Metaverse Basic and Applied Research. 2022; 1:22
doi: 10.56294/mr202222

ORIGINAL

Human-Computer Interaction in Robotics: A bibliometric evaluation using Web of Science

Interacción Humano-Ordenador en el área de la Robótica: Una evaluación bibliométrica utilizando Web of Science

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Cite as: Chandran R. Human-Computer Interaction in Robotics: A bibliometric evaluation using Web of Science. Metaverse Basic and Applied Research. 2022; 1:22. https://doi.org/10.56294/mr202222

Submitted: 14-10-2023 **Revised:** 06-11-2022 **Accepted:** 20-12-2022 **Published:** 27-12-2022

Editor: Dra. Patricia Alonso Galbán

ABSTRACT

Introduction: the field of Human-Computer Interaction (HCI) is fundamental for the development of robotics, as it enables effective communication between humans and robots. HCI is essential for creating robots that can be used in a variety of environments, from industry to home. Robots designed with good HCI can be more efficient and safer at work, which can increase productivity and reduce errors and accidents.
Aim: to perform a bibliometric evaluation using Web of Science on Human-Computer Interaction in the Robotics field.
Methods: a bibliometric study was conducted on Human-Computer Interaction in the field of Robotics using the Web of Science database. A total of 592 documents were recovered.
Results: the number of published documents increased gradually from 2 in 1999 to a peak of 79 in 2019, but decreased in 2020 to 30 and in 2021 to 41. The number of received citations also increased over time, with a peak of 547 in 2015, and has decreased in subsequent years. China tops the list with 159 documents and 544 citations, but has a relatively low average citations per document (Cpd) of 3,42 and a total link strength of 8. In comparison, the United States has a much lower number of documents (71), but a much higher number of citations (1941) and a much higher Cpd of 27,34. During the analysis of the terms present in the articles, it can be observed that the term “Human-Computer Interaction” is the most commonly used, with a frequency of 124, indicating that it remains the most frequently used term to describe the discipline.
Conclusions: the findings of this study suggest that Human-Computer Interaction in the field of robotics is an active and constantly evolving research area, with a focus on enhancing usability and user experience through various research techniques and theoretical approaches. These results may be useful for researchers and professionals interested in this field, as they provide valuable insights into recent trends and developments in the scientific literature.

Keywords: Human-Computer Interaction; Human-Robot Interaction Robotics; Natural interfaces; Bibliometrics; Web of Science.

RESUMEN

Introducción: el campo de la Interacción Humano-Computadora (IHC) es fundamental para el desarrollo de la robótica, ya que permite una comunicación efectiva entre humanos y robots. La IHC es esencial para crear robots que puedan utilizarse en una variedad de entornos, desde la industria hasta el hogar. Los robots diseñados con buena IHC pueden ser más eficientes y seguros en el trabajo, lo que puede aumentar la productividad y reducir errores y accidentes.
Objetivo: realizar una evaluación bibliométrica utilizando Web of Science sobre Interacción Humano-Computadora en el campo de la Robótica.

Métodos: se realizó un estudio bibliométrico sobre la Interacción Humano-Computadora en el campo de la Robótica utilizando la base de datos Web of Science. Se recuperaron un total de 592 documentos.
Resultados: el número de documentos publicados aumentó gradualmente de 2 en 1999 a un pico de 79 en 2019, pero disminuyó en 2020 a 30 y en 2021 a 41. El número de citas recibidas también aumentó con el tiempo, con un pico de 547 en 2015, y ha disminuido en años posteriores. China encabeza la lista con 159 documentos y 544 citas, pero tiene un promedio de citas por documento (Cpd) relativamente bajo de 3,42 y una fuerza de enlace total de 8. En comparación, Estados Unidos tiene un número mucho menor de documentos (71), pero un número mucho mayor de citas (1941) y un Cpd mucho más alto de 27,34. Durante el análisis de los términos presentes en los artículos, se puede observar que el término "Interacción Humano-Computadora" es el más utilizado, con una frecuencia de 124, lo que indica que sigue siendo el término más utilizado para describir la disciplina.
Conclusiones: los hallazgos de este estudio sugieren que la Interacción Humano-Computadora en el campo de la robótica es un área de investigación activa y en constante evolución, con un enfoque en mejorar la usabilidad y la experiencia del usuario a través de diversas técnicas de investigación y enfoques teóricos. Estos resultados pueden ser útiles para investigadores y profesionales interesados en este campo, ya que proporcionan información valiosa sobre las tendencias y desarrollos recientes en la literatura científica.

Palabras clave: Interacción Humano-Computadora; Interacción Humano-Robot; Robótica; Interfaces Naturales; Bibliometría; Web of Science.

INTRODUCTION

The field of Human-Computer Interaction (HCI) is fundamental for the development of robotics, as it enables effective communication between humans and robots.[1,2,3] HCI focuses on how people interact with technology and how technology can be designed to be more user-friendly and understandable. In the context of robotics, HCI focuses on how humans interact with robots and how robots can be designed to be more intuitive and accessible to users.[4,5]

HCI is essential for creating robots that can be used in a variety of environments, from industry to home. Robots designed with good HCI can be more efficient and safer at work, which can increase productivity and reduce errors and accidents. In addition, robots designed to be intuitive and easy to use can be more accessible to non-technical users, which can broaden the adoption of robotics in different fields.[6,7,8,9,10]

This article aims to perform a bibliometric evaluation using Web of Science on Human-Computer Interaction in the Robotics field.

METHOD

Study type: a bibliometric study was conducted on Human-Computer Interaction in the field of Robotics using the Web of Science database.

Search strategy: a search was conducted on the Web of Science database using the search strategy: TS="Human-Computer Interaction" in the "Robotics" category.

Analysis techniques: the R software was used for data analysis and processing, and Vosviewer was used to perform qualitative, thematic, institutional, country and co-citation analyses of the collected documents.

RESULTS

Graph 1 shows the number of documents (Ndoc) published each year, as well as the number of citations received (Ncit) by those documents. The number of published documents increased gradually from 2 in 1999 to a peak of 79 in 2019, but decreased in 2020 to 30 and in 2021 to 41. The number of received citations also increased over time, with a peak of 547 in 2015, and has decreased in subsequent years. This suggests a steady increase in the amount of research in the area of Human-Computer Interaction in Robotics, with fluctuations in the number of documents and citations received in recent years.

Figure 1 shows the co-authorship network of the articles included in the study, highlighting the fact that the most frequent author on the list is Zhang Y, who has been included in 6 articles. Several authors appear in 5 articles, including Weng DD, Dautenhahn K, Li J, and Ju ZJ. In addition, there is a group of authors who appear in 4 articles, including Zhang XD, Sun Y, Zhang L, Yanco HA, Liu Y, Billinghurst M, and Wang SX.
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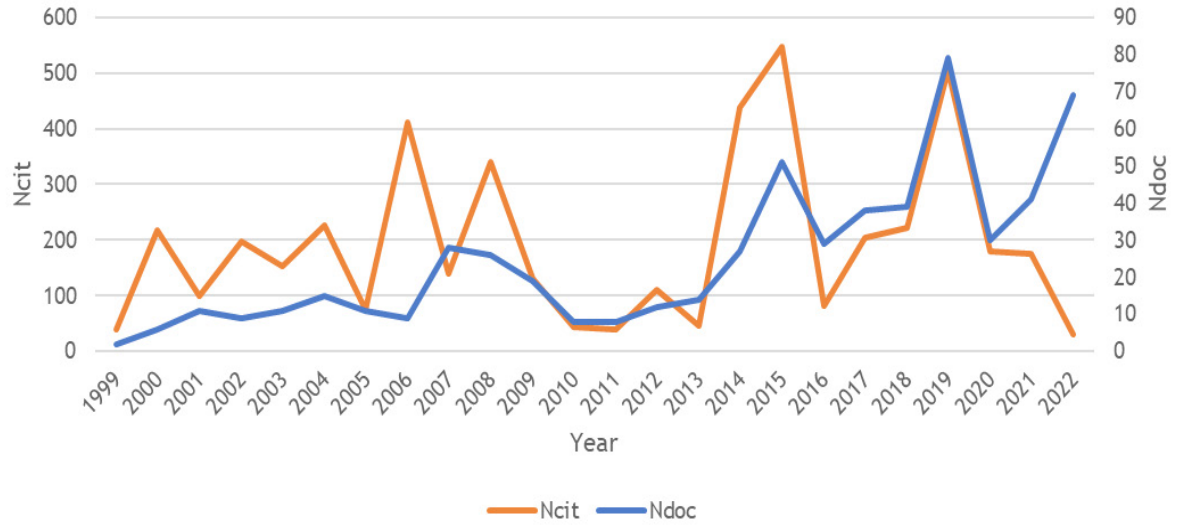
Figure 2 shows the co-citation network of the references of the analyzed documents, and Figure 3 show collaboration networks between institutions.



Graph 1. Number of documents and citations received per year

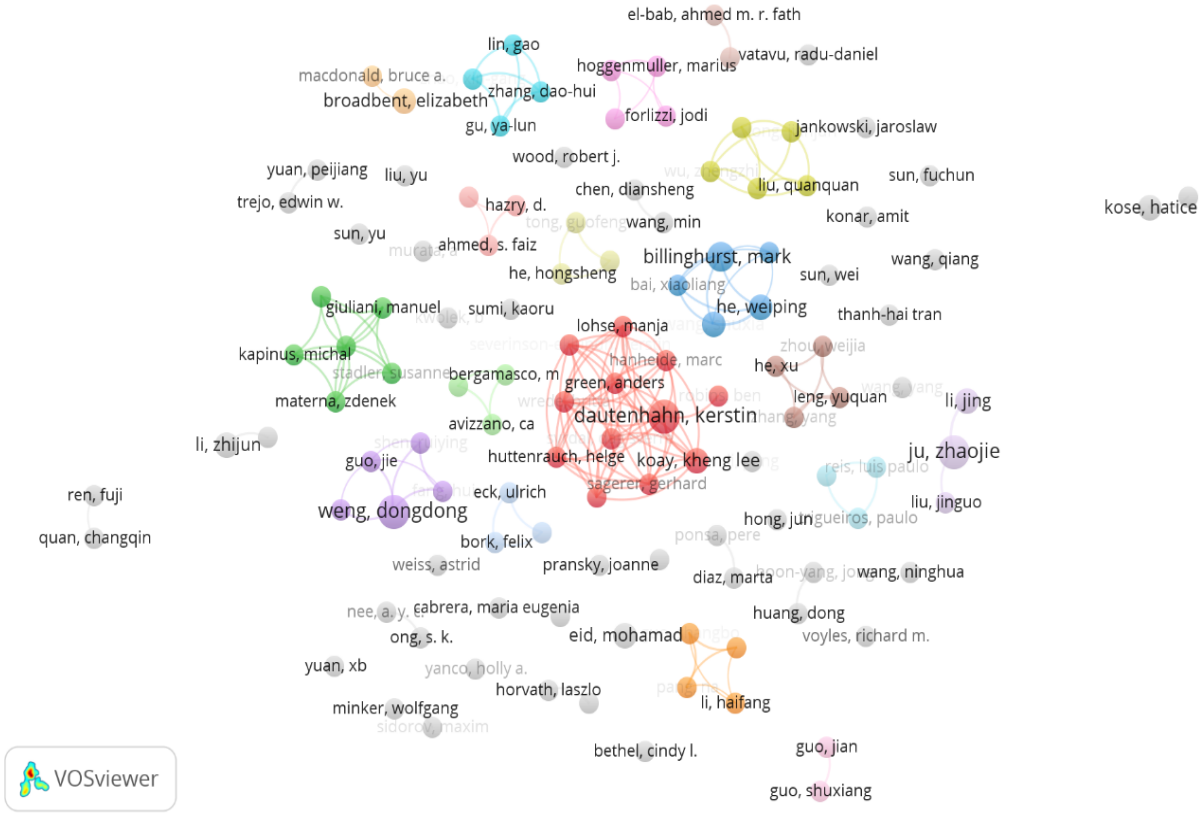


Figure 1. Co-authorship network

The analysis of Table 1 shows that China tops the list with 159 documents and 544 citations, but has a relatively low average citations per document (Cpd) of 3,42 and a total link strength of 8. In comparison, the United States has a much lower number of documents (71), but a much higher number of citations (1941) and a much higher Cpd of 27,34. However, their total link strength is only 6. Japan and Germany have a similar number of documents and citations, but their Cpd and total link strength are both 0. The UK has a moderate number of documents and citations, a high Cpd of 14,11, but a total link strength of only 3.

During the analysis of the terms present in the articles (Figure 5), it can be observed that the term “Human-Computer Interaction” is the most commonly used, with a frequency of 124, indicating that it remains the most frequently used term to describe the discipline. Additionally, it can be noted that the term “Human interaction” is the second most used term, with a frequency of 58, suggesting that there is some variability in how this term is used.

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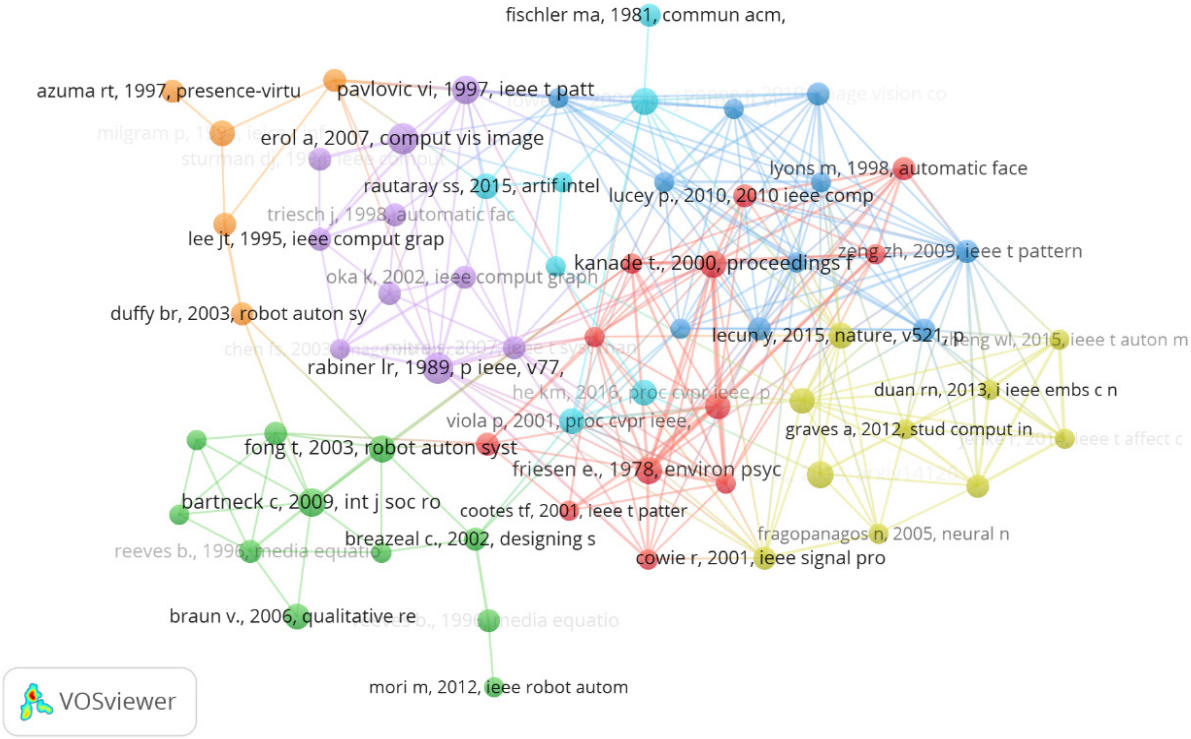

Figure 2. Cocitation network

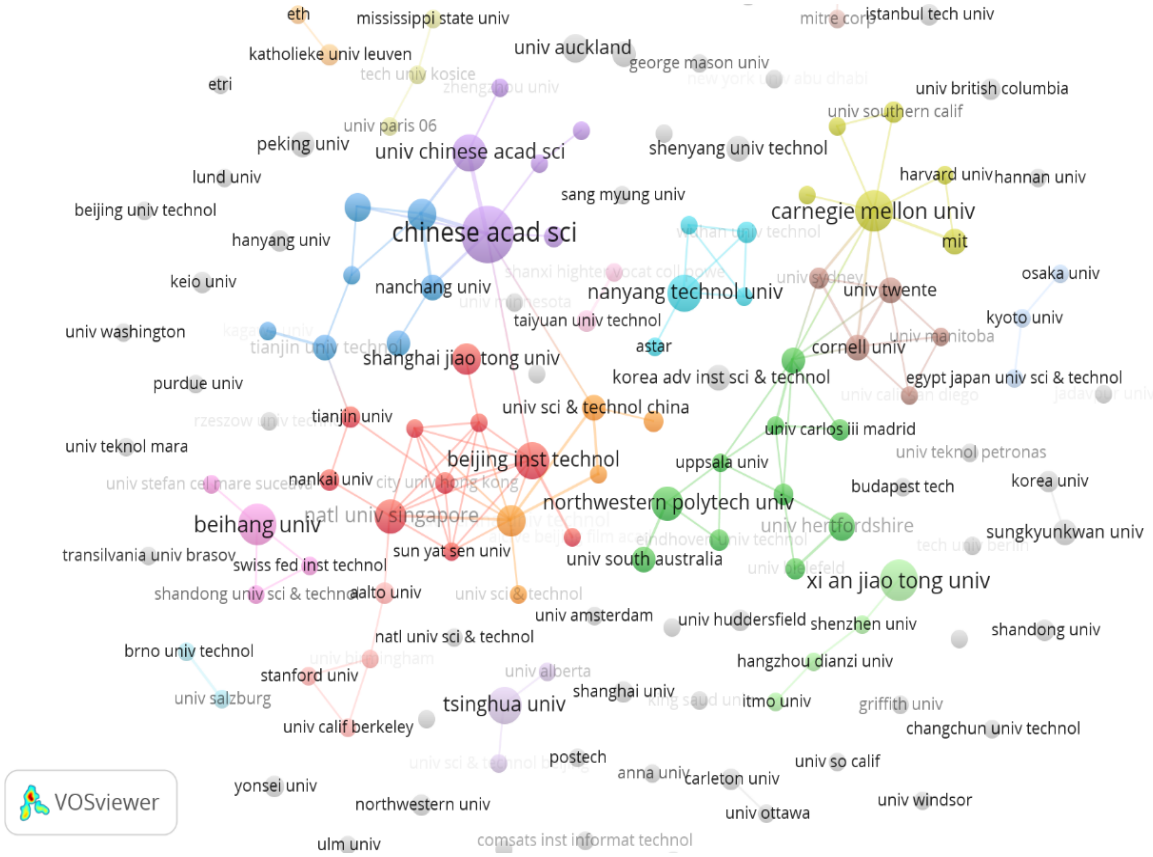

Figure 3. Collaboration networks between institutions

Other terms (Figure 5), such as “Human-centered computing” and “human-robot interaction,” are the third and fourth most used terms, respectively, indicating a growing interest in human-robot interaction. Moreover, it can be observed that “Virtual reality” is the fifth most used term, suggesting that it remains an area of interest

https://doi.org/10.56294/mr202222

in HCI. Other notable terms in the table include “Computer vision” and “augmented reality,” indicating an interest in applying computer vision in human-computer interaction, as well as in augmented reality. Terms such as “Gesture recognition,” “machine learning,” “artificial intelligence,” “robotics,” “mixed/augmented reality,” “deep learning,” “hand gesture recognition,” and “convolutional neural network” are also relevant and frequently used in research in HCI and related disciplines.

Table 1. Bibliometric indicators by country

Country	Ndoc	Ncit	Cpd	Total link strength
China	159	544	3,42	8
USA	71	1941	27,34	6
Japan	43	188	4,37	0
Germany	34	241	7,09	0
United Kingdom	28	395	14,11	3
South Korea	28	169	6,04	0
Canada	20	130	6,50	0
Netherlands	17	172	10,12	2
Singapore	15	242	16,13	2
Australia	14	94	6,71	4
India	14	37	2,64	2
Spain	14	65	4,64	0
Italy	13	134	10,31	2
Malaysia	10	70	7,00	0
Sweden	10	105	10,50	0

Graph 4 shows the collaboration networks between countries, where a central role of China is observed.

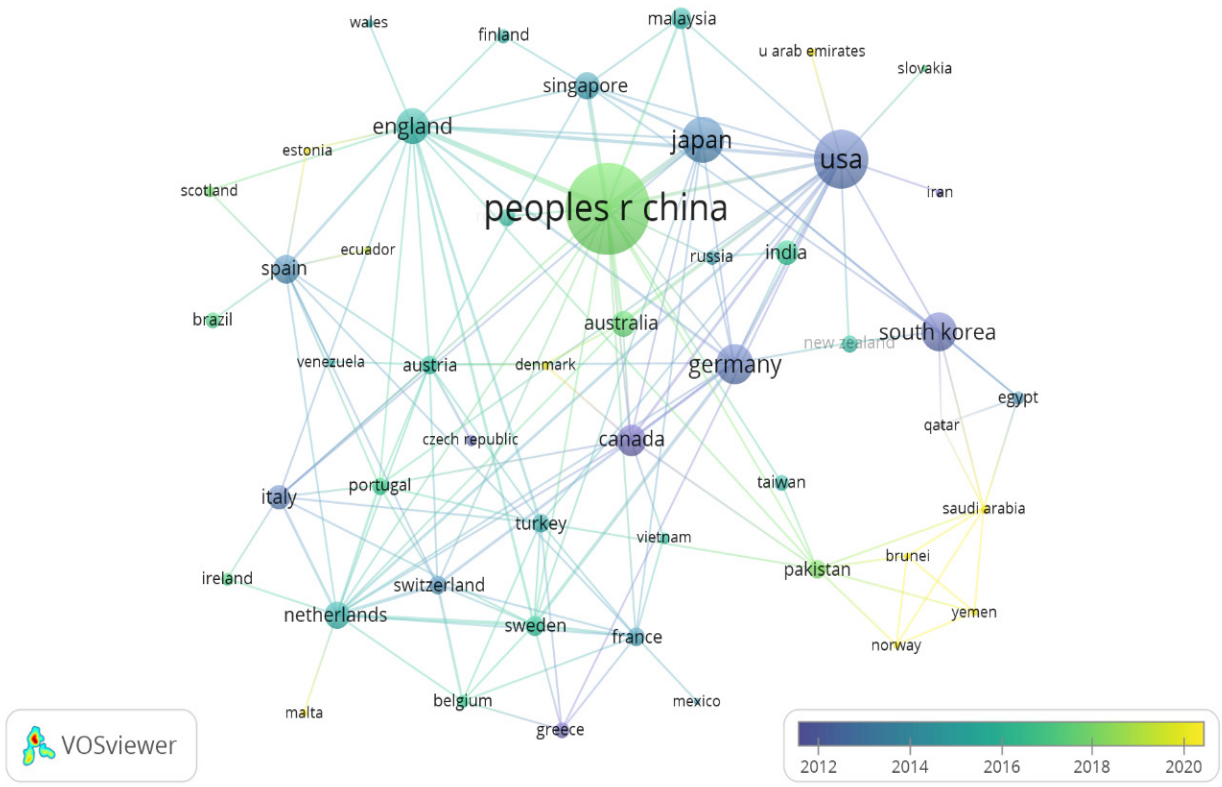

Figure 4. Overlay Visualization

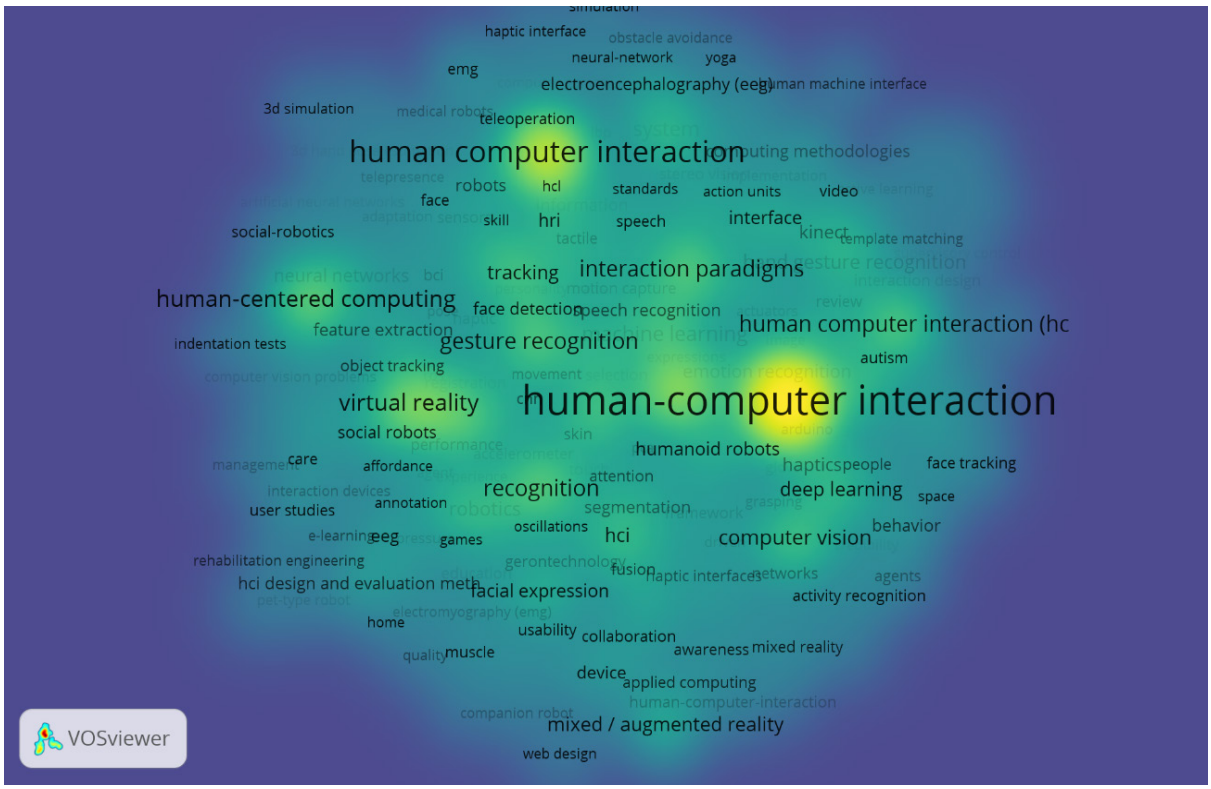

Figure 5. Density Visualization

The term cooccurrence matrices are shown in Figure 6.

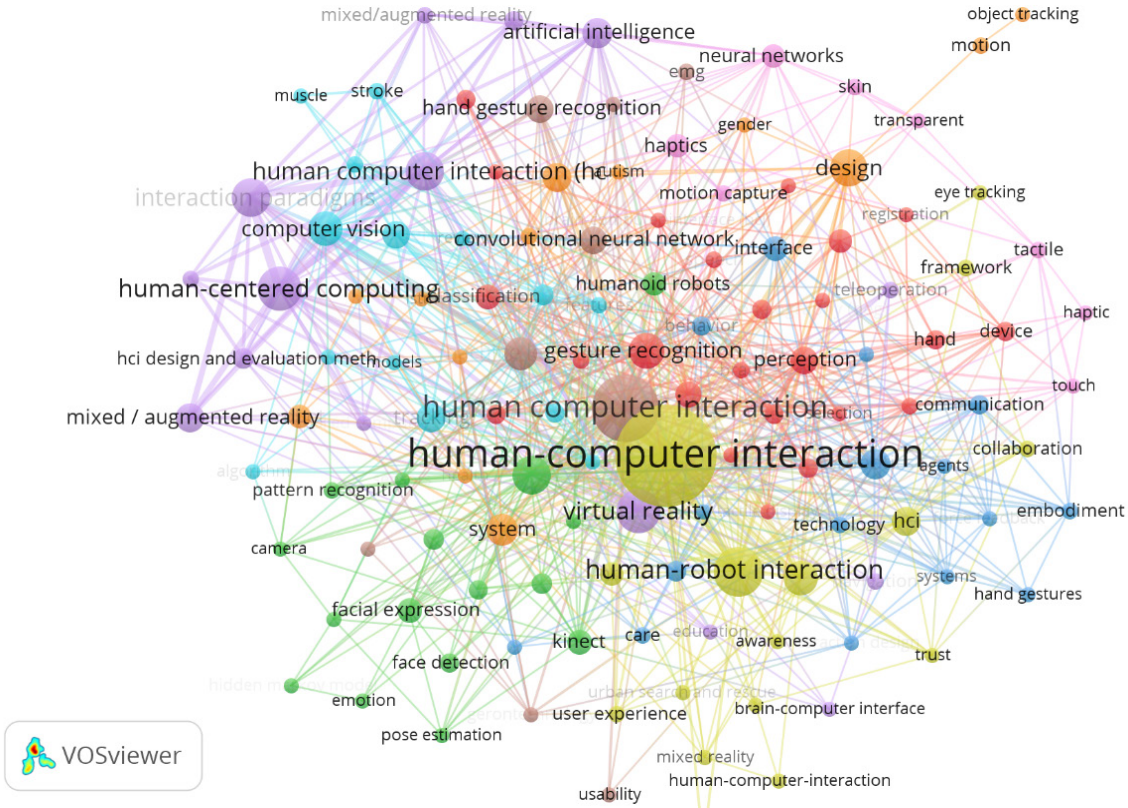

Figure 6. Co-occurrence term matrices.

DISCUSSION

The results of this study show that human-computer interaction (HCI) has evolved significantly in recent

decades, allowing users to interact with technology in a more intuitive and natural way. Robotics is a field that has greatly benefited from advances in HCI, as more intuitive and efficient user interfaces have made programming and controlling robots much more accessible for users with varying skill levels.[11,12,13,14]

One of the most promising applications of HCI in robotics is teleoperation. With teleoperation, users can control a robot through a user interface that allows them to see and control the robot in real-time, as if they were physically present. This can be particularly useful in situations where human access is limited or dangerous, such as exploring remote locations or handling toxic or hazardous substances. Moreover, teleoperation can also enable users to control multiple robots simultaneously, which may be useful in production and manufacturing environments.[15,16,17,18]

Another field that emerged from the qualitative analysis was the design of intuitive user interfaces for autonomous robots. Autonomous robots can perform complex tasks on their own, but they need intuitive user interfaces for humans to interact with them effectively. Researchers are working on designing user interfaces that allow users to communicate with autonomous robots more naturally, using gestures and voice, which can make using autonomous robots more accessible to a broader range of users.[19,20,21,22,23]

HCI can also enhance the interaction between robots and humans in collaborative environments. Robots can work alongside humans in manufacturing and production tasks, and HCI can help robots better understand human movements and intentions.[24] For example, robots can learn to recognize human gestures and facial expressions, allowing them to adjust their behavior accordingly and work more effectively with their human counterparts.

Another potential area of application with significant potential is the user experience with service robots. Service robots, such as cleaning robots and personal assistance robots, can be used by people of all ages and abilities, and HCI can make their use more accessible and easy to understand. Researchers are working on designing user interfaces that allow users to interact with service robots more intuitively and provide useful and relevant information about the tasks the robots are performing.[25,26,27]

A study published Stowers et al.[28] found that human-robot interaction is crucial for the acceptance and effective use of robots in various settings, such as healthcare and education. The researchers found that users perceived robots more positively when the robots demonstrated socially acceptable behavior and were easy to use and interact with.

Issa et al.[29] found that robots designed with good HCI can significantly improve work efficiency and safety. Researchers discovered that workers experienced less stress and fatigue when working with robots that had a good user interface and were easy to control.

In the field of education, HCI has also been shown to be important for effective collaboration between robots and students. A study published by Ahn & Clegg found that robots designed with good HCI and communication skills significantly improved student learning and motivation to learn.[30]

Study limitations:

A significant limitation of the study is that only the Web of Science database was used for selecting articles to analyze. Although this database is widely used in the scientific community, it does not include all relevant scientific journals and may have omitted studies not indexed in the database. Therefore, the results may not be representative of the entire body of research in this field.

On the other hand, it is important to note that the analysis focused on the most common terms in the selected articles, which may not have captured all important topics and the relationships between them.

CONCLUSIONS

The findings of this study suggest that Human-Computer Interaction in the field of robotics is an active and constantly evolving research area, with a focus on enhancing usability and user experience through various research techniques and theoretical approaches. These results may be useful for researchers and professionals interested in this field, as they provide valuable insights into recent trends and developments in the scientific literature.

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FUNDING

No financing.

CONFLICTS OF INTEREST

None.

AUTHOR CONTRIBUTIONS

Conceptualization: Barnali Gupta.
Investigation: Barnali Gupta.
Methodology: Barnali Gupta.
Writing - original draft: Barnali Gupta.
Writing - review and editing: Barnali Gupta.