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Research Trends of Entertainment Robot: A Comprehensive Review of the literature from 1998 to 2024

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Keywords: Entertainment Robot, Social Robot, Service Robot, Bibliometric analysis

1. Introduction

The term “social robot” was first introduced by Billard, Dautenhahn and Breazeal in the early 20th century (Weber, 2008). Social robot refers to “a physical entity embodied in a complex, dynamic, and social environment sufficiently empowered to behave in a manner conducive to its own goals and those of its community” (Duffy et al., 1999, p. 5). These robots “are designed to interact with people in a natural, interpersonal manner – often to achieve positive outcomes in diverse applications such as education, health, quality of life, entertainment, communication, and tasks requiring collaborative teamwork” (Breazeal et al., 2016, p. 1935).

Despite the early conceptualization, there were very few social robots available for the laypersons in the market in the 1990s to early 21st century. However, with the advancement of artificial intelligence (AI) and various human-robot interaction (HRI) technologies, social robots with various applications such as education, rehabilitation, therapy, tourism and entertainment were introduced in the 2010s and various research have been conducted regarding these social robots (Belpaeme et al., 2018; Giansanti, 2021; Neerinx et al., 2021; Nieto et al., 2014; Rakhymbayeva et al., 2021).

The social robot and entertainment robot market itself is also witnessing a rapid growth.

According to Blue Frog Robotics, a market leader of entertainment robots, by 2025 the consumer robotics industry will reach \$41 billion worldwide, and entertainment robot industry will reach \$29 billion (Blue Frog Robotics, n.d.). In addition, a report by The Business Research Company, the entertainment robots market size is expected to grow to \$89.42 billion in 2028 at a compound annual growth rate (CAGR) of 25.5% (The Business Research Company, 2024).

However, despite entertainment feature of social robot being an important application, previous research mostly focused on the practical applications of social robots such as in the educational or therapeutic field, leaving the entertainment application rather unnoticed. One bibliometric analysis of 3,334 social robotics articles showed that over 90% of the articles were divided into eight clusters. The clusters included categories such as ‘robots as social partners’, ‘human factors and ergonomics in human robot interaction’, and ‘robotics for child development’ but did not include entertainment application (Weber, 2008). Another research that conducted bibliometric analysis of social robot interaction design identified 5 clusters, where entertainment application was not one of them (Wang et al., 2023).

As such, the widely accepted application of social robot—entertainment—has been often

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disregarded in social robot research. Because of such neglects, there has been a discrepancy between research and the industry. Various researchers have warned such phenomena, pointing out that there is a disparity between the expectations and the reality of the industry and that such disparity lies on factors such as technical factors, economic reasons, and legal, ethical and societal issues (Tulli et al., 2019). Such discrepancy can disappoint and dissatisfy the users (Berzuk & Young, 2023). One of the discrepancy lies on entertainment feature as entertainment serves as a starting point of human-robot relationship (Pollmann et al., 2023). In order to ensure the integral aspect of social robot—to interact with people—it is important to reduce the discrepancy of entertainment between research and the industry.

Despite the expected rapid growth and recent emergence of entertainment robots and considering the importance of entertainment, it is important to study the existing literatures to outline the current research status and to possibly identify the research gap. Current understanding of entertainment robots is insufficient. To our knowledge, there is no comprehensive review of entertainment robots. Therefore, this study aims to examine the research trends of literature from 1998 to 2024 to identify the research status and research gap of existing entertainment robot research.

2. Literature Review

2.1 Conceptual definition of entertainment robot

The International Organization for Standardization (ISO) and the International Federation of Robotics (IFR) classify robots as industrial robots and service robots (International Federation of Robotics, 2023). Service robots refer to non-industrial robots, further classifying them into professional or commercial and personal or non-commercial robots. Social robots can be classified into both professional and personal robots and figure 1 depicts such classification.

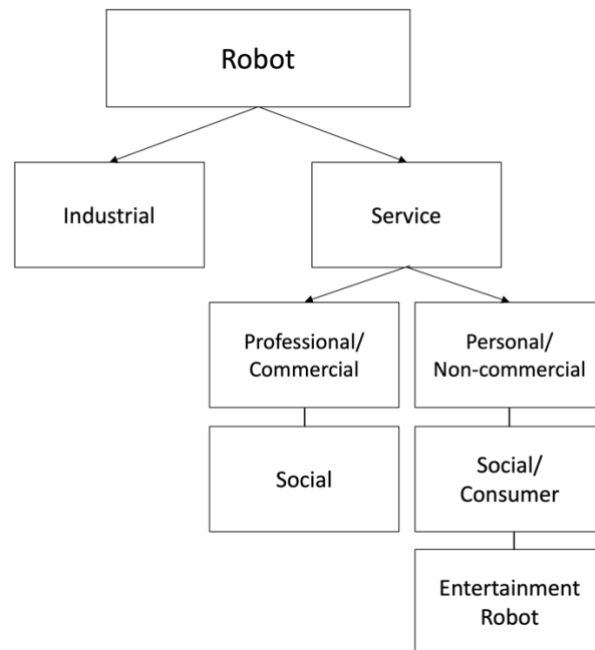


Figure 1. Classification of Robots

Social robots can be further classified, by their applications, into various robots such as education, therapy, rehabilitation, education and entertainment. However, as a single device, at times, serves more than one application, these terms are often used interchangeably. Under the IFR classification of service robots by application, this study will consider entertainment robots as a sub-category of consumer robots for social interaction (IFR International Federation of Robotics, n.d.).

2.2.1 Social Robots and Service Robots

Social robots are different from autonomous mobile robots as autonomous robots are robots often used by specialists or used to perform specific task, whereas social robots are designed to interact with people in an interpersonal manner and are often considered as partners in various domains including education, health and entertainment (Breazeal et al., 2016). Thus, it could be argued that one of the most important features of a social robot is interaction with humans. Likewise, a service robot could be also defined as a robot that can be perceived as a social entity, which has the ability to engage in human interactions (Belanche et al., 2020). Although the term ‘social robot’ and ‘service robot’ are often used interchangeably, service robot is generally used as a broader term. Service robots are “often fundamentally machine-

like in their behaviors and appearance with minimal, constrained, and inherently ‘functional’ contacts with human beings” whereas “‘social robots’ constitute a different category altogether ... that interact socially not only with each other, but more importantly with human beings” (Dautenhahn et al., 2002, p. 1). Therefore, social robots could be seen as service robots that are more specialized in their interaction with human beings.

2.2.2 Entertainment Robots

Entertainment robots are a type of social robots. Thereby, entertainment robots should also encompass the characteristics of a social robot and service robot. Entertainment robots, therefore, could be defined as a robot that interacts with people providing leisurely purposes. This leads to another question: what is entertainment? The term ‘entertainment’ is a vague term used in various contexts. Definition of entertainment could be understood as the act of keeping the attention of people watching or listening. However, to our knowledge, there is no research that clarifies entertainment feature of social robot, causing discrepancy between industry and research. Therefore, this study will conduct a bibliometric analysis of preceding entertainment robot literatures and identify the research status and research gap.

RQ : What is the current trend of academic research on entertainment robot?

3. Methodology

3.1 Collection Process of Literatures

This study employs both bibliometric analysis on preceding entertainment robot research. Bibliometric analysis will be conducted to answer the research question, by summarizing large quantities of bibliometric data (Donthu et al., 2021).

To employ bibliometric analysis, papers related to entertainment robots were collected in the process illustrated in Figure 2. Of various international academic databases, Scopus was chosen as the main source for the collection process as Scopus “indexes a larger number of journals than [PubMed, Web of Science, and Google Scholar]”

and “includes a more expanded spectrum of journals” than other databases (Falagas et al., 2008). Hence, this study utilized Scopus to search literatures related to entertainment robots. Search keywords such as “social robot” or “service robot” in addition to “entertainment” were used. Conference reviews, notes, and books were excluded, and search scope was limited to title, abstract and keywords. In addition, Boolean operators such as ‘AND’ and ‘OR’ were used to search for literatures that included both ‘social robot’ and ‘entertainment’ or ‘service robot’ and ‘entertainment’ in its search scopes. Hence, the exact query for the search was “(TITLE-ABS-KEY (entertainment AND "social robot") OR TITLE-ABS-KEY (entertainment AND "service robot")) AND (LIMIT-TO (LANGUAGE , "English")) AND (EXCLUDE (DOCTYPE , "cr") OR EXCLUDE (DOCTYPE , "no") OR EXCLUDE (DOCTYPE , "bk"))”. Terms ‘social robot’ and ‘service robot’ were used separately as these terms, in definition, are very closely related to each other. In addition, as literatures regarding entertainment robots were very limited, all literatures that satisfied the query were taken into consideration without adjustment of time scope or adjustment of subject area. The first literature that satisfied search query was from 1998. Therefore, the literatures used in this study was from 1998 to April 2024. After screening for errors and duplication, 2 literatures were excluded, finalizing with 237 literatures. Of the 237 literatures, 142 were conference papers, 74 were articles, 12 were book chapter and 9 were reviews.

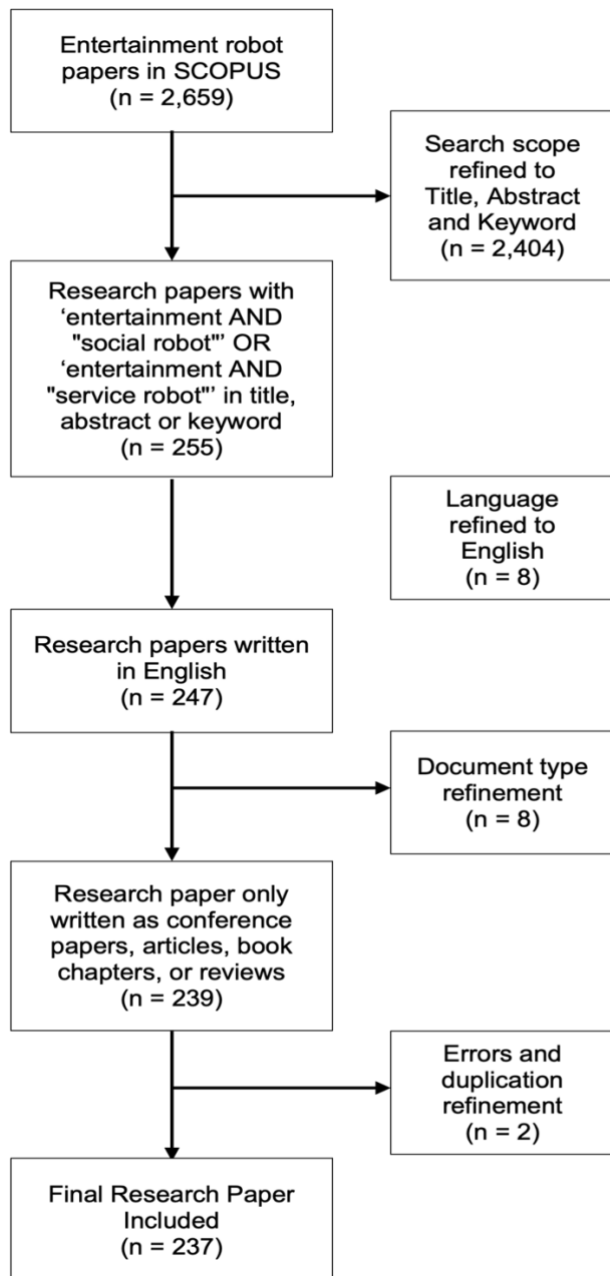


Figure 2. Paper collection process

3.2 Bibliometric Analysis

Scopus allows users to extract bibliometric data of each literature including publication year, authors, title, abstract and others. Using this feature, bibliometric data were extracted into Excel. Excel and free software program VOSviewer (van Eck & Waltman, 2010) were used to analyze and visualize various bibliometric data. Each literature was coded by co-work, funding status, affiliation country, affiliation continent, and research area. VOSviewer was utilized to conduct co-occurrence of keywords and co-authorship.

4. Results

4.1 Bibliometric Analysis

4.1.1 Publication by year

The number of publications over years of a topic can serve as an indicator of growth in interest of specific topic. As depicted in Figure 3, the publications of entertainment robot literatures have been gradually increasing since 1998. A steady growth of publications of 1 to 10 literatures has continued until 2015 and since 2016 the numbers of publications have been increasing more rapidly, with 30 literatures published in 2021. One explanation for such rapid growth would be development of artificial intelligence in the mid 2010s. The advancement of entertainment robots has always been accompanied by the advanced of AI as AIBO, very first entertainment robot, itself is also an abbreviation of Artificial Intelligence Robot. Social robots are considered as technology artifacts with AI technology capable of interacting with human beings verbally and non-verbally, which generates social responses from the users (Fosso Wamba et al., 2023). Sarrica, who examined scientific and popular definitions of social robot, also stated that a social robot should have the ability to respond to environmental cues (Sarrica et al., 2020). Because of such importance of AI and with the advancement of AI in the mid 2010s, various social robots, both with and without entertainment features, were introduced, and therefore lead to increase of publications in the mid 2010s. Similar results were found in other bibliometric and systematic analysis of social robots, whether in publications of social robots in general or publications of social robots in specific domain as education (Fosso Wamba et al., 2023; Pai et al., 2024).

However, because of the “discrepancy between the user expectations, the market expectations and the companies’ expectations”, not only promising companies but also “companies born as a spin-off from Universities” have faced crisis (Tulli et al., 2019, p. 2). A significant portion of literatures written in the late 2010s to early 2020s utilized these social robots in their research, whether it be case study using these social robots or descriptions of various technologies that could be incorporated into these social robots. In addition, there were limited but some literatures related to COVID19 and the effect and influence of social robots during this period. Therefore, after hitting its peak at year 2021, the publication trend has been witnessing decline.

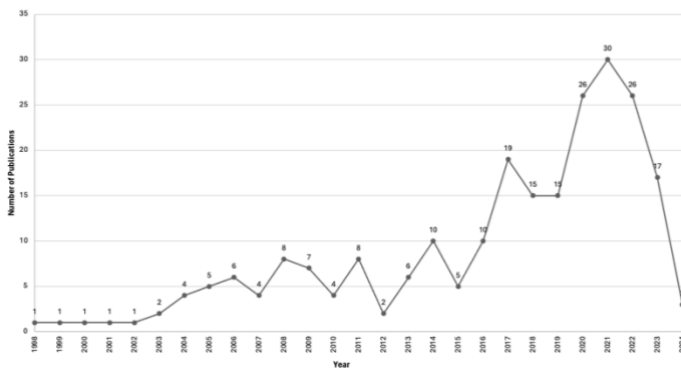


Figure 3. Publications by year

4.1.2 Authors and Authors’ affiliations

The 239 publications were written by a total of 160 authors. 88.1% of the authors were only accounted for one or two publications (n=141), whereas the remaining 19 authors were credited for at least 3 publications on the topic of entertainment robots. Such finding was consistent with observations of other fields, where a small group of authors were accounted for significant numbers of publication on a specific topic (van Nunen et al., 2018).

It was also found that most productive authors on the topic of entertainment robots were from the same affiliation. Malfaz was founded to be the most productive author, with 8 publications, continued by Salichs, Castro-González, Breazeal and Maroto-Gómez. 4 of the top 5 most productive authors were from the same affiliation—Charles III University of Madrid. Many of the publications

produced by these authors were often co-written. Such analysis was also evident in co-authorship analysis using VOSviewer. As displayed in Figure 4, when co-authorship analysis was conducted with authors with at least 2 documents, 72 authors met the threshold and there was a strong link between the top productive authors from Charles III University of Madrid. In addition, table 1 outlines the top 5 of most productive affiliations, in which Charles III University of Madrid placed number one with 12 publications, continued by CNRS, Vrije University, MIT Media Lab and University of Lisbon respectively.

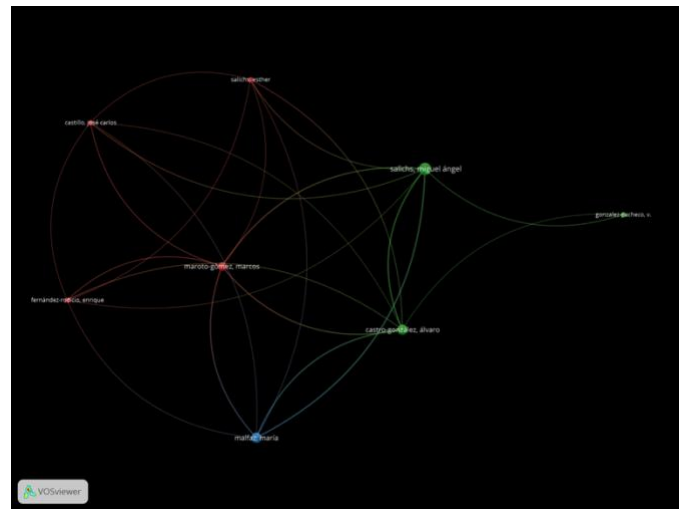


Figure 4. Co-Authorship

Affiliation	Count
Charles III University of Madrid	12
The National Centre for Scientific Research (CNRS)	6
Vrije Universiteit Amsterdam	6
MIT Media Lab	5
University of Lisbon	5

Table 1. Top 5 of the productive affiliations

Authors’ affiliations refer to academic or research institutions to which the authors are affiliated. Authors’ affiliations provide important information about the context in which the research is conducted. It also displays the imbalance between countries and continents of where the research is being conducted. In order to analyze the authors’ affiliations, the literatures were coded based on their affiliations. If a literature had more

than one affiliation, all the affiliations were multi-coded. Figure 5 displays the countries of such affiliations. The darker the color of a country signifies that more literature was published from affiliations in that country. The top five countries were the United States (n=51), Spain (n=25), Japan (n=21), China (n=20) and Germany and the United Kingdom (both n=14). Continentally, affiliations in Europe (n=128) published the most literatures, continued with Asia (n=101) and North America (n=56). Table 2 outlines the detailed information regarding each continent and full list of countries of each continent with percentage ratio. It was found that Spain, China, The United States, Australia, and Brazil to be the most productive countries in each continent regarding the topic of entertainment robots.

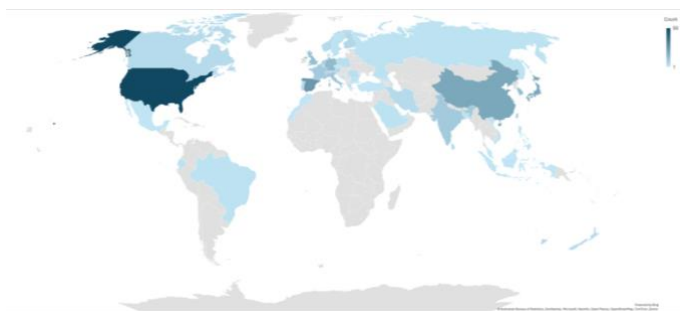


Figure 5. Authors' Affiliated Countries

Continent	Count (Countries)	Count	Percentage
Europe	Spain (25) , Germany (14), United Kingdom (13), Italy (10), France (9), Netherlands (8), Belgium (7), Switzerland (6), Austria, Finland (5), Norway, Portugal (4), Poland, Romania (3), Bulgaria, Denmark, Greece, Sweden (2), Bosnia and Herzegovina, Czech Republic (1)	126	42.71%
Asia	China, Japan (20) , South Korea (13), Taiwan (10), India (9), Iran, Sri Lanka (4), Singapore (3), Bangladesh, Hong Kong, Philippines, Russian Federation, Saudi	100	33.90%

	Arabia, Viet Nam (2), Burnei Darussalam, Indonesia, Malayisa, Turkey, United Arab Emirates (1)		
North America	United States of America (50) , Canda (4), Mexico (1)	55	18.64%
Oceania	Australia (5) , New Zealand (4)	9	3.05%
South America	Brazil, Ecuador (2)	4	1.36%
Africa	Morocco (1)	1	0.34%
Antarctica	N/A	N/A	N/A
Total		295	100%

Table 2. Authors' Affiliated Countries and Continents

4.1.3 Field of Study

This study used the Scopus filter count function to analyze the field of study of literatures. It was found that the majority of the literatures were in the STEM field such as computer science, engineering and mathematics. Only 68 literatures were included in the non-STEM field of study, even with health professions and multidisciplinary included. This is displayed in table 3. The bolded subject area refers to non-STEM fields and includes social sciences, psychology, arts and humanities, health professions, business, management and account, multidisciplinary and economics, econometrics and finance. This in terms of ratio only accounts for 14.4%. Therefore, it could be presumed that many non-STEM aspects such as psychological and economical is not fully put into consideration, thus causing "disparity between the expectations and the reality" (Tulli et al., 2019, p. 3). As social robots are entitled to interact with the users, understanding of the human is as important as advancing the technology. Literatures that highlight the discrepancy between the expectation and reality anticipate that "several theories regarding expectations in interactions between humans ... may be relevant to robots as well" and that "psychological phenomena, such as the pratfall effect (people perceived as highly capable become more likeable after making a mistake, while people who are already perceived as unreliable become less likeable after making the same mistake)" (Berzuk & Young, 2023, p. 232).

However, the Scopus filter count multi-codes the literatures, which means that if a single document were to be included in more than 1 non-STEM subject area, this would have skewed the number of literatures in the non-STEM field. Therefore, by coding each literature with the given filter provided by Scopus, it was found out that only 45 of 237 literatures were in the non-STEM field of study. This accounts for 18.99% of the literatures. Even though this value is greater than the ratio derived from the Scopus filter count, it can be still seen that the majority of the literatures were written from a technical perspective.

Subject Area	Count (Percentage)
Computer Science	199 (42.16%)
Engineering	107 (22.67%)
Mathematics	47 (9.96%)
Social Sciences	25 (5.30%)
Psychology	17 (3.60%)
Arts and Humanities	12 (2.54%)
Medicine	9 (1.91%)
Decision Sciences	7 (1.48%)
Health Professions	6 (1.27%)
Physics and Astronomy	6 (1.27%)
Biochemistry, Genetics and Molecular Biology	4 (0.85%)
Business, Management and Accounting	4 (0.85%)
Chemical Engineering	4 (0.85%)
Energy	4 (0.85%)
Materials Science	4 (0.85%)
Neuroscience	4 (0.85%)
Chemistry	3 (0.64%)
Environmental Science	3 (0.64%)
Multidisciplinary	3 (0.64%)
Nursing	3 (0.64%)
Economics, Econometrics and Finance	1 (0.22%)
Total (Multi-Coded)	472 (100%)

Table 3. Field of Study

4.1.4 Co-Work Analysis

Figure 6 outlines the co-work status of the literatures. Literatures were coded into three categories based on the authors' affiliations. If the authors were all from the same affiliation of the same country, they were categorized into the same category, which accounts for 49.4% (n=118). The second category was where the authors were from the same country but different affiliation, which accounted for 34.7% (n=83). Finally, if the authors

were from different affiliation of different countries, the literature was categorized into the same category, which accounted for 15.9% (n=38). Such results show that about half of the research was conducted by researchers of the same affiliation of the same country. Even when the authors were from different affiliations, majority were from the same country.

As there was a rapid growth of literature publication since 2016, it was interesting to inspect the difference between publication trend of Period 1 (1998~2015) and Period 2 (2016~2024). Both in Period 1 and Period 2, similar amount of research was conducted or co-conducted with non-academic organizations such as robotics company or manufacturing companies. However, in terms of ratio, in the earlier period, it was noted that about 23% of the research was conducted by or with non-academic organizations, whereas in period 2, this ratio has decreased to 11%. This indicates that higher ratio of research is now being conducted by academic organizations compared to the earlier period. Figure 7 displays the number of research conducted by academic organizations and non-academic organizations. Such phenomena could have also caused disparity between the research and industry. As "developing and selling robots is challenging and require market knowledge that companies born as a spin-off from Universities may not have", it is crucial to work cooperatively with the industry in order to decrease such discrepancy (Tulli et al., 2019, p. 2).

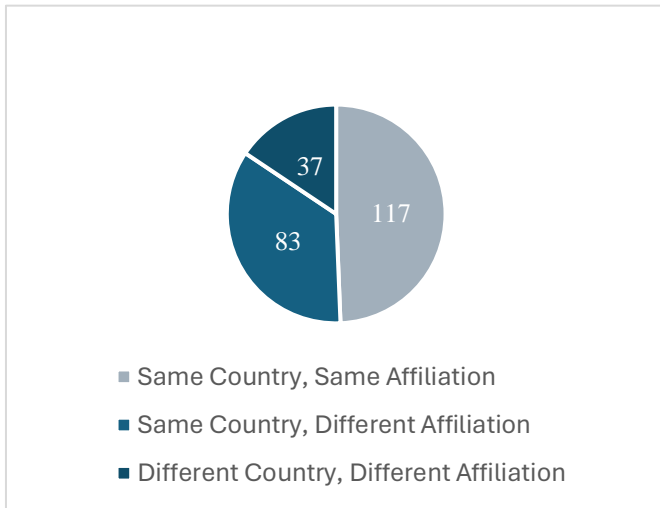


Figure 6. Co-Work Status

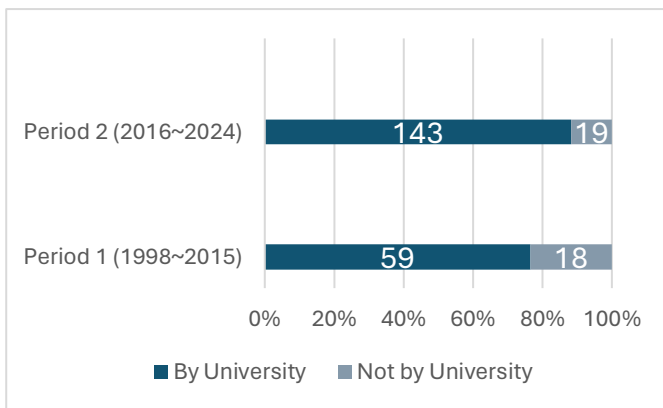


Figure 7. Ratio of research conducted by non-academic organizations

4.1.5 Funding

The amount of research funded can serve as an indicator of the public's interest of a topic. Table 4 displays the funding status. It was founded that 61.5% (n=147) of the research was not funded. Research that was funded were, at times, funded by more than one organization and therefore was multi-coded. Of the 92 research that were funded, 75 were funded by national or continental organizations such as the European Commission or European Research Council, whereas 29 were funded by universities and 4 by private funds. In terms of national or continental fund, the European Union or European Research Council was the most active, continued by Australia, Brazil, and China respectively.

Funding	Count (Percentage)
None	147 (57.64%)
Public – National/Continental	75 (29.41%)
Public – University	29 (11.37%)

Private	4 (1.57%)
Total (Multi-Coded)	255 (100%)

Table 4. Funding

4.1.6 Keyword Analysis

Table 5 displays the top 20 of the most common keywords among the literatures. The top 5 keywords are social robots, robotics, robots, human robot interaction and machine design. This shows that entertainment robots are closely linked to social robots and that human robot interaction is an important part of entertainment robots. Other keywords in the list such as human-robot interaction, human computer interaction, artificial intelligence all shows that interaction between human and the robot is an important component of entertainment robot. In addition, there are also various types of robots in the top 20 of the most common keywords such as agricultural robots, mobile robots, anthropomorphic robots, and educational robots. One explanation for this is that with the development of social robots, many robots have been serving more than one purpose. For example, it is common to see a social robot serving as a companion, and as an assistant, as well as an entertainment source.

Keyword	Count	Keyword	Count
Social Robots	126	Man Machine Systems	31
Robotics	75	Human Computer Interaction	25
Robots	63	Anthropomorphic Robots	22
Human Robot Interaction	49	Entertainment	22
Machine Design	49	Social Robot	21
Intelligent Robots	40	Entertainment Robots	20
Human-robot Interaction	38	Social Robotics	20
Service Robots	37	Artificial Intelligence	19
Agricultural Robots	35	Educational Robots	19
Mobile Robots	35	Behavioral Research	16

Table 5. Top 20 of the most common keywords

Co-occurrence analysis of all keywords (including author keywords and index keywords)

using VOSviewer also resulted in similar results, as displayed in Figure 8. When co-occurrence analysis was conducted based on the bibliographic data from Scopus, of 1952 keywords, 53 keywords met the threshold of minimum of 5 occurrences. Then, 53 keywords were divided into 7 clusters. As displayed in table 6 and figure 8, the first group in red contained words such as social robot, HRI, man-machine systems, social robotics, and speech recognition. Such words highlight the interaction between human and robot, which is the essential part of a social robot. Other keywords such as face recognition, speech recognition, machine learning, deep learning were also labelled as the same cluster, which refer to technologies widely used in robots to enhance the interaction with the users.

Second group in yellow included keywords such as agricultural robots, anthropomorphic robots, entertainment robot and humanoid robot. These keywords represent social robots of various forms and domain. This shows that the entertainment feature is used in various types of social robots. It also shows that the design of robots—anthropomorphic, humanoid, zoomorphic—plays an important role in the domain of entertainment robot. This is also evident from previous literatures that showed factors such as robot appearance, familiarity, or humanness influence people’s interest and communication with robots (J. Barnes et al., 2017; Kamide et al., 2013).

Third group in green included keywords such as machine design, intelligent robots, service robot, mobile robots, human computer interaction and industrial robots. These keywords are related to user experience. How machine is designed and its applications in different domain affect the user experience.

Fourth group in blue included keywords such as robot, robotics, economic and social effects and older adults. Some of the more minor keywords included elderly care, patient rehabilitation, diseases and children. These keywords refer to some of the most widely used entertainment robot domains. One of the domains where social robots with entertainment functions are most widely used commercially is field of health, in emphasis on rehabilitation and care of elderly and children.

Although the primary purpose of these robots is focused on well-being of the users, these robots often provide entertainment in purpose or coincidentally.

Fifth group in purple included keywords educational robots, artificial Intelligence, entertainment and behavioral research. These keywords are related to the behavioral aspect of the robot, which is an important aspect of social robot.

Lastly, there were two clusters, each in turquoise and orange, each had one keyword—robot design and social interactions respectively. These two keywords represent integral aspect of social robotics. As mentioned before, social interaction is a key feature that distinguishes social robots from other autonomous robots and robot design affects the interaction of social robots. However, in comparison to the giant red cluster, which contains keywords related to interaction of social robots from a technical perspective, these two clusters are smaller in size and lacks related keywords. This once again shows that the discrepancy between research and industry is greater in the non-technical field of study.

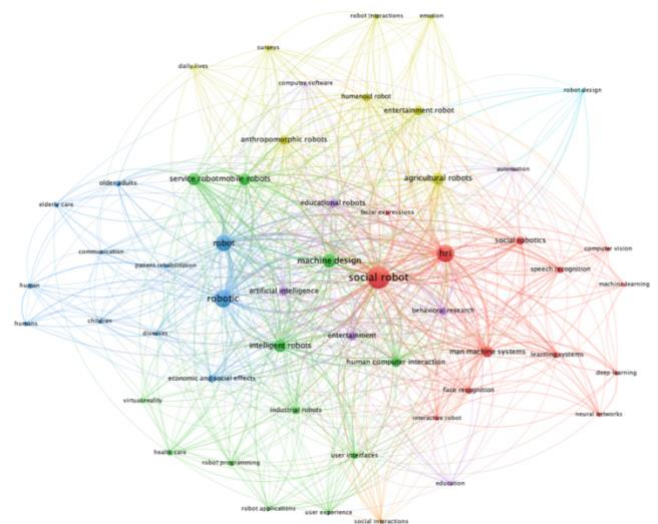


Figure 8. Co-occurrence analysis of all keywords

Color of Cluster (Topic)	Major Keywords
Red (Interaction)	Social Robot, HRI, Man-machine Systems, Social Robotics, Speech Recognition
Yellow (Types of Robots)	Agricultural Robots, Anthropomorphic Robots, Entertainment Robot, Humanoid Robot

Green (User Experience)	Machine Design, Intelligent Robots, Service Robot, Mobile Robots, Human Computer Interaction, Industrial Robots
Blue (Different domain and health)	Robot, Robotics, Economic and Social Effects, Older Adults
Purple (Behavioral)	Educational Robots, Artificial Intelligence, Entertainment, Behavioral Research
Turquoise (Robot Design)	Robot Design
Orange (Social Interactions)	Social Interactions

Table 6. Clusters of keywords

5. Conclusion

The result showed that the majority of the literatures were written from a technical perspective with computer science being the most common subject area. Literature written from technical perspective mainly focused on the advancement of technologies applied in robots and advancement of human-robot interaction. This was again shown in the co-occurrence analysis of keywords, where social interaction was only identified as a small cluster. Social robots are entities that interact with human beings, and the understanding of human beings is also an important factor to be considered. The lack of research that attempted to understand human factors and lack of research from a non-technical perspective led to discrepancy between the research and industry. More studies should be conducted to understand social robots from non-technical perspective, enhancing the understanding of social robots from users' perspective.

In addition, the ratio of research conducted by non-university organizations has decreased by half over time and majority of research was also conducted by researchers from the same affiliation. As highlighted by researchers who criticized the discrepancy between industry and market, designing and selling robot requires cooperative work with the industry. Thus, future research should seek collaboration between diverse affiliations and fields of study and active research

between industry and university should be promoted.

As for future research, researchers should attempt to compile the definition of “entertainment robot”. Because entertainment robots are used in robots with various applications and functions, it was seen that the term was used without consistency. Presenting a specified definition of the term can be the basis for future academic work. Furthermore, researchers should attempt to understand the users from more diverse perspectives. Previous research and theoretical frameworks have found that features like the level of human-likeness, gender, ethnicity, and culture could all affect human robot interaction (Belanche et al., 2020). However, as seen in the co-occurrence analysis, robot design research was only conducted from a very specific perspective—anthropomorphic, humanoid or zoomorphic. In addition, because many of the firms that develop robots originate from a limited number of countries, such products reflect those countries' cultural characteristic. This could serve as a hindrance to customers of different cultural and societal backgrounds and therefore requires adaptation of these products to different cultures with varying ethnic features (Obaid et al., 2016). Thus, future research should be conducted from more specified perspectives.

This study provides an important outline of entertainment robot research. Among various discrepancies that lies on research and industry, this study identified that there is a discrepancy between entertainment feature of social robot. Majority of related research is conducted from technical perspective, which advanced the technology required for the successful operation of these robots but failed to understand the other main agent of this relationship—human being. Without thorough understanding of the human beings, it will be impossible to establish successful human-robot interaction, which has been the case with the social robot industry. Therefore, this study provides a valuable academic implication that more research should be conducted from non-technical perspective, aiming to understand the human beings.

In addition, social robot is a physical entity that interacts with human beings and entertainment could serve as a starting point of human-robot interaction. However, most of the preceding research rather focused on more technical perspective, advancing the technology used in these robots. Although not overlooking the importance of these technologies, such advancement could be not as crucial for the success of social robots. It has been witnessed that such technological advancement often leads to user dissatisfaction. Therefore, this study provides an industrial implication that more user-centered social robots should be developed to increase the chances of success.

This study has several limitations. First limitation is related to the data collection process. This study only utilized literatures in the database Scopus, neglecting possible literatures in the other database. This could have accentuated the discrepancy between research and industry, even if it were addressed in other literatures in a different database. Also, because social robot is currently witnessing an exponential growth, diverse robots are being introduced and researched, without unified naming or conceptualization. Therefore, entertainment robots are often addressed as leisure robots or addressed with keywords such as fun instead of entertainment. Therefore, limiting the search scope to 'entertainment' could have led to exclusion of relevant studies. In addition, the term 'social robot' is also addressed with different terminology including AI bot or co-bot. However, as these robots often do not have physical entity or has limited automation does not fulfill the properties of a social robot, and thus were excluded from this study. This, however, could have also led to exclusion of relevant studies.

In addition, this study only conducted bibliometric analysis, focusing on the quantitative data. This allowed this study to identify and reiterate that there is a discrepancy between research and industry in terms of entertainment features. However, was not able to identify the exact discrepancy, addressing future studies. Therefore, conducting systematic literature review

and focusing on the qualitative data could derive more meaningful research gaps.

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Reference

- Belanche, D., Casaló, L. V., Flavián, C., & Schepers, J. (2020). Service robot implementation: A theoretical framework and research agenda. *The Service Industries Journal*, 40(3–4), 203–225. <https://doi.org/10.1080/02642069.2019.1672666>
- Belpaeme, T., Kennedy, J., Ramachandran, A., Scassellati, B., & Tanaka, F. (2018). Social robots for education: A review. *Science Robotics*, 3(21), eaat5954. <https://doi.org/10.1126/scirobotics.aat5954>
- Berzuk, J. M., & Young, J. E. (2023). Clarifying Social Robot Expectation Discrepancy: Developing a Framework for Understanding How Users Form Expectations of Social Robots. *Companion of the 2023 ACM/IEEE International Conference on Human-Robot Interaction*, 231–233. <https://doi.org/10.1145/3568294.3580078>
- Breazeal, C., Dautenhahn, K., & Kanda, T. (2016). Social Robotics. In *Springer Handbooks*. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85137001369&doi=10.1007%2f978-3-319-32552-1_72&partnerID=40&md5=b98650493739f454afeca8ebd5a510fe

- Dautenhahn, K., Ogden, B., & Quick, T. (2002). From embodied to socially embedded agents – Implications for interaction-aware robots. *Situated and Embodied Cognition*, 3(3), 397–428. [https://doi.org/10.1016/S1389-0417\(02\)00050-5](https://doi.org/10.1016/S1389-0417(02)00050-5)
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285–296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
- Duffy, B. R., Rooney, C., O’Hare, G. M. P. (Greg M. P.), & O’Donoghue, R. (1999). *What is a social robot?*
- Falagas, M. E., Pitsouni, E. I., Malietzis, G. A., & Pappas, G. (2008). Comparison of PubMed, Scopus, Web of Science, and Google Scholar: Strengths and weaknesses. *The FASEB Journal*, 22(2), 338–342. <https://doi.org/10.1096/fj.07-9492LSF>
- Fosso Wamba, S., Queiroz, M. M., & Hamzi, L. (2023). A bibliometric and multi-disciplinary quasi-systematic analysis of social robots: Past, future, and insights of human-robot interaction. *Technological Forecasting and Social Change*, 197, 122912. <https://doi.org/10.1016/j.techfore.2023.122912>
- Giansanti, D. (2021). The Social Robot in Rehabilitation and Assistance: What Is the Future? *Healthcare*, 9(3). <https://doi.org/10.3390/healthcare9030244>
- J. Barnes, M. FakhrHosseini, M. Jeon, C. -H. Park, & A. Howard. (2017). The influence of robot design on acceptance of social robots. *2017 14th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI)*, 51–55. <https://doi.org/10.1109/URAI.2017.7992883>
- Kamide, H., Kawabe, K., Shigemi, S., & Arai, T. (2013). Development of a psychological scale for general impressions of humanoid. *Advanced Robotics*, 27(1), 3–17. <https://doi.org/10.1080/01691864.2013.751159>
- Mejia, C., & Kajikawa, Y. (2017). Bibliometric Analysis of Social Robotics Research: Identifying Research Trends and Knowledgebase. *Applied Sciences*, 7(12). <https://doi.org/10.3390/app7121316>
- Neerincx, A., Hiwat, T., & de Graaf, M. (2021). Social Robot for Health Check and Entertainment in Waiting Room: Child’s Engagement and Parent’s Involvement. *Adjunct Proceedings of the 29th ACM Conference on User Modeling, Adaptation and Personalization*, 120–125. <https://doi.org/10.1145/3450614.3463413>
- Nieto, D., Quesada-Arencibia, A., García, C. R., & Moreno-Díaz, R. (2014). A Social Robot in a Tourist Environment. In R. Hervás, S. Lee, C. Nugent, & J. Bravo (Eds.), *Ubiquitous Computing and Ambient Intelligence. Personalisation and User Adapted Services* (pp. 21–24). Springer International Publishing.
- Obaid, M., Salem, M., Ziadee, M., Boukaram, H., Moltchanova, E., & Sakr, M. (2016). Investigating Effects of Professional Status and Ethnicity in Human-Agent Interaction. *Proceedings of the Fourth International Conference on Human Agent Interaction*, 179–186. <https://doi.org/10.1145/2974804.2974813>
- Pai, R. Y., Shetty, A., Dinesh, T. K., Shetty, A. D., & Pillai, N. (2024). Effectiveness of social robots as a tutoring and learning

- companion: A bibliometric analysis. *Cogent Business & Management*, 11(1), 2299075.
<https://doi.org/10.1080/23311975.2023.2299075>
- Pollmann, K., Loh, W., Fronemann, N., & Ziegler, D. (2023). Entertainment vs. Manipulation: Personalized human-robot interaction between user experience and ethical design. *Technological Forecasting and Social Change*, 189.
<https://doi.org/10.1016/j.techfore.2023.122376>
- Rakhymbayeva, N., Amirova, A., & Sandygulova, A. (2021). A Long-Term Engagement with a Social Robot for Autism Therapy. *Frontiers in Robotics and AI*, 8.
<https://www.frontiersin.org/articles/10.3389/frobt.2021.669972>
- Sarrica, M., Brondi, S., & Fortunati, L. (2020). How many facets does a “social robot” have? A review of scientific and popular definitions online. *Information Technology & People*, 33(1), 1–21.
<https://doi.org/10.1108/ITP-04-2018-0203>
- Tulli, S., Ambrossio, D. A., Najjar, A., & Rodríguez Lera, F. J. (2019). *Great expectations & Aborted business initiatives: The paradox of social robot between research and industry*. CEUR Workshop Proceedings.
<https://www.scopus.com/inward/record.uri?eid=2-s2.0-85075057039&partnerID=40&md5=eedc5564d09417550022bde674cd9c86>
- van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, 84(2), 523–538. Scopus.
<https://doi.org/10.1007/s11192-009-0146-3>
- van Nunen, K., Li, J., Reniers, G., & Ponnet, K. (2018). Bibliometric analysis of safety culture research. *Safety Science*, 108, 248–258.
<https://doi.org/10.1016/j.ssci.2017.08.011>
- Wang, J., Chen, Y., Huo, S., Mai, L., & Jia, F. (2023). Research Hotspots and Trends of Social Robot Interaction Design: A Bibliometric Analysis. *Sensors*, 23(23).
<https://doi.org/10.3390/s23239369>
- Weber, J. (2008). Human-Robot Interaction. In S. Kelsey & K. St.Amant (Eds.), *Handbook of Research on Computer Mediated Communication* (pp. 855–867). IGI Global. <https://doi.org/10.4018/978-1-59904-863-5.ch061>