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Human–Computer Interaction (2000–2026): Scopus-Based Bibliometric Mapping of Core Topics and Methodological Trends

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ABSTRACT

In this paper, bibliometric methods have been applied to analyze the development and knowledge structures of Human–Computer Interaction (HCI) from 2000 to 2026. The Scopus database was used for data acquisition and VOSviewer software was employed for visualizing research collaboration patterns, identifying prominent papers, and examining keyword trends in HCI research. Co-authorship, citation, and keywords co-occurrences were applied for analyzing the development of HCI. Results indicated that over time, the main focus of HCI research changed from usability and user interface issues to more advanced topics like integration of artificial intelligence technologies, deep learning, and domain-specific applications such as health-care sciences. Regarding collaboration among researchers in HCI, results depicted strong clusters of research inside this field with some connections to the outside world. Furthermore, the main reason for the high number of citations was the use of methodological tools that could be applied in all other fields and were considered generalizable. Overall, the findings of this study indicated the increasing trend towards developing an intelligent and adaptive HCI system based on machine learning.

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1. INTRODUCTION

With the development of time, the study of how people interact with technology and how technology should be developed in a way that meets human requirements has emerged as an interdisciplinary topic known as Human-Computer Interaction (HCI). Being an interdisciplinary area, HCI lies between computer science, behavioral sciences, and design and tries to improve usability and user experience with regard to various systems. The last few decades have seen rapid growth in technology due to which interaction has become very complex because of developments like ubiquitous computing, artificial intelligence, etc [1], [2].

Since the beginning of the twenty-first century, there has been a notable growth in HCI research. The earlier era of HCI was focused on GUIs and Internet-based computing, while the new era introduced several paradigms of HCI including mobile computing, social computing, and immersion. Empirical findings reveal that the publication of HCI literature grew considerably from 2001. This is an indication that there is increasing interest among academics and

practitioners in this field of study. This growth has been informed by digital transformation where computing technologies have been incorporated into our daily lives [3], [4].

The rising intricacy in HCI has also spurred a greater variety in topics and methodologies. Modern HCI research addresses issues related to human-AI interaction, virtual/augmented reality, affective computing, and collaboration platforms. Current bibliometric research suggests that new trends in HCI are progressively more aligned with intelligent, adaptive, and human-centric systems. This trend is a result of the impact that Industry 4.0 and digital ecosystems have had on HCI research. In terms of methodology, there has been a move away from purely quantitative methods toward a combination of different methodologies, including qualitative analysis and big data analytics [5]–[7].

The use of bibliometric tools has proved to be an effective technique in understanding the growth of research in the field of HCI. The sheer volume of publications and the nature of interdisciplinarity make traditional literature review inadequate when applied in such scenarios. With bibliometrics, researchers can be able to examine databases, such as Scopus, containing quality peer-reviewed scientific articles, to discover patterns, trends, and other key issues. Tools like keyword co-occurrence analysis, network visualization, and thematic clustering can all be used for this purpose.

Furthermore, the fast adoption of AI in HCI has created new avenues for researchers to explore. AI-based interfaces, intelligent assistants, and adaptive systems have transformed the way users engage with technology, changing the emphasis from usability to collaboration and adaptation between human beings and technology. New research on the subject indicates that while there is a rising interest in AI-assisted HCI, mapping studies that outline the entire research domain have been scarce. This calls for an updated study of the literature that includes not only established themes in HCI but also innovative methods employed, especially in the period between 2000 and 2026.

While Human–Computer Interaction research has grown tremendously, expanded in scope, and diversified in its approaches, there is still a scarcity of bibliometric mapping that could holistically identify the main themes and methods within the field in the long term, especially from 2000 to 2026. Current literature tends to concentrate on particular subfields like health informatics or human-computer interaction with artificial intelligence or use restricted data samples, thus failing to provide a full picture of HCI's scientific knowledge base and development. This means that current researchers may find it hard to grasp the most common topics, new areas of investigation, and methodological approaches that are typical for HCI as a whole. Therefore, a Scopus-based bibliometric mapping of HCI will be needed to address these gaps.

The purpose of this study is to perform a bibliometric mapping of research articles related to Human Computer Interaction that have been published from 2000 until 2026 according to the Scopus database. In particular, the goals of this study include (1) assessing the development and pattern of HCI publication output over time, (2) defining key research themes and clustering based on keywords and co-citation analysis, and (3) tracing methodological developments that have contributed to the evolution of the field under study.

2. METHODS

In this study, a quantitative bibliometric approach will be employed to investigate the evolution of HCI research between 2000 and 2026. Bibliometrics is commonly used for the evaluation of scientific literature through quantitative and computational methods and allows detecting patterns and relations among vast amounts of data. The data set used in this paper has been extracted from the Scopus database, a popular source featuring peer-reviewed journals, conferences and symposia, and other scholarly publications covering multiple areas

of expertise. A systematic search query has been formulated using the appropriate keywords including "human-computer interaction" and "HCI". The inclusion criteria for the data collection stage were narrowed down to English language publications from the period between 2000 and 2026 and included only articles, conference papers, and reviews.

After data gathering, the obtained literature records were exported and analyzed. Important bibliographic details like authors, titles, abstracts, keywords, publication dates, and references were obtained. This research uses bibliometric methods such as publication trend analysis, keyword co-occurrence analysis, co-citation analysis, and collaborative network analysis to investigate the intellectual structure of HCI studies. Visual and network analyses are performed through VOSviewer that are used in creating scientific knowledge maps. Through visual and network analyses, it is possible to identify important themes, influential publications, and linkages among research themes, both existing and emerging.

In order to make sure the outcomes of this study would be valid and reliable, a systematic process of data processing was used. Prior to the analysis stage, data cleansing was done through the deletion of duplicate entries, standardization of author names and keywords. Some threshold criteria have been employed (for example, minimum amount of citation or keyword occurrences) in order to narrow down the data set to the most essential papers. Both quantitative measures (the number of publications, amount of citations) and qualitative insights (cluster analysis and trend evolution) were employed in order to interpret the results.

3. RESULTS AND DISCUSSION

3.1 Co-Authorship Analysis

The co-authorship study has been carried out to investigate the pattern of collaboration among the researchers in the area of Human Computer Interaction. Through the analysis of co-authorship, the main contributors, the network of collaboration, and the level of collaboration between institutions and nations have been identified.

1. Author-level Visualization

This co-authorship network graph visualization displays the collaboration amongst scholars from the domain of Human-Computer Interaction, with the basis being taken from the publications indexed within Scopus database. This visualization of co-authorship network graph uses VOSviewer, whereby different authors are visualized as nodes whereas the edges signify their collaboration amongst each other.

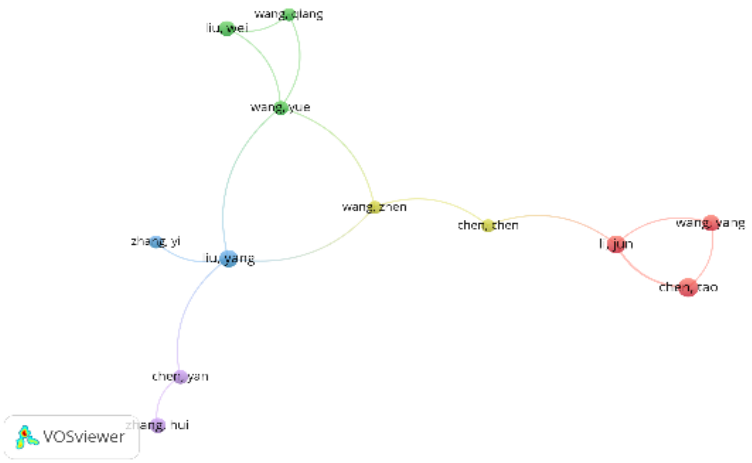

Figure 1. Author-level Visualization

Source: Data Analysis

The graph depicts various clusters of collaborations with the use of various colors, demonstrating the presence of relatively independent research teams in the field of HCI. For example, the red cluster denotes a well-connected set of researchers that often collaborate with one another, indicating a well-established research team. The same case applies to the green cluster, which consists of well-connected researchers. This indicates the fact that research in the field of HCI is fairly divided into separate communities working in different areas.

Aside from the clustering groups, there are also some bridging authors in this network visualization who link different clustering groups, hence helping to facilitate knowledge integration through the network. Some authors located between clusters serve as the bridges, which link some different research groups together. This shows that interdisciplinary cooperation occurs in the area of research. However, based on the few links between clusters, it can be seen that interdisciplinary cooperation among the different groups is quite limited.

2. Institution-level Visualization

Co-authorship network in institutional level represents the collaboration amongst institutions that participate in the research area of Human-Computer Interaction. With VOSviewer tool, a network map can be generated for institutions' collaboration based on the research output of those institutions, which reflects both the intensity and structure of the collaboration relationship. Each dot is an institution, and each line represents co-authorship between two institutions.

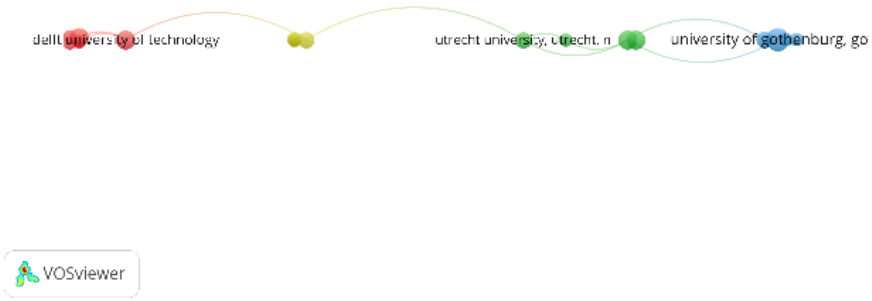

Figure 2. Institution-level Visualization

Source: Data Analysis

From the figure, the collaboration pattern can be described as linear with very little interaction between organizations, implying that there are a few organizations which interact within the network. The diagram depicts some organizations such as Delft University of Technology, Utrecht University, and University of Gothenburg as playing an important role in the collaboration network. Collaboration within the diagram is through intermediary links implying that collaboration is selective rather than wide spread in nature. There exist small clusters implying that collaboration is carried out selectively by organizations within a narrow network.

In addition, the visualization also shows how some intermediate nodes function as intermediaries bridging institutions that otherwise remain separated into their own clusters. Such linking nodes ensure communication and collaboration among diverse academic groups, but the network density is relatively low. This implies that

even though there exist certain collaborative relationships between some institutions, the HCI research domain is quite segmented from an institutional perspective. In other words, there exists room for growth in terms of collaborations involving different institutions, which can help contribute positively towards knowledge sharing and greater advances in the area of HCI.

3. Country-level Visualization

Visualization of the co-authorship network at the country level shows how international collaboration is taking place in the domain of Human-Computer Interaction through Scopus-indexed publications. The above map, using VOS viewer software, shows how various countries connect through their collaborative research work. Countries are shown as nodes while linkages show co-authorship. Size of nodes shows the number of publications while different colors denote collaborative groups.

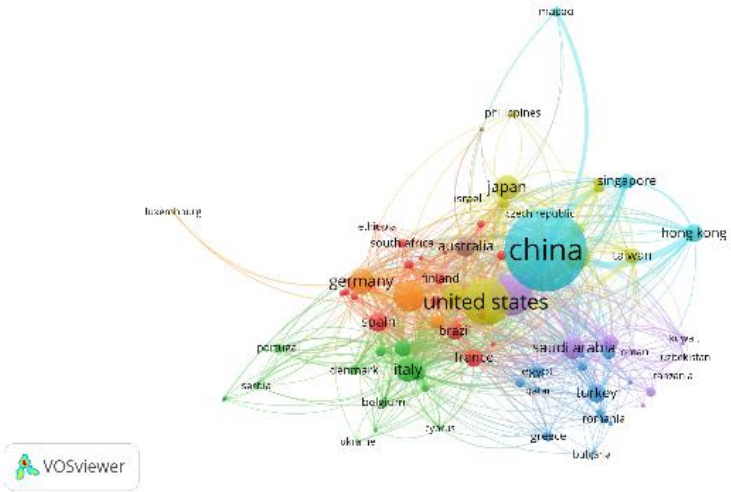

Figure 3. Country-level Visualization
Source: Data Analysis

This illustration shows that there are some countries that function as the major connecting points in the global network for research on HCI, especially China and the US as the largest and most connected nodes. This is because these countries have collaborated with many other countries and hence are key influencers in the research activities taking place internationally. Moreover, there are other countries like Germany, UK, and Japan that are highly connected in the network, showing that they are involved in international research collaboration. The existence of clusters in the network indicates that research in HCI is internationally distributed but still interconnected.

In addition, the presence of high levels of cooperation between various nations within the network is observable due to several cross-linkages established between nations of different continents, namely Asia, Europe, and North America. For instance, Singapore, Hong Kong, and South Korea emerge as crucial nodes of connectivity that link bigger research centers. However, the position of small nations as peripheral nodes demonstrates their low level of cooperation.

3.3 Citation Analysis

Citation analysis is employed to assess the academic impact and influence of publications within Human–Computer Interaction research.

Table 1. The Most Impactful Literatures

Citations	Authors and year	Title
40277	[8]	Cytoscape: A software Environment for integrated models of biomolecular interaction networks
13291	[9]	Model-based analysis of ChIP-Seq (MACS)
12997	[10]	Haploview: Analysis and visualization of LD and haplotype maps
11988	[11]	The blockade of immune checkpoints in cancer immunotherapy
10814	[12]	Metascape provides a biologist-oriented resource for the analysis of systems-level datasets
7915	[13]	GEPIA: A web server for cancer and normal gene expression profiling and interactive analyses
7085	[14]	From game design elements to gamefulness: Defining gamification
6853	[15]	DrugBank 5.0: A major update to the DrugBank database for 2018
6231	[16]	The Perseus computational platform for comprehensive analysis of (prote)omics data
6003	[17]	The STRING database in 2021: Customizable protein-protein networks, and functional characterization of user-uploaded gene/measurement sets

Source: Scopus, 2026

As shown in Table 1, the literatures which are frequently cited are mostly about methodologies and tools rather than theoretical concepts. The most significant contribution to the scientific community are made by essential tools and platforms such as Cytoscape (Shannon et al., 2003), MACS (Zhang et al., 2008), and Haploview (Barrett et al., 2005). It is evident that there would be no big leaps in bioinformatics without tools for processing and analyzing large amounts of data. Moreover, important databases like Metascape, GEPIA, DrugBank, Perseus, and STRING contribute significantly to current research. Finally, the fact that Pardoll (2012) on cancer immunotherapy and Deterding et al. (2011) on gamification appear among the most cited works proves that a breakthrough idea may make an impact on the scientific community despite not being directly related to bioinformatics.

3.4 Keyword Co-Occurrence Analysis

The analysis of keyword co-occurrence serves as a means for examining the major research areas and the developing topics within the domain of Human-Computer Interaction. Through the process of keyword co-occurrence analysis, there can be gained insights into the thematic clusters and conceptual associations within the relevant literature.

1. Network Visualization

This keyword co-occurrence network map shows the conceptual framework of research conducted in the area of Human-Computer Interaction (HCI), using papers indexed in the database Scopus. This map can be generated with the help of the software package VOSviewer, whereby the connections between the most frequent keywords will be established and classified into clusters of research topics. In this map, each node represents a keyword, whereas links represent co-occurrences of the same keyword.

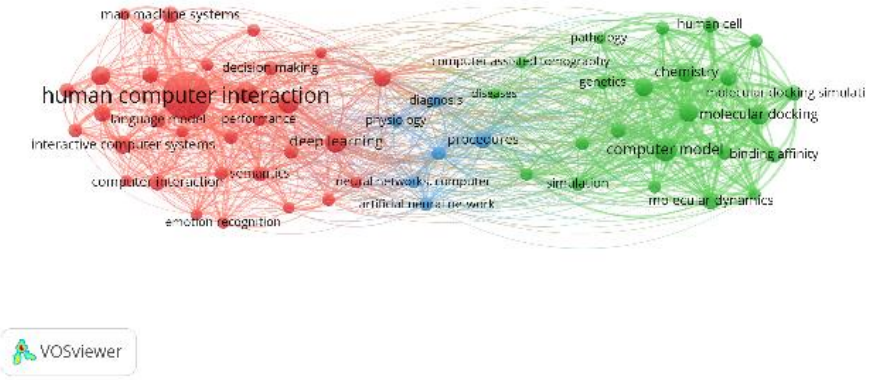

Figure 4. Network Visualization
Source: Data Analysis

From the above figure, one can see that "human-computer interaction" plays a role of a key and predominant keyword in the research paper because it is placed at the core of the map and forms connections with many other clusters of themes. As for the red cluster found on the left side of the map, it is related to conventional HCI themes like interactive computer systems, UI design, emotions, and cognition. Therefore, this cluster demonstrates a rather mature stream of research since it was based on conventional aspects of HCI investigation.

As we move closer to the middle and the right side of the network map, there is a visible progression toward the adoption of more technically advanced topics. Terms such as deep learning, artificial neural networks, and computer-aided diagnosis are some of the examples of bridging terms connecting classic HCI research with new developments in computing technologies. This implies that there is a rising tendency towards incorporating artificial intelligence in HCI, which makes the systems increasingly adaptive and intelligent.

The green cluster on the extreme right-hand side refers to a different yet linked discipline, characterized by the use of biomedical and molecular approaches, where terms like molecular docking, molecular dynamics, and drug design are commonly used. The existence of this cluster implies the expansion of the HCI-related topics into disciplines like bioinformatics and computational biology, which seem remote from the usual HCI-related concepts but nonetheless feature in the visualization network.

2. Density Visualization

In addition to revealing the most studied concepts in the field of HCI, the density graph of keyword co-occurrence shows a quick insight into the subjects that have received most attention in recent times. The map generated using VOSviewer uses colors to demonstrate the concentration of the frequently used and interconnected keywords, where areas with higher frequency are more brightly colored than others.

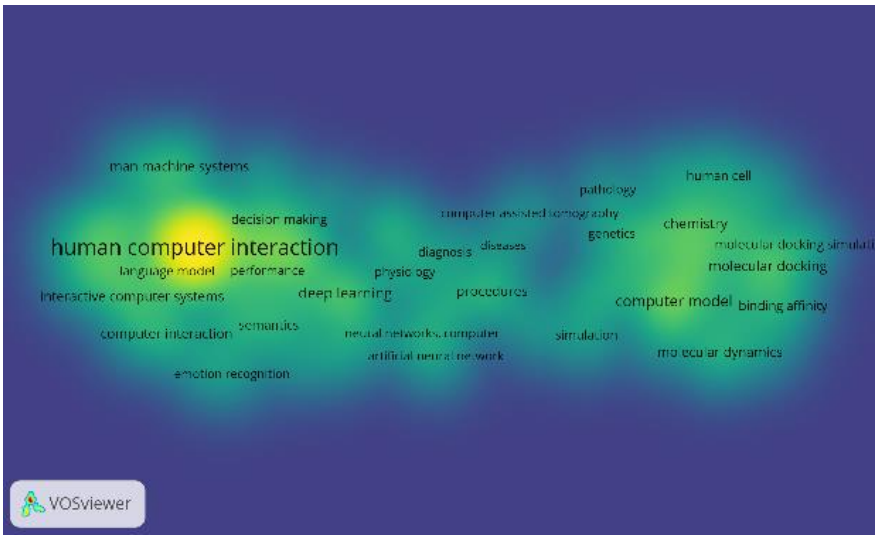

Figure 5. Density Visualization

Source: Data Analysis

From the above chart, it is very clear that human-computer interaction is located at the most prominent and densely-packed section, which signifies that human-computer interaction serves as the core of the subject under research. The surrounding words associated with the central theme include interactive computer systems, computer interaction semantics, emotion recognition, and language models, representing a dense cluster of the traditional subjects of HCI. It is obvious from the density and prominence of the section that user-oriented design, interaction, and evaluation still continue to be prominent themes in this area.

Apart from the main cluster, there are several clusters with a moderate degree of density that signify the directions in which new researches have been conducted by combining different disciplines in order to make them more effective. Words like deep learning, artificial neural networks, and computer-aided diagnosis demonstrate how artificial intelligence is being applied to studies in HCI. Moving towards the right side of the diagram, there is a cluster related to biomedical and computational sciences. The topics include molecular docking, molecular dynamics, and computer simulation.

Discussion

The results of this bibliometric study clearly reveal that HCI research has experienced considerable development and evolution from 2000 to 2026, not only in terms of themes but also in its collaborative approach. The gradual rise in publications along with the formation of different clusters of research clearly indicates that HCI is a fully-fledged discipline, one that is highly multidisciplinary in nature. Starting off as a branch of studies focused on usability and interfaces, the domain has gradually transformed itself to be based on computational methodologies in alignment with the digital revolution being witnessed worldwide.

As seen from the co-authorship analysis, collaboration in the field of HCI research has a characteristic feature, namely intensive collaboration in the inner clusters, yet limited integration between clusters. Collaboration on the level of authors and institutions can be seen to occur primarily within research groups, which suggests the existence of specialist communities dedicated to their own unique subfield. Yet, it is important to note that the appearance of bridging nodes proves that some individuals and institutions play an important role in bridging gaps between fragmented groups. On the level of countries, the domination of China and the USA demonstrates inequalities in global participation in research activity.

Citation Analysis reveals that some of the highest cited works included in the

dataset are mostly those relating to methods or tools. The high citations of publications including software, analytical tools, and datasets reveal that one way to achieve impact in the study of HCI includes the creation of useful and accessible content to users. Moreover, another way to attain influence is through conceptual papers that make innovative contributions to theory, such as gamification. Therefore, this result shows that not only technology but also concepts are crucial factors in driving scholarly impact in HCI.

The analysis of the keyword occurrences and densities gives further information about the knowledge structure and evolution of studies in the area of human-computer interaction. First, the importance of traditional research directions such as user interaction, system design, and usability shows that there is a continued interest in basic principles of HCI. Second, an increase in the number of keywords related to the field of artificial intelligence demonstrates the tendency to develop intelligent and adaptive interaction systems. Third, the emergence of interdisciplinary clusters, which relate to the use of HCI approaches in other branches of science, shows the possibility of expanding the application area of the studied theories.

The contribution of this study to existing studies lies in the fact that it provides an elaborate map of conceptual and methodological pathways followed in HCI studies. From the findings, it can be suggested that the emphasis of future research efforts needs to shift towards ensuring greater cooperation between different disciplines as well as between regions to prevent fragmentation and ensure an integrated approach to the growth of knowledge in this field. Another area that deserves attention relates to studying areas such as human-centered artificial intelligence, immersion, and application of HCI in specific domains.

4. CONCLUSION

This bibliometric study provides a comprehensive overview of the development and intellectual structure of Human–Computer Interaction (HCI) research from 2000 to 2026. The findings reveal that HCI has evolved into a dynamic and interdisciplinary field, characterized by strong foundational themes in user interaction and system design, alongside emerging trends driven by artificial intelligence and domain-specific applications. Collaboration patterns indicate both the presence of well-established research communities and opportunities for broader international and cross-disciplinary integration. Additionally, the dominance of methodological and tool-oriented publications highlights the practical and application-driven nature of impactful research in this field. This study not only maps the past and present landscape of HCI research but also provides strategic insights for future exploration, emphasizing the importance of innovation, collaboration, and interdisciplinary engagement in advancing the field.

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