acceptance**

To collaborate with robots efficiently, healthcare personnel need to undergo specialised training. Staff members who mistrust robotic systems or fear losing their jobs may also oppose it. Successful integration requires overcoming this reluctance and making sure that adequate training programmes are in place. (Broadbent, Stafford and MacDonald, 2009)

3. State-of-the-Art Solutions and Their Pros and Cons

Health care robots are currently developing and have produced a number of cutting-edge technologies.

i. **Assistants in robotic surgery:**

- Pros: enhanced surgeon skills, shorter recovery periods, minimally invasive operations, and high precision. Surgeons can perform more precise surgeries thanks to robots like the Da Vinci Surgical System, which improve dexterity and visualisation. With their unmatched accuracy and stability, these devices can decrease surgical errors and enhance patient outcomes. (Nejat, Wong and Mihailidis, 2015)

- Cons: cons include expensive prices, a challenging learning curve, and the possibility of technological issues. Surgeons need substantial training due to the complexity of these devices, which also demand significant investment and continual maintenance. The dependence on technology also increases the possibility of hardware malfunctions or software bugs, which could have disastrous consequences during crucial operations. (Nejat, Wong and Mihailidis, 2015)

ii. **Telepresence Robots:**

- Pros: Benefits include less patient travel, improved access to remote care, and the capacity to provide specialised treatment in disadvantaged areas. Patients who live in isolated or rural areas now have better access to care because of telepresence robots, which allow healthcare providers to conduct virtual consultations. Through the use of technology, professionals can now reach patients who might not otherwise have access to high-quality care due to geographic barriers. (Janika Leoste et al., 2024)

- Cons: limited in-person engagement, possible security flaws, and reliance on strong internet connectivity. Inadequate internet connectivity can limit the efficacy of telepresence robots and worries about cybersecurity and data privacy exist. Additionally, the inability to physically be present could make it more difficult to conduct some tests or interventions, which could have an impact on the standard of care. (Janika Leoste et al., 2024)

iii. **Robotic Medicine Dispensers:**

- Pros: Better medicine distribution accuracy, fewer human errors, and more efficient pharmacy operations. Medication errors are decreased when accurate dosage and prompt administration of pharmaceuticals are guaranteed by

automated devices such as PillPack. These technologies reduce the possibility of erroneous dosing, which can enhance patient safety and adherence to treatment plans. (Weerarathna et al., 2023)

- Cons: High start-up expenses, possible technological problems, and ongoing maintenance and monitoring requirements. Infrastructure investment is necessary for these systems, and human intervention may be necessary in the event of problems. Furthermore, since inconsistencies in the administration of medication might have serious repercussions, it is imperative to guarantee the security of these systems to prevent manipulation or errors. (Sivaraman et al., 2019)

iv. **Exoskeletons for Rehabilitation**

- Pros: increased treatment results, individualised rehabilitation programmes, and increased patient mobility and independence. Exoskeletons can help patients with limited movement by supporting them and making rehabilitation exercises easier. With the help of these gadgets, people with spinal cord injuries or other movement issues can engage in activities that they might not otherwise be able to, thus enhancing their quality of life.

- Cons: Exorbitant expenses, restricted capacity to customise treatment plans for specific patients, and possible pain with extended use. Exoskeleton availability and suitability for all patients may be limited by their cost and design, and continuous use may result in weariness or discomfort. Furthermore, optimising these devices' comfort and efficacy requires that they be customised to each patient's specific requirements and physical attributes.

4. Future Works to Improve the Solutions

Several topics need to be addressed in order to improve human-robot collaboration in the healthcare industry:

i. **Advanced AI Integration:**

Creating more complex AI algorithms to enhance robot flexibility and decision-making in dynamic healthcare settings. This might entail using machine learning techniques to improve the comprehension and response of robots in intricate medical situations. (Fasola and Matarić, 2013)

ii. **Cost Reduction**

To lower the cost of robotic solutions, research and apply economical materials and manufacturing techniques. Robotic systems can be more affordable thanks to advances in materials science and economies of scale, which will enable a wider range of healthcare facilities to use them. (M. Kyrarini, F. Lygerakis et al., 2021)

iii. **Interoperability Standards**

To guarantee the smooth integration of robotic systems with current medical technologies, uniform standards for interoperability must be established. Creating standardised interfaces and communication protocols is one way to make it easier to integrate various robotic and medical devices. (Weerarathna et al., 2023)

iv. **Ethical Frameworks**

Creating thorough moral standards and legal frameworks to handle consent, privacy, and the wider social effects of medical robots. This entails collaborating with stakeholders to develop strong and inclusive regulatory frameworks, including patients, healthcare providers, and legislators. (M.Kyrarini, F.Lygerakis et al., 2021)

v. **Improved Training Initiatives**

Establishing comprehensive training initiatives for medical professionals in order to promote the uptake and efficient application of robotic technology. This involves creating training courses and certification schemes to guarantee healthcare personnel are competent in managing and repairing robotic devices. (Broadbent, Stafford and MacDonald, 2009)

vi. **User-Centric Design**

This approach aims to improve patient and healthcare worker comfort, usability, and acceptance by concentrating on the ergonomic and psychological aspects of human-robot interaction. This entails creating robotic systems that are user-friendly and intuitive while also taking end users' requirements and concerns into consideration. (Nejat, Wong and Mihailidis, 2015)

5. Conclusion

Robotics integration in healthcare offers a ground-breaking chance to improve the standard, effectiveness, and accessibility of medical care. Notwithstanding these obstacles, continued

technological developments and industry-academia cooperation are opening the door to more efficient and smoother human-robot interactions. Robots have the potential to revolutionise healthcare by focusing on future advancements and tackling current limits. This might lead to a more accurate, accessible, and efficient medical care system in the future.

6. Self-Reflection of the RSS Unit

- Member 1: Thinking back on the developments in healthcare robotics has been insightful, emphasising the need to strike a balance between creativity and morality.

- Member 2: The investigation into the collaboration between humans and robots in healthcare highlighted the significance of interdisciplinary approaches in resolving complicated issues.

- Member 3: The topic of this research focused on the necessity of ongoing technological advancement and adaptability to fulfil changing healthcare demands.

- Member 4: This report has reaffirmed how robots have the ability to revolutionise healthcare and how crucial it is to take preventative measures to overcome obstacles.

7. References

- L. Ragno, A. Borboni, F. Vannetti, C. Amici, and N. Cusano, "Application of Social Robots in Healthcare: Review on Characteristics, Requirements, Technical Solutions," 2023, pp. 1-40.

- Fasola, J. and Matarić, M. J., 2013. A socially assistive robot exercise coach for the elderly. *Journal of Human-Robot Interaction*, 2(2), pp.3-32.

- Janika Leoste, Kadri Strömberg-Järvis, Tarmo Robal, Kristel Marmor, Katrin Kangur, and Anne-Mari Rebanec. "Testing scenarios for using telepresence robots in healthcare settings" 2024 , pp 105-114

- Nejat, G., Wong, C. and Mihailidis, A., 2015. The roles of socially assistive robots in healthcare: A systematic review. *Journal of Human-Robot Interaction*, 4(1), pp.1-25.

- Weerarathna, Induni & Raymond, David & Luharia, Anurag. (2023). "Human-Robot Collaboration for Healthcare: A Narrative Review". pp. 1-11.

- M. Kyrarini, F. Lygerakis, A. Rajavenkatanarayanan, C. Sevastopoulos, H. R. Nambiappan, K. K. Chaitanya, A. R. Babu, J. Mathew, and F. Makedon, "A survey of robots in healthcare," 2021, pp. 1-26.

- Broadbent, E., Stafford, R. and MacDonald, B., 2009. Acceptance of healthcare robots for the older population: Review and future directions. *International Journal of Social Robotics*, 1(4), pp.319-330.