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Landscape of research in haptics and digital games revealed by co-occurrence analysis

Saptarshi Samanta

saptarshi.samanta@iitg.ac.in

IIT Guwahati https://orcid.org/0000-0003-3252-6499

Sharmistha Banerjee

IIT Guwahati https://orcid.org/0000-0002-1647-6922

Pankaj Upadhyay

IIT Guwahati https://orcid.org/0000-0002-9775-6618

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Author names: Saptarshi Samanta

Author affiliations: Department of Design, IIT Guwahati

Address: Department of Design, Indian Institute of Technology Guwahati, Guwahati, Assam, India 781039

Email: saptarshi.samanta@iitg.ac.in

Orcid: 0000-0003-3252-6499

Author names: Sharmistha Banerjee

Author affiliations: Department of Design, IIT Guwahati

Address: Department of Design, Indian Institute of Technology Guwahati, Guwahati, Assam, India 781039

Email: sharmistha@iitg.ac.in

Orcid: 0000-0002-1647-6922

Author names: Pankaj Upadhyay

Author affiliations: Department of Design, IIT Guwahati

Address: Department of Design, Indian Institute of Technology Guwahati, Guwahati, Assam, India 781039

Email: pankaj.upadhyay@iitg.ac.in

Orcid: 0000-0002-9775-6618

Corresponding author information:

Name: Saptarshi Samanta

Email: saptarshi.samanta@iitg.ac.in

Abstract

While haptic feedback has been integrated into commercial game controllers since 1997, the intellectual structure of research at the intersection of haptics and digital games remains unmapped. We conducted a bibliometric co-occurrence analysis of 1,871 Scopus-indexed publications spanning 1995 to June 2025, using a three-stage methodology of retrieval, screening, and keyword co-occurrence analysis in VOSviewer to identify research clusters, emerging themes, and knowledge gaps in this domain. Applying a minimum co-occurrence threshold of 10, the analysis retained 62 keyword items organised into six research clusters. Virtual reality emerged as the dominant research theme, with the haptics-VR link strength of 77. Research is concentrated in serious games and healthcare applications across all major clusters. Emerging themes include wearables, gamification, metaverse, extended reality, mixed reality,

passive haptics, and neurorehabilitation. Notably, entertainment digital games remain structurally peripheral to the research domain, with weak co-occurrence links between the video games node and all major haptic research themes, and no link between quality of experience and video games. This structural disconnect between academic research priorities and commercial industry practice highlights the relative underexploration of haptic design for entertainment digital games and motivates a dedicated research agenda for haptic experience evaluation in player-centred contexts.

Keywords

Game design, haptics, haptic modality, co-occurrence analysis, bibliometric analysis

Statements and Declarations

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1. Introduction

Digital games have been of interest for HCI since the early days of its inception in the 1970s. Formal studies of digital games in the context of HCI started emerging in the 1980s, focusing on aspects like educational computer games (Malone, 1981) or connecting game design principles to HCI interface design (Malone, 1982). At present, digital games have become an integral part of a large number of individuals' daily lives. From a mode of enjoyment once available in arcades, it has now moved into people's homes through gaming on computers, consoles, or handheld devices, such as mobile phones. Games are designed to engage the individual's senses and provide an enjoyable playing experience. While most games primarily engage the visual and the aural modalities, efforts are being made to engage the other sensory modalities for a broader multimodal experience (Min et al., 2017). Using haptics is one such exploration towards expanding the multimodal gameplay experience in digital games. Research about the uses of the haptic modality has progressed significantly from applying force feedback in a joystick device for PC games (Ming et al., 1995) to skin-integrated wireless haptic interfaces for virtual and augmented reality (AR) applications (Yu et al., 2019). In the commercial space, Nintendo first introduced haptic feedback as “Rumble Pak” in 1997 in its game controllers (Söderström et al., 2022). The same year, Microsoft introduced the Sidewinder Force Feedback Pro controller, and Sony launched its DualShock controller for PlayStation (Padasinavik, 2017). Since then, vibrotactile haptic feedback has become common in most commercially available game controllers. Zyda (2005) highlights the importance of combining the haptic, visual, and aural modalities to enhance immersion. The authors point out that haptics is a key research area that needs focused research and development to enhance its effect on stimulating the senses and creating a feeling of immersion.

A significant body of research literature exists on the use of haptic modality in digital games. Systematic literature reviews are a valuable source for obtaining an overview of the landscape of a specific research area in a domain and are particularly best suited for small datasets that can be manually reviewed. In the research domain of haptic modalities in digital games, among the systematic reviews identified in our

search, we observe that there is a focus on the use of haptics and digital games in healthcare and rehabilitation (Hogle et al., 2008; Ma & Zheng, 2011; Salkini et al., 2010; Tuttle & Carter, 2022; Waters & Johnson, 2024). Although systematic literature reviews related to haptics and digital games provide insights into specific areas of research, a broader perspective is needed to identify the most prominent research areas. This is where bibliometric analysis has an advantage over systematic literature reviews. Bibliometric analysis can be used to analyse large datasets of research literature by utilising well-established and proven objective and subjective evaluation methods. Bibliometric analysis can aid research scholars by providing a comprehensive overview, isolating knowledge gaps, identifying new avenues for investigation, and determining the area of contribution for a research domain (Donthu et al., 2021).

We observe that bibliometric analysis has been primarily used in the domain of HCI in evaluating the use of gamification in education, game-based learning, and serious games (Aliu et al., 2025; Behl et al., 2022; Hallinger et al., 2020; Kanade & Duffy, 2020; Pek et al., 2025; Sabri et al., 2024). In some cases, it has been used to analyse game design aspects (Wu et al., 2025), the knowledge structure of research in games (Al Ardha et al., 2024; Sun et al., 2024), and wearable devices (Hu et al., 2024; Xu et al., 2023; Zhang et al., 2024). Samanta et al. (2023) have used bibliometric analysis to provide an overview of VR research and haptics. However, no comprehensive research literature is available that scopes the landscape of research in digital games and haptics. Furthermore, we are also interested in how the research in entertainment digital games links to that in digital games and haptics, given the surge in haptic integration in commercially available entertainment digital games. This leads us to our research questions:

RQ1: What are the various research areas in the domain of digital games and haptics?

RQ2: What is the extent of research in entertainment digital games in relation to research in digital games and haptics?

The answers to the above research questions will provide researchers with insights into the most researched areas in the domain of digital games and haptics, and also shed light on less-explored research areas, opening new avenues for future research. It also sheds light on methodological trends and conceptual gaps in haptic experience design.

The remainder of this article comprises five sections. In Section 2, we briefly describe bibliometric analysis methods and discuss all research related to the use of bibliometric analysis in the domain of digital games and haptic modality. Section 3 will cover the research methodology and identify the quantity of research literature required for the analysis. In Section 4, we will discuss the results of the analysis. Section 5 covers the implications of the results and their impact on research in digital games and the haptic modality. We discuss the conclusions and future research directions in Section 6.

2. Related work

Bibliometric analysis involves the application of quantitative techniques like citation analysis, co-citation analysis, and co-occurrence analysis to bibliometric data such as units of publication, citation, and keywords, through which research scholars can derive the required overview of insights about a particular research domain or field (Donthu et al., 2021). Bibliometric analysis is not a new field or a new tool for research. Research interest in bibliometrics started in the 1950s (Wallin, 2005). However, the interest in using bibliometric analysis methods for research is recent (Donthu et al., 2021).

Bibliometric analysis is usually divided into performance analysis and science mapping. Performance analysis focuses on the contributions of research constituents for a particular domain of research. The commonly used metrics in performance analysis are the number of publications or citations per year or research constituents. On the other hand, science mapping deals with the relationship between research constituents, meaning the intellectual interactions and structural connections that exist between

different research constituents. Science mapping includes citation analysis, co-citation analysis, bibliographic coupling, co-word analysis, and co-authorship analysis as methods for performing science mapping (Donthu et al., 2021).

The following subsections will discuss how bibliometric analysis has been used in digital games and HCI and haptics, respectively.

2.1 Application of bibliometric analysis in digital games and HCI

In Table 1, we have summarised the application of bibliometric analysis in digital games and HCI.

Table 1: Publications related to digital games and HCI where bibliometric analysis has been used

Paper	Focus Area	Derived Insights
(Carbonell et al., 2009)	• Addiction to the internet, video games, and cell phones • Evolution of research in these fields	• Lack of clear terminology affects the analysis of the field • Findings are relevant for healthcare
(Martin, 2018)	• Patterns and research themes in research literature related to games produced between 1966 and 2016	• Identified the different communities within which game research is divided • Existence of a knowledge gap between academic research and the game industry • Design is the bridge between different game research communities
(Sun et al., 2024)	• Knowledge structure of various academic fields in the domain of Massive Multiplayer Online Role-Playing Games	• Players' motivation, players' demographics, in-game social interactions, and pathological usage identified as primary research areas
(Zhao et al., 2023)	• Research related to video game social communication	• Four areas of research were identified: • Gaming behaviours, gender studies, media effects, gaming experience
(Trinidad et al., 2021)	• Intellectual structure of gamification research and evolution of the field between 2011 and 2019	• Research in gamification has been primarily associated with education, healthcare, and wellness • Need for the development of a common ground theory for gamification and gamification design
(Saikia et al., 2023)	• Preparedness of libraries towards adopting gamification in the context of application in teaching and learning purposes • Growth of literature on gamification	• Most widely utilized in the education domain
(Nadi-Ravandi & Batooli, 2022)	• Overview of the landscape of research related to gamification in education	• Learning, motivation, and participation for students improved with the use of gamified interventions
(Behl et al., 2022)	• Emerging trends in gamification and e-learning for young students	• Personalisation, game elements, learner styles, and learner engagement identified as potential new research areas
(Sharma et al., 2024)	• Overview of the research landscape on the use of gamification in business between 2012 and 2022	• Video games, metaverse, industry-specific designs, e-commerce, and sustainable development identified as potential emerging

Paper	Focus Area	Derived Insights
		areas for the application of gamification in a business
(Aguilar-Cuesta et al., 2024)	• Role of educational technology in social sciences	• Geography is the most prevalent field making use of educational technology at various stages of education • Video games, AR, and VR are gaining more visibility in educational processes
(Schöbel et al., 2021)	• Studied the utilisation of game concepts in digital learning environments between 2000 and 2019	• VR, game design, virtual worlds, performance, collaboration, motivation, and stimulation are identified as saturated research areas • Mobile games, flow, AR, competition, and engagement were identified as developing research areas • Satisfaction, badges, cognitive load, avatar, computer-based learning, MOOC, active, enjoyment, and AI were identified as emerging research areas
(Marín-Suelves et al., 2022)	• Research trends relating to video games and education	• Highlights the positive impact of video games on learning, motivation, and class dynamics • Exploration of the possible usefulness and challenges to the adoption of video games in the classroom and the necessity of training teachers about utilizing active methodologies in teaching, were identified as some of the emerging research trends
(Chen et al., 2021)	• Evaluate how game-based learning (GBL) has influenced science and mathematics education between 1991 to 2020	• GBL is used at present in science and mathematics to improve learner motivation and engagement and lower learning anxiety
(Tyni et al., 2022)	• Use of rewards in serious and educational games between 1969 and 2020	• Gamification, physical activity, health, game design, and game-based learning were identified as the most prominent research areas

From Table 1, we observe that gamification, game-based learning, serious games, and health-related or intellectual structure of research in games are the prevalent themes in research literature related to the use of bibliometric analysis in the domain of digital games and HCI. The research of Carbonell et al. (2009) can be considered as the first use of bibliometric methods in the context of digital games. The use of bibliometric methods to evaluate the intellectual structure of research in digital games is fairly recent. The predominant focus of the use of bibliometric analysis to date has been on gamification and game-based learning or educational games. Only two studies, Sun et al. (2024) and Zhao et al. (2023), has used bibliometric analysis in the context of entertainment digital games, focusing on the knowledge structure of research in massive multiplayer online role-playing games and video game social communication, respectively.

2.2 Application of bibliometric analysis in haptics

In Table 2, we have summarised the application of bibliometric analysis in research related to haptics.

Table 2: Publications where bibliometric analysis has been used in relation to haptics

Paper	Focus Area	Derived Insights
(Wang et al., 2023)	• Identify the latest research trends in the field of design related to virtual products and multimodal senses.	• VR-related research most prevalent in the domain of research on virtual technologies • Majority of the research is still focused on the visual modality despite growing interest in other sensory modalities • Research in haptic interfaces is an important future research trend
(Samanta et al., 2023)	• Intellectual structure of the research literature in the domain of VR and haptics	• Research related to haptic devices, haptic interfaces, and user experience continues to remain an important focus area • Medical science and healthcare were the earliest adopters of VR and haptic technology in research and applications • Tactile internet, remote teleoperation, and remote rehabilitation are emerging research themes
(Hsu & Chang, 2023)	• Application of haptic force feedback technology in dental education	• Applications related to VR are the dominant theme • An increased number of research publications related to the application of haptic force feedback in dental education indicates a higher interest in the technology for this field

The use of bibliometric analysis methods in research related to haptic modality is a much more recent phenomenon than their use in digital games and HCI. We also observe that the bibliometric analysis in haptics is closely associated with research in VR.

From the above-reviewed literature, we infer that bibliometric analysis methods have been used to independently analyse research literature related to digital games and research in haptic technology. Systematic reviews are available on specific research cases of haptic modality in digital games, particularly in the context of serious games. However, we observe that there is no comprehensive study that provides a detailed overview of the intellectual structure of research related to the haptic modality and digital games, nor identifies the prevalent research themes in this domain. In this article, we aim to identify the most prominent areas of research in the domain of digital games and haptics by employing bibliometric methods.

3. Methodology

To evaluate the current landscape of research in haptics concerning digital games, we conducted a bibliometric co-occurrence analysis using the Scopus database. The methodology we used followed a three-stage process of retrieval, screening, and analysis, summarised in Figure 1.

Stage 1: Literature retrieval. We searched the Scopus database using the keyword string "gam* AND (haptic* OR haptics)". The intent of this search string was to capture the broadest possible set of publications that exist at the intersection of digital games and haptics. We used wildcard operators to include morphological variants (e.g., *game*, *games*, *gaming*; *haptic*, *haptics*, *haptically*). The search was conducted on publications from 1995 — the year of the first identified research at this intersection (Ouhyoung et al., 1995) — through June 2025. The search returned 1,871 records encompassing articles, conference papers, book chapters, reviews, editorials, books, and short surveys. All records were in the English language.

We did not include the Web of Science (WoS) database in our study as it returned considerably lesser number of record for the same keyword search string, which suggests limited indexing depth in this

domain. Apart from this coverage difference, combining databases from Scopus and WoS within VOSViewer is technically unfeasible, and this aspect has been highlighted by Waltman (2023) in the VOSviewer version 1.6.20 manual where they have stated that "combining data from different data sources is not possible" (Lim et al., 2024). Hence, our single database approach is not only methodologically appropriate on the basis of evading erroneous cross-database comparisons (Schöbel et al., 2021), but is also the technically valid approach for VOSViewer-based co-occurrence analysis. We have also excluded the Google Scholar database due to its lack of a transparent indexing policy, susceptibility to database inflation through duplication, and overall inconsistent record quality (Halevi et al., 2017). Thus Scopus was selected as the sole source for our study and is consistent with established practises in bibliometric studies of comparable scope (Donthu et al., 2021). Furthermore, for the specific domain of our study, Scopus provides a significantly broader coverage of HCI literature than WoS, primarily due to its indexing of ACM and IEEE peer-reviewed conference proceedings, the two publication families which are most relevant to haptics and games research (Meho & Rogers, 2008).

Stage 2: Screening and keyword normalisation. From the 1,871 retrieved records, we extracted citation metadata, abstracts, and author-assigned keywords as an RIS file from Scopus. We then screened the dataset for keyword ambiguity. We standardised terminological variants to single canonical forms: *VR* → virtual reality, *AR* → augmented reality, *HCI* → human-computer interaction, *virtual environment* → virtual environments, *serious game* → serious games, *haptic interface* → haptic interfaces, *visual impairment* → visual impairments, *haptic device* → haptic devices, *game* → games, and *QoE* → quality of experience. The terms *haptic* and *haptics* were not merged, as their use in the literature is context-dependent and carries distinct meanings. After normalisation, we imported the cleaned dataset into VOSviewer (Version 1.6.20) (Centre for Science and Technology Studies, 2020).

Stage 3: Co-occurrence analysis and relevance filtering. We applied co-occurrence analysis to the normalised keyword dataset. Co-occurrence analysis is a quantitative bibliometric method that identifies and measures how frequently specific terms, such as keywords, concepts, or author names, appear together across a collection of research documents, revealing the intellectual structure and thematic clusters of a research domain (Callon et al., 1983; White & McCain, 1998). Based on the guidelines of van Eck and Waltman (2014), we set a minimum co-occurrence threshold of 10, which ensures only keywords appearing at least 10 times across the corpus were retained for analysis. This threshold serves a dual function. Methodologically, it suppresses low-frequency noise and produces more stable, interpretable clusters. As a relevance filter, it operationally excludes publications in which the keywords appear only peripherally — such as papers that reference haptics or games in a single sentence or in a bibliography entry — since such papers are unlikely to contribute to the minimum-occurrence count of any keyword pair. The threshold we set thus provides an implicit but principled quality screen beyond the initial keyword search, which is analogous in function to the relevance screening stage of a systematic review. This process yielded 62 retained keyword items organised into six clusters. The full screening and analysis process is represented in Figure 1.

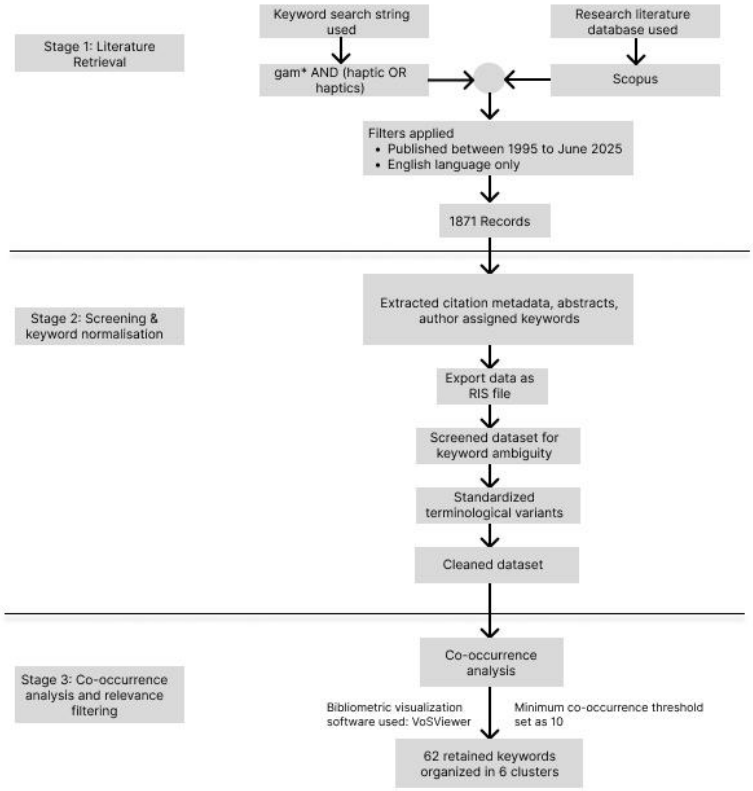


Figure 1: Methodology used for co-occurrence analysis of research literature in the domain of digital games and haptics

4. Results

In this section we present the results of the co-occurrence analysis performed on the 1,871 records we had identified from the Scopus database. We begin with the density and overall network visualisations to establish the broad landscape, then examine three thematic patterns that emerge from the network analysis: VR as the dominant gravitational centre of the field, serious games as the primary application domain, and the systematic underrepresentation of entertainment digital games. We conclude with the overlay visualisation, which identifies emerging and declining research themes. The results are summarised in Table 5.

4.1. Density Visualisation: First Signal of the Research Landscape

The density visualisation (Figure 2) provides us with the first overview of research concentration in the domain of digital games and haptics. The large bright red region surrounding haptics and VR[1] indicates that these are by far the most densely researched areas in the corpus. Notable yellow concentrations visible around haptic feedback, haptic interfaces, serious games, rehabilitation, and HCI identify these as the next tier of significant research activity. The regions surrounding AR and games show a less intense but meaningful yellow spread, confirming these as secondary research areas.

Of particular relevance to this study, we observe that the video games node and quality of experience node are surrounded by distinctly light blue regions, indicating low publication density. The small area of these regions signals not only low volume, but also isolation from the denser research clusters — a pattern that the network visualisation quantifies in detail.

[1] All figures use virtual reality as we replaced VR with virtual reality. However, in the text we represent it as VR for brevity. Similar is the case with augmented reality in figures but presented as AR in text and human-computer interaction as HCI.

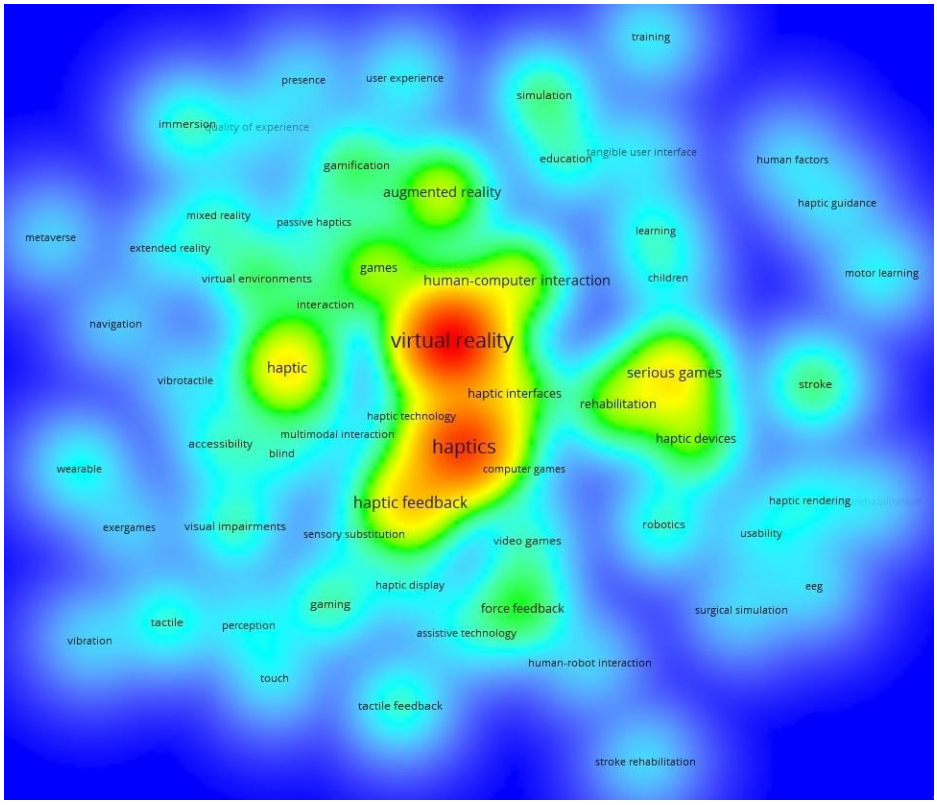


Figure 2: Co-occurrence Analysis - Density Visualisation Diagram. Red corresponds to the highest density, and blue corresponds to the lowest density

4.2 Network Visualisation: Overall Structure and Six Research Clusters

Figure 3 presents the network visualisation, which identified 62 co-occurring keyword items organised into six clusters. VR is the largest observed node in the network, with 56 links, a link strength of 515, and 341 occurrences; haptics is the second largest node, with a link strength of 317 and 251 occurrences. The link strength between VR and haptics is 77 — the strongest pairwise relationship in the entire network — confirming that these two research areas define the structural core of the domain.

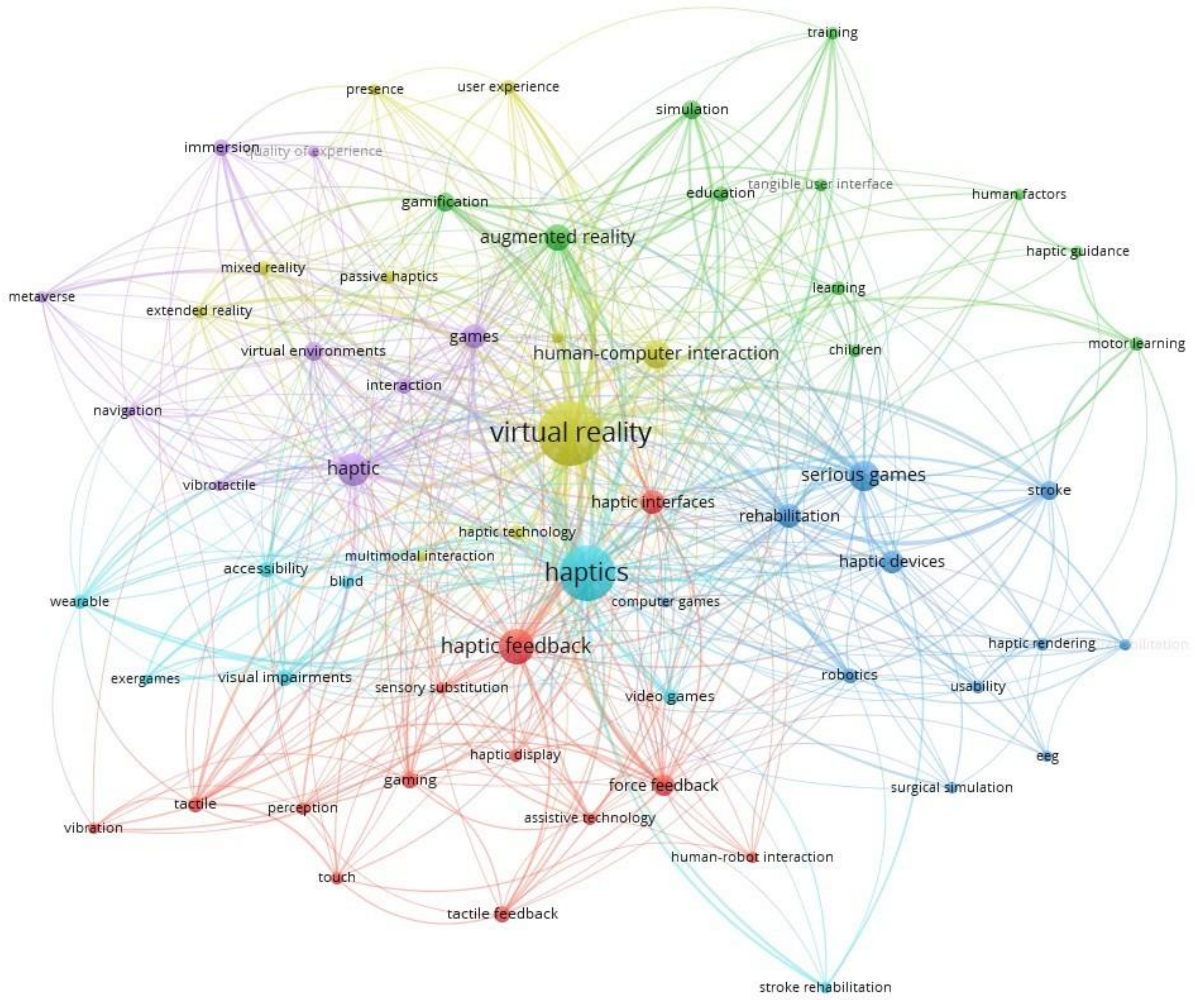


Figure 3: Co-occurrence Analysis - Network Visualisation Diagram[2].

Table 3 provides the full cluster-level data. The overarching research focus area of each cluster is determined by observing the most prominent research area in a cluster based on its number of links, link strength, and number of occurrences as well as how the other research areas in a cluster are thematically linked to it. Based on this, we identify six overarching research focus areas, summarised in Table 4: haptic feedback and its applications (Cluster 1); training and education (Cluster 2); medical applications of haptics and digital games (Cluster 3); medium of interaction (Cluster 4); human perception in virtual settings (Cluster 5); and medical rehabilitation and assistance (Cluster 6).

We note that Clusters 3 and 6 both involve medical contexts and are conceptually distinguishable by their dominant application mode. Cluster 3 is anchored by the serious games node and encompasses task-focused clinical simulation — surgical training, procedural learning, and stroke recovery exercises in a game format. Cluster 6 is anchored by the haptics node and encompasses therapeutic recovery and assistive access — haptic aids for visual impairment, exergames for rehabilitation, and wearable assistance for disability. The shared medical domain reflects a genuine concentration of haptics-games research in healthcare, while the different dominant nodes help us to confirm that these are structurally separate research communities within that domain.

[2] VOSViewer has adopted a distance-based approach for the visualisation of the various bibliometric networks. In distance-based bibliometric mapping, the distance between two items or nodes represents the strength of the relationship between the items or the nodes. A shorter distance is indicative of a strong relationship and vice versa (Ludo Waltman et al., 2010)

Table 3: Clusters identified from network visualisation of co-occurrence analysis

Cluster	Items	Links	Total link strength	Occurrences	Avg. Publication Year
Cluster 1	Assistive technology	18	27	15	2020
	Force feedback	24	69	37	2014
	gaming	16	34	24	2017
	Haptic display	11	20	15	2014
	Haptic feedback	34	109	101	2018
	Haptic interfaces	25	51	50	2014
	Human-robot interaction	9	13	11	2019
	Perception	16	24	14	2016
	Sensory substitution	14	19	11	2018
	Tactile	18	45	20	2019
	Tactile feedback	13	24	22	2015
	Touch	11	20	13	2017
	Vibration	9	13	11	2017
Cluster 2	Augmented reality	30	108	61	2020
	Children	12	12	13	2016
	Education	14	35	19	2019
	Gamification	22	27	32	2022
	Haptic guidance	7	14	12	2014
	Human factors	9	14	11	2015
	Learning	20	29	18	2017
	Motor learning	10	28	16	2019
	Simulation	16	47	29	2016
	Tangible user interface	10	18	13	2018
	Training	12	30	15	2019
Cluster 3	Computer games	12	16	10	2012
	EEG	7	10	12	2019
	Haptic devices	17	46	44	2018
	Haptic Rendering	14	20	15	2016
	Neurorehabilitation	11	21	12	2022
	Rehabilitation	31	117	49	2015
	Robotics	20	41	21	2015
	Serious games	37	127	79	2019
	Stroke	20	69	31	2015
	Surgical simulation	8	15	11	2013
	Usability	12	18	13	2017
Cluster 4	Extended reality	18	38	14	2024
	Haptic technology	15	20	16	2019
	Human-computer interaction	30	83	62	2019
	Mixed reality	17	31	18	2020

Cluster	Items	Links	Total link strength	Occurrences	Avg. Publication Year
	Multimodal interaction	9	11	10	2020
	Multisensory	16	19	11	2020
	Passive haptics	12	26	15	2021
	Presence	14	22	11	2018
	User experience	17	29	16	2022
	Virtual reality	56	515	341	2019
Cluster 5	Games	38	84	50	2018
	Haptic	41	121	87	2017
	Immersion	17	46	22	2019
	Interaction	19	36	20	2015
	Metaverse	14	25	11	2024
	Navigation	17	31	10	2016
	Quality of experience	7	10	12	2016
	Vibrotactile	15	24	11	2017
	Virtual environments	22	46	30	2015
Cluster 6	Accessibility	20	38	19	2019
	Blind	14	28	15	2015
	Exergames	8	19	10	2016
	Haptics	56	317	251	2016
	Stroke Rehabilitation	7	19	12	2013
	Video games	20	35	19	2017
	Visual impairments	17	40	23	2018
	Wearable	17	39	18	2021

Table 4: Research focus areas identified from the network visualisation of co-occurrence analysis

Cluster Number	Main Research Focus
Cluster 1	Haptic feedback and its applications
Cluster 2	Training and education
Cluster 3	Medical applications of haptics and digital games
Cluster 4	Medium of interaction
Cluster 5	Human perception in virtual settings
Cluster 6	Medical rehabilitation and assistance

In the following three subsections, we analyse the thematic patterns that emerge from closer examination of the network.

4.3 VR as the Gravitational Centre of the Field

The most pervasive structural pattern we observe across the network is the convergence of all major haptic research themes toward VR. This is not simply a finding about VR in isolation — it is a finding about how the entire field is organised. Across every prominent node in the network, we observe that VR represents the strongest or second-strongest co-occurrence relationship. We demonstrate this pattern by examining the haptic feedback, haptic interfaces, force feedback, HCI, and AR nodes.

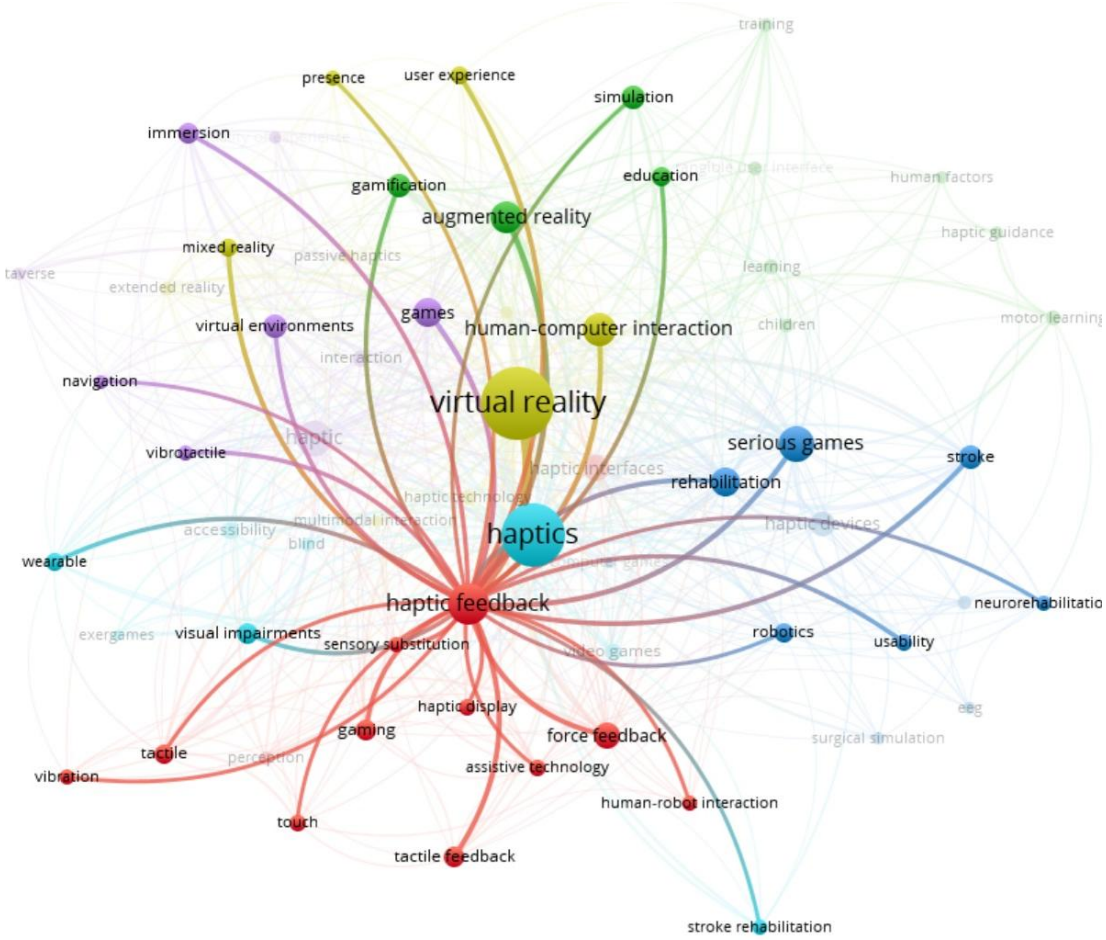


Figure 4: Focusing on the haptic feedback node in the network diagram of the co-occurrence analysis

We observe that Haptic feedback (Figure 4) is the most prominent node in Cluster 1, with 34 links, a link strength of 109, and 101 occurrences. Its strongest relationship is with VR (link strength = 34), establishing that research on haptic feedback technology is predominantly framed within VR contexts. The link with AR (link strength = 6) is present but substantially weaker, and the link with serious games (link strength = 4) is weak enough to suggest that haptic feedback research has not deeply penetrated even the serious games literature. Notably, from the overlay visualisation, we observe that (Figure 13), wearables, neurorehabilitation, mixed reality, and gamification are emerging as new research directions associated with haptic feedback — a signal that the technology is beginning to expand beyond its VR core.

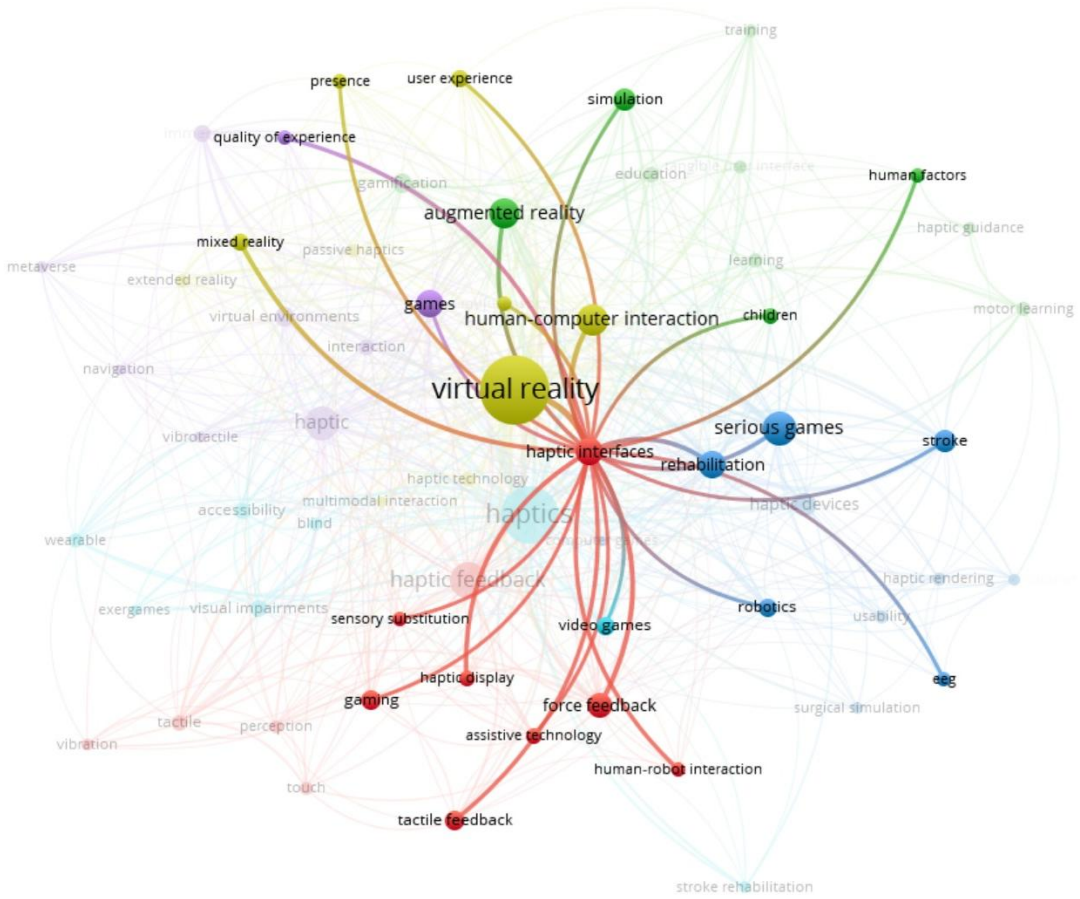


Figure 5: Focusing on the haptic interfaces node in the network diagram of the co-occurrence analysis

Haptic interfaces (Figure 5) shows a structurally distinct pattern that reinforces the VR dominance finding from a different angle. Unlike haptic feedback, we observe that the haptic interfaces node has no link to the haptics node at all, despite being spatially close to it in the network. Its strongest relationship is with VR (link strength = 10), with a secondary link to AR (link strength = 2). This absence of a direct link to haptics — the field's definitional core — suggests that research on the physical devices that deliver haptic experience has become so thoroughly embedded in VR discourse that it is rarely discussed in terms of haptics independently. The link strengths with video games (1) and serious games (2) are negligible, indicating that haptic interface research has not meaningfully engaged with games as a primary application context.

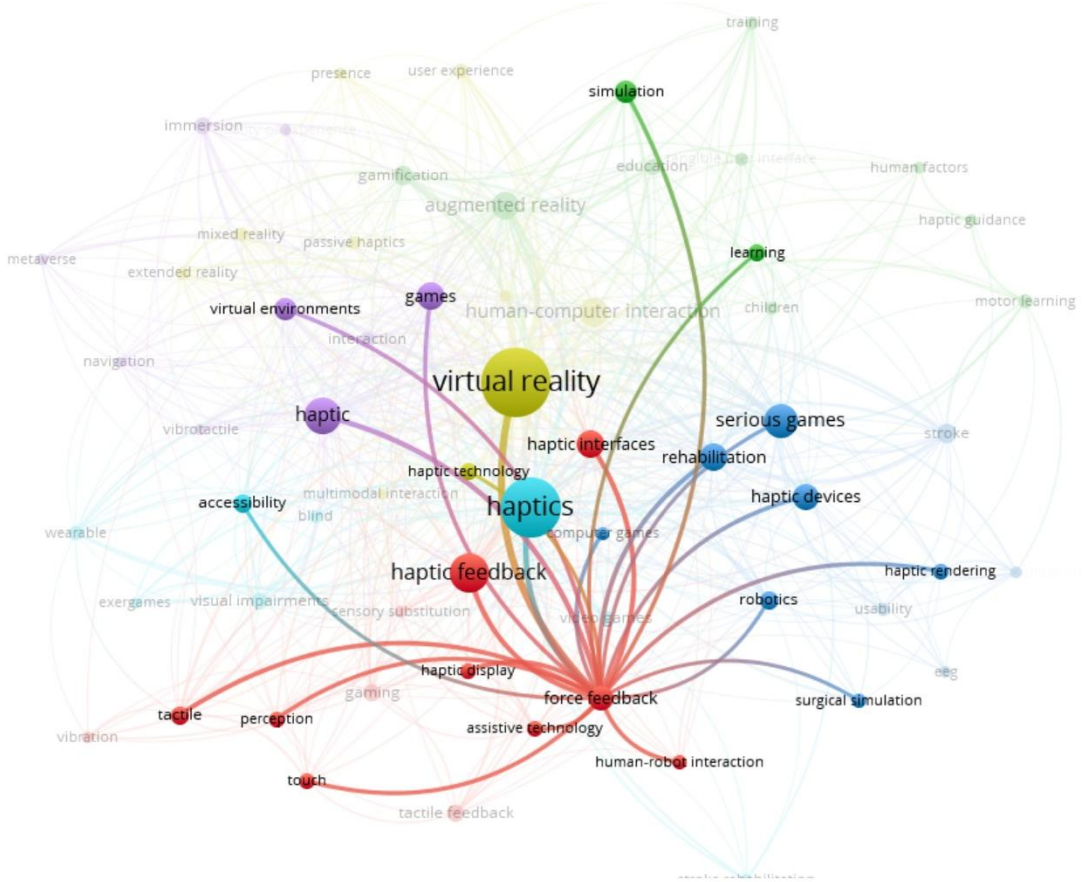


Figure 6: Focusing on force feedback nodes in the network diagram of the co-occurrence analysis

We observe that Force feedback (Figure 6) presents a more nuanced picture. With 24 links and a link strength of 69, it is a well-connected node, but its relationship to games is structurally weak. Its strongest co-occurrence is with VR (link strength = 15), followed by connections to serious games and rehabilitation — predominantly through simulated procedural training contexts such as surgical simulation. It is worth noting that there is no link between the force feedback node and the video games node, and no link to the quality of experience node. Even though force feedback is a technology commercially integrated in game controllers — like racing wheel resistance or DualSense's adaptive triggers — however, this commercial reality is entirely absent from the research literature. This constitutes one of the clearest illustrations of the academia-industry disconnect our study identifies.

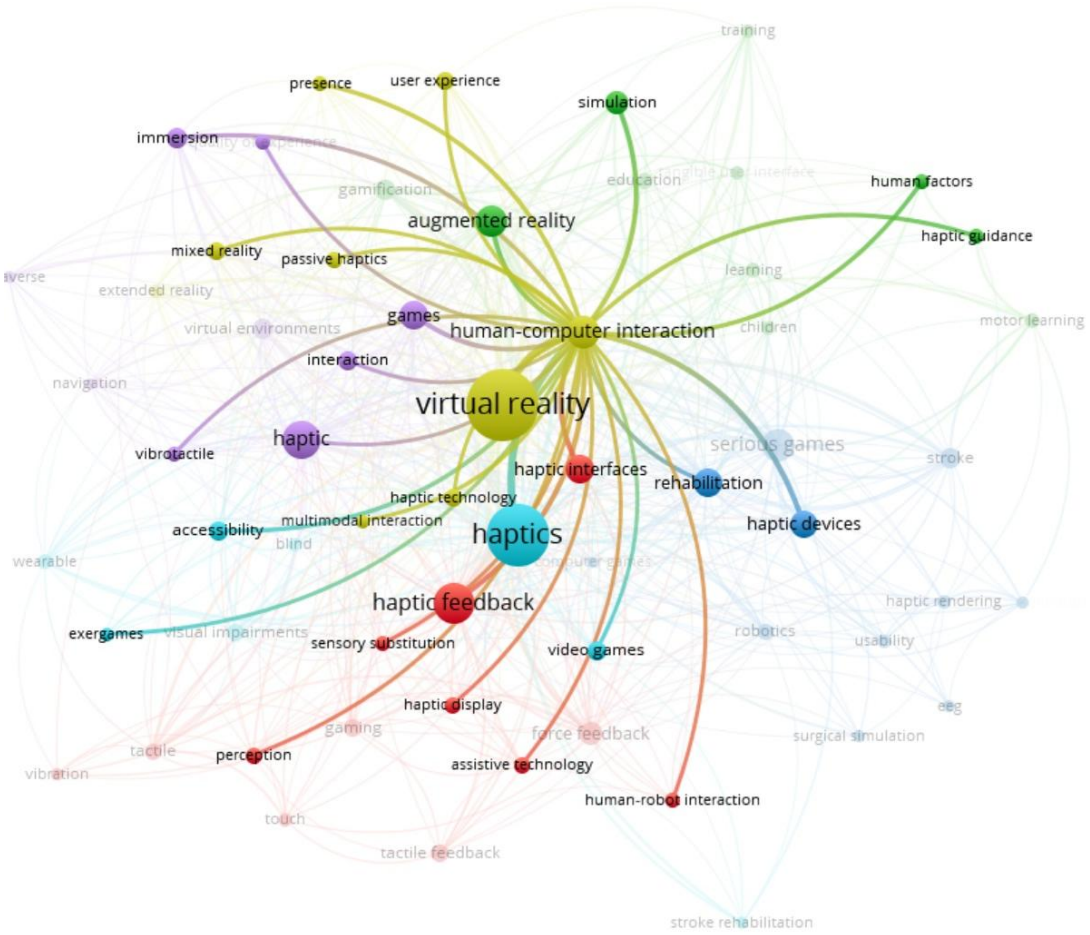


Figure 7: Focusing on HCI nodes in the network diagram of the co-occurrence analysis

HCI (Figure 7) is Cluster 4's second-largest node after VR, with 30 links, a link strength of 83, and 62 occurrences. Its relationship with VR (link strength = 17) and haptics (link strength = 16) is nearly equal, confirming that HCI research in this domain treats VR and haptics as roughly co-equal concerns. However, we observe that HCI's connection to the granular aspects of player experience — interaction, quality of experience, immersion, presence — is structurally weak, with all these nodes appearing at considerable distance from the HCI node despite conceptual proximity. HCI's link to video games carries a link strength of only 1, the lowest possible meaningful connection, indicating that the discipline that studies human relationships with computational systems has largely overlooked entertainment gaming as a context for haptic investigation.

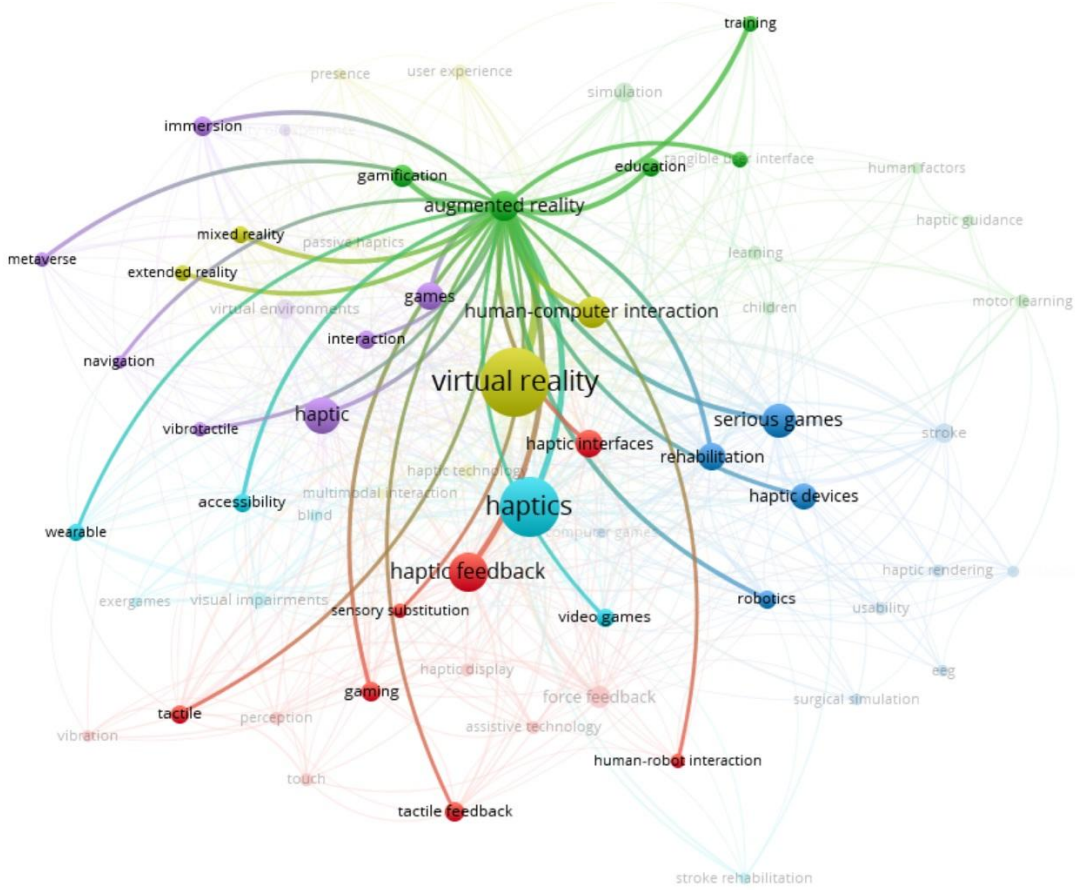


Figure 8: Focusing on the AR node in the network diagram of the co-occurrence analysis

It is interesting to observe how AR (Figure 8) deviates from this pattern in one revealing way. While AR's strongest link is predictably with VR (link strength = 28), its link strength with haptic feedback (6) is relatively higher than with other haptic categories. This suggests that AR-specific haptic research has engaged more with feedback technology than with haptic systems or interfaces more broadly — possibly reflecting AR's reliance on visual overlay and gesture, where tactile feedback serves the purpose of supplementary confirmation rather than a primary experience channel. The AR node's links to gamification (5), games (4), and serious games (4) are roughly equal, distinguishing AR from VR's overwhelming bias toward serious game applications. However, its link to video games remains weak (1), which is consistent with the broader observed pattern.

Taken together, these five nodes tell a consistent story: irrespective of which haptic research theme or HCI concept is examined, VR exerts the dominant gravitational pull. The field has organised itself around the VR-haptics axis to such an extent that even logically adjacent concepts — force feedback, haptic interfaces, HCI — are primarily understood in VR terms rather than in terms of the broader digital games landscape, and particularly not in terms of entertainment gaming.

4.4 Serious Games as the Dominant Application Domain

Within the VR-centred structure of the field, we observe that serious games constitute the primary application framework through which haptics research reaches practice. The serious games node(Figure 9) is the largest in Cluster 3, with 37 links, a link strength of 127, and 79 occurrences. Its co-occurrence relationships trace the contours of what the field means by "applied haptics in games": rehabilitation (link strength = 9), VR (29), stroke (16), haptic devices (5), and learning contexts including simulation, surgical simulation, and motor learning.

What is notable is not just where serious games connects, but where it does not. The link strengths between serious games and haptic feedback (4), AR (4), and haptic interfaces (2) are all weak. This means that research on the technology of haptic feedback is not substantially co-occurring with research on

serious games applications — the two communities are producing parallel, largely non-integrating bodies of work. The serious games field is borrowing haptic devices and VR as enabling platforms, but the richer discourse on what haptic feedback feels like and how to design it is happening elsewhere.

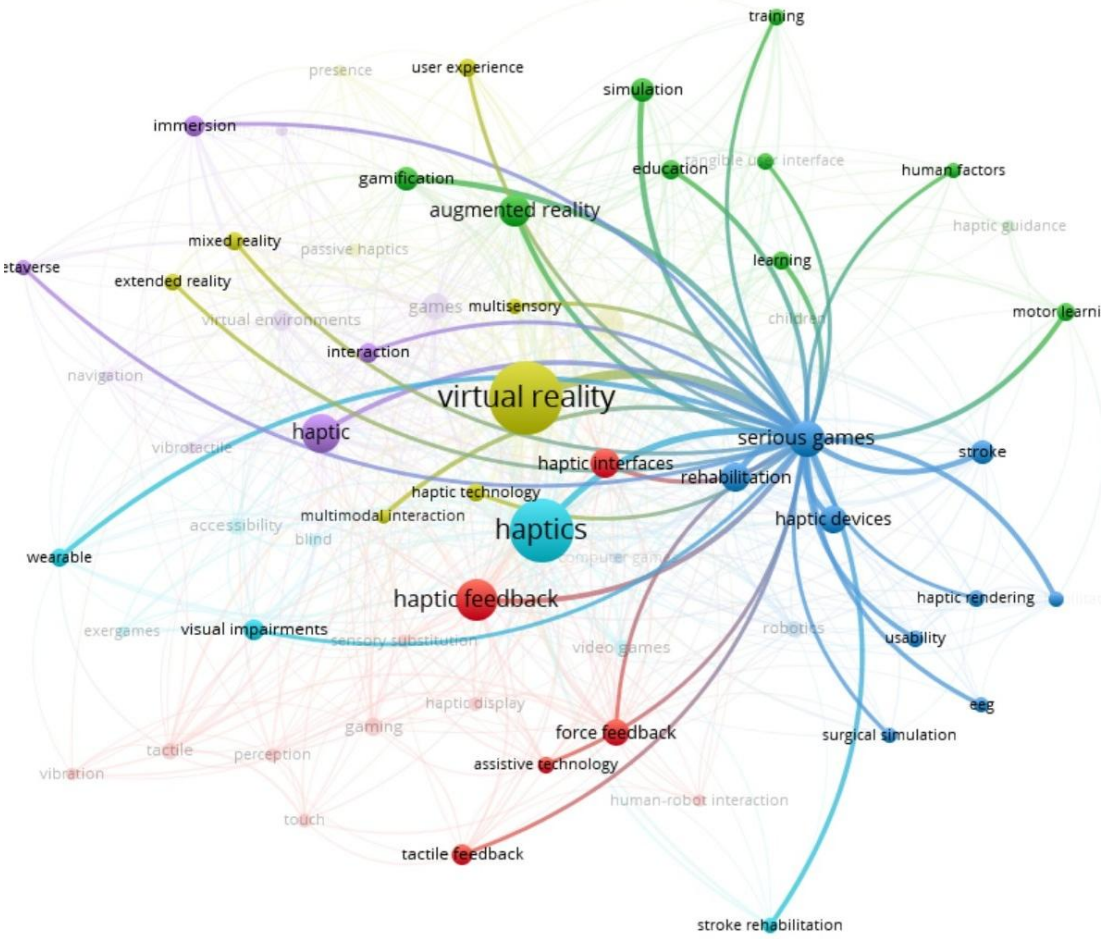


Figure 9: Focusing on Serious Games and rehabilitation nodes in the network diagram of the co-occurrence analysis

The distinction between Clusters 3 and 6 becomes meaningful here. Cluster 6's dominant nodes — haptics (251 occurrences), video games (19 occurrences), accessibility (19 occurrences), visual impairments (23 occurrences), and wearables (18 occurrences) — indicate that the research community is focused on assistive and rehabilitative access rather than clinical training simulation. This community is engaging with haptics as an accessibility modality, and the presence of video games in this cluster reflects research using commercial game formats as the delivery mechanism for therapeutic intervention. These are digital games with haptics in the service of disability support, not entertainment gaming in the service of player experience — an important distinction that the cluster structure makes visible.

4.5 The Entertainment Digital Games Gap

The second research question our study addresses — the extent of research in entertainment digital games relative to the broader haptics-games landscape — is answered by three converging lines of evidence from the network: the video games node, the computer games node, and the quality of experience node. When examined together, we observe that these nodes reveal not only an absence of research, but also a systematic structural disconnection between entertainment gaming and every major haptic research theme in the corpus.

Video games (Figure 10) is a small node located in Cluster 6, with 20 links, a link strength of 35, and 19 occurrences. Despite its spatial proximity to the haptics node in the visualisation, the link strength between the two is only 4 — one of the weakest meaningful connections in the network, particularly given that haptics is the second-largest node overall. The link with VR (8) is the strongest the video games node

carries, yet even here, the spatial distance between the nodes indicates a low probability of co-occurrence. The research areas that do link to video games — stroke, rehabilitation, learning, accessibility, blind, assistive technology — are all associated with serious game applications. Entertainment digital gaming, the commercially dominant form of video game consumption, does not appear as a research context for the video games node in its own right.

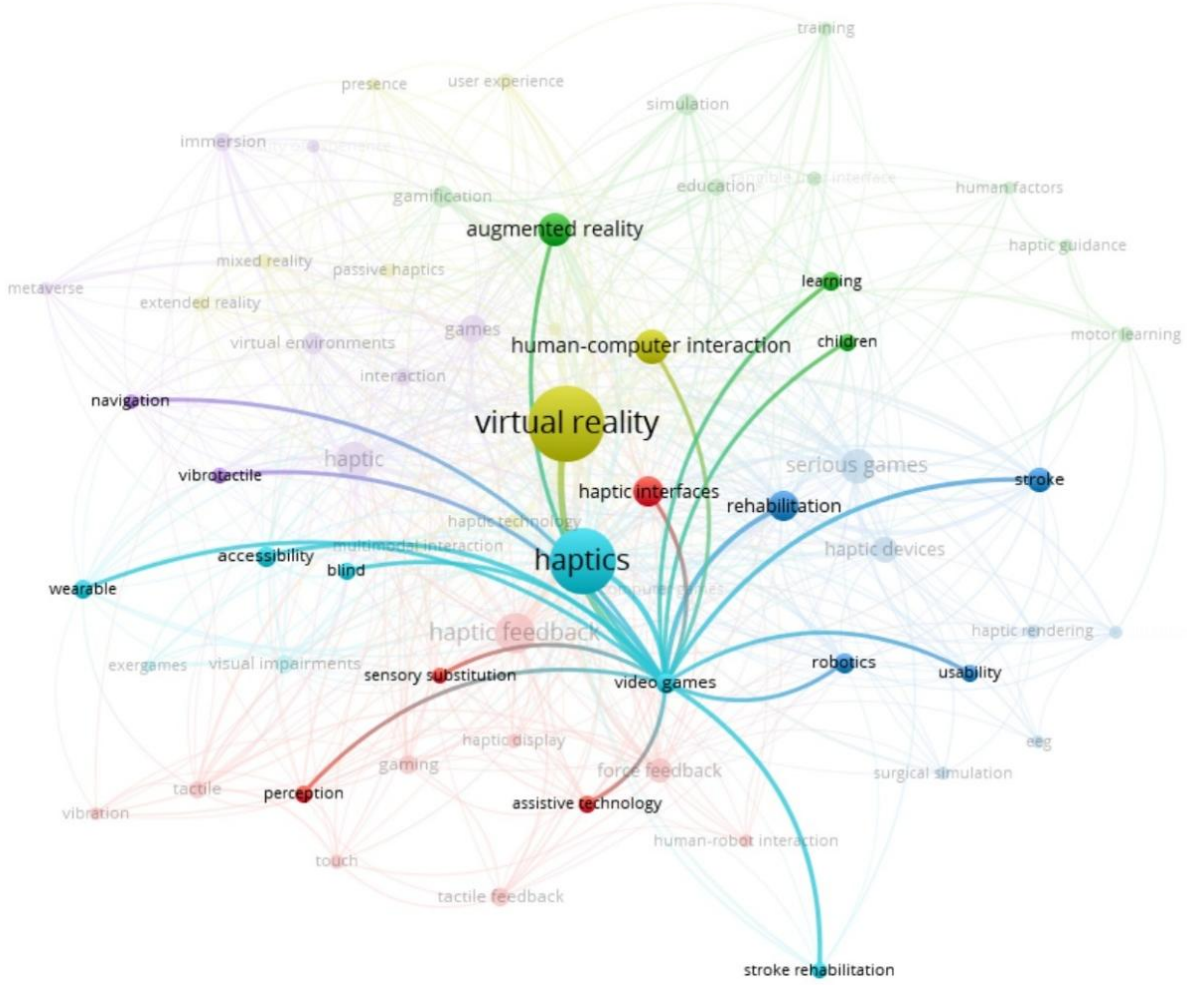


Figure 10: Focusing on the video games node in the network diagram of the co-occurrence analysis

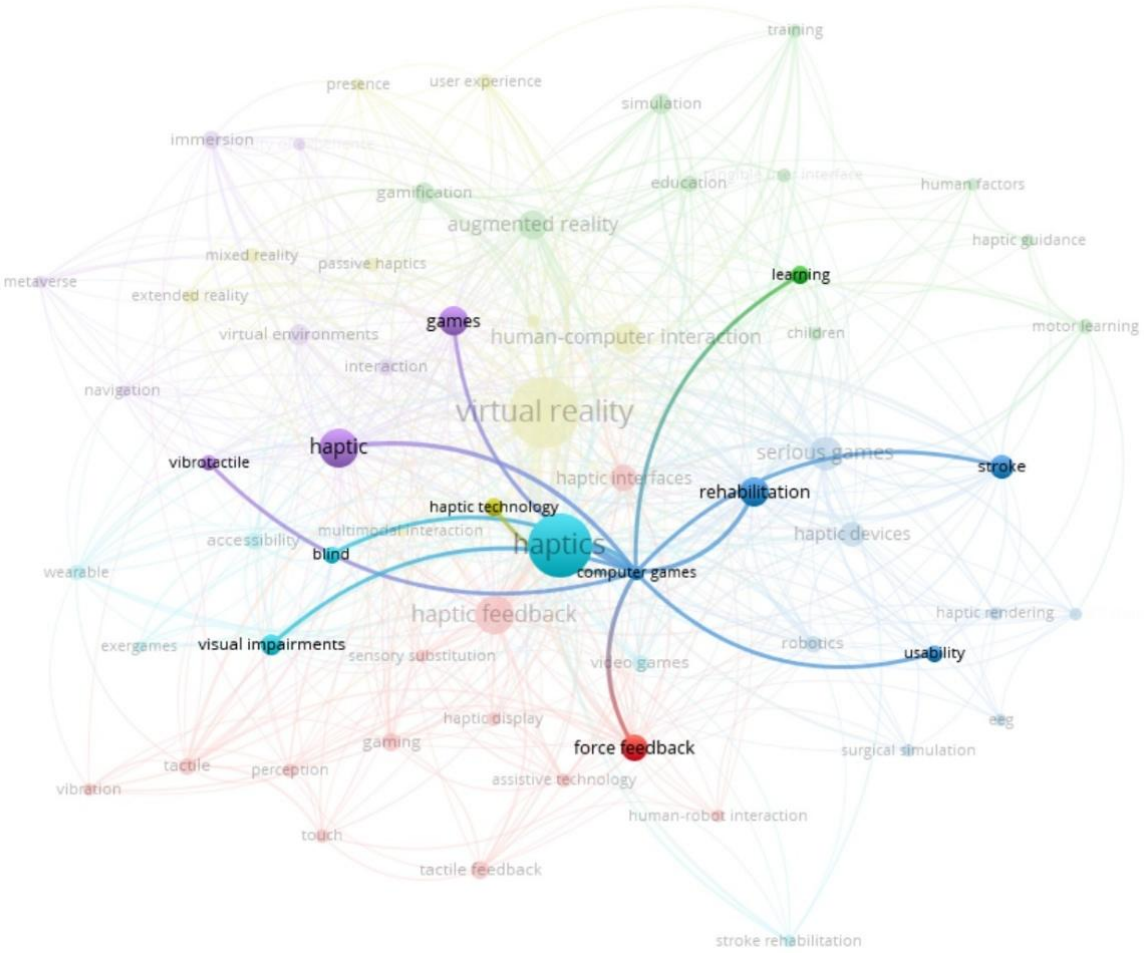


Figure 11: Focusing on the computer games node in the network diagram of the co-occurrence analysis

Computer games shows a parallel pattern (Figure 11). With an average publication year of 2012, it is one of the oldest themes in the network by temporal signature, suggesting that early haptics-games research used "computer games" as its framing before the terminology evolved toward "video games" and, separately, toward "serious games." Its current structural position — distant from all major nodes, weakly linked — is indicative of terminological obsolescence rather than active research decline.

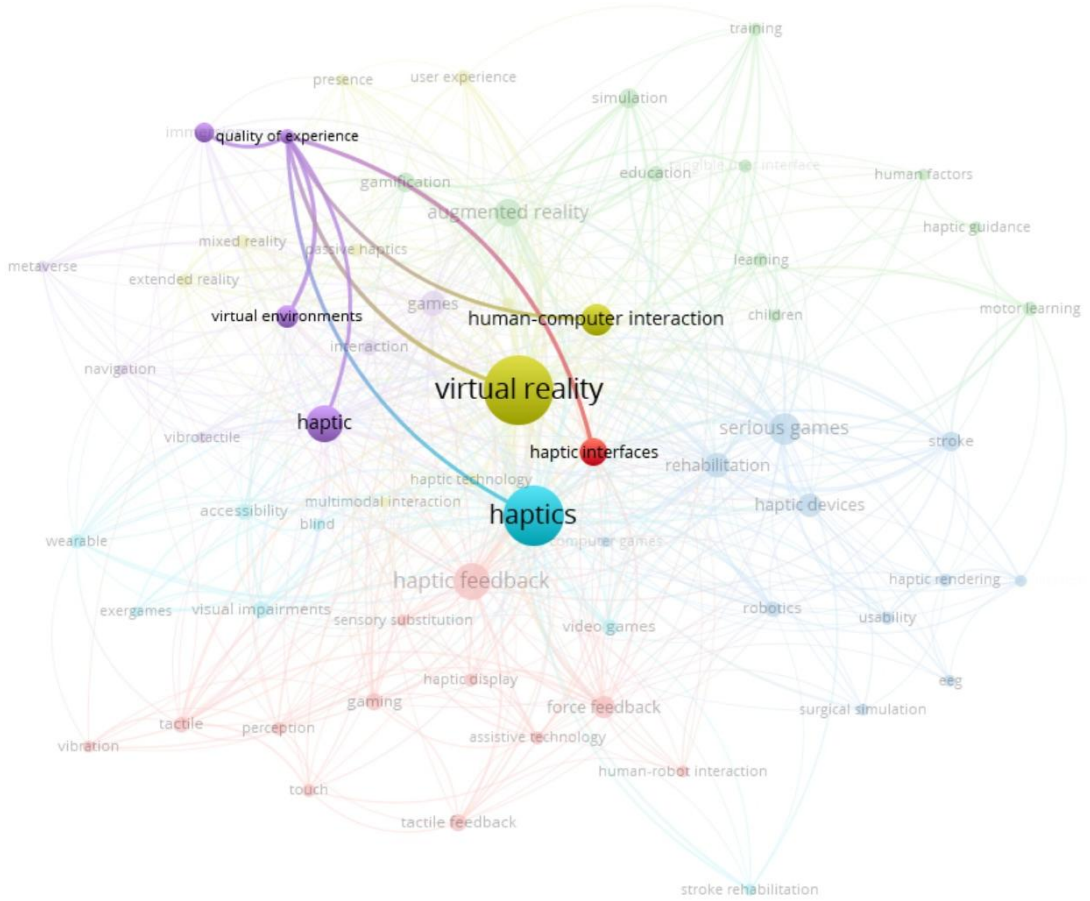


Figure 12: Focusing on the Quality of Experience node in the network diagram of the co-occurrence analysis

Quality of experience (Figure 12) provides the most direct answer to what is missing. Though this node is linked to VR, haptics, HCI, and haptic interfaces, it carries weak link strengths with all of them, and has no link whatsoever to either serious games or video games. This means that across 1,871 publications, essentially no research has meaningfully brought together haptics, digital games, and user experience evaluation into a co-occurring research conversation. The concept of how haptics shapes what a player feels — the quality of their experience — is the precise question that entertainment game design requires, and it is structurally absent from the literature.

The convergence of these three nodes reveals a clear story. We can see that academic research in haptics and digital games has organised itself around VR, healthcare, and assistive technology. Entertainment digital games — despite constituting the largest commercial application of haptic technology, from console rumble motors to the DualSense's adaptive triggers — remain on the periphery of the research landscape. This gap is not incidental but structural: the weak link strengths and large spatial distances are not the signature of an emerging research area finding its feet, but of a domain that has not yet entered the field's mainstream discourse.

4.6 Overlay Visualisation: Emerging and Declining Research Themes

The overlay visualisation (Figure 13) maps the temporal dimension of the network by colouring nodes according to their average publication year. Red-tinted nodes (average publication year 2020 or above) identify emerging research themes; deep blue-tinted nodes identify older or declining themes.

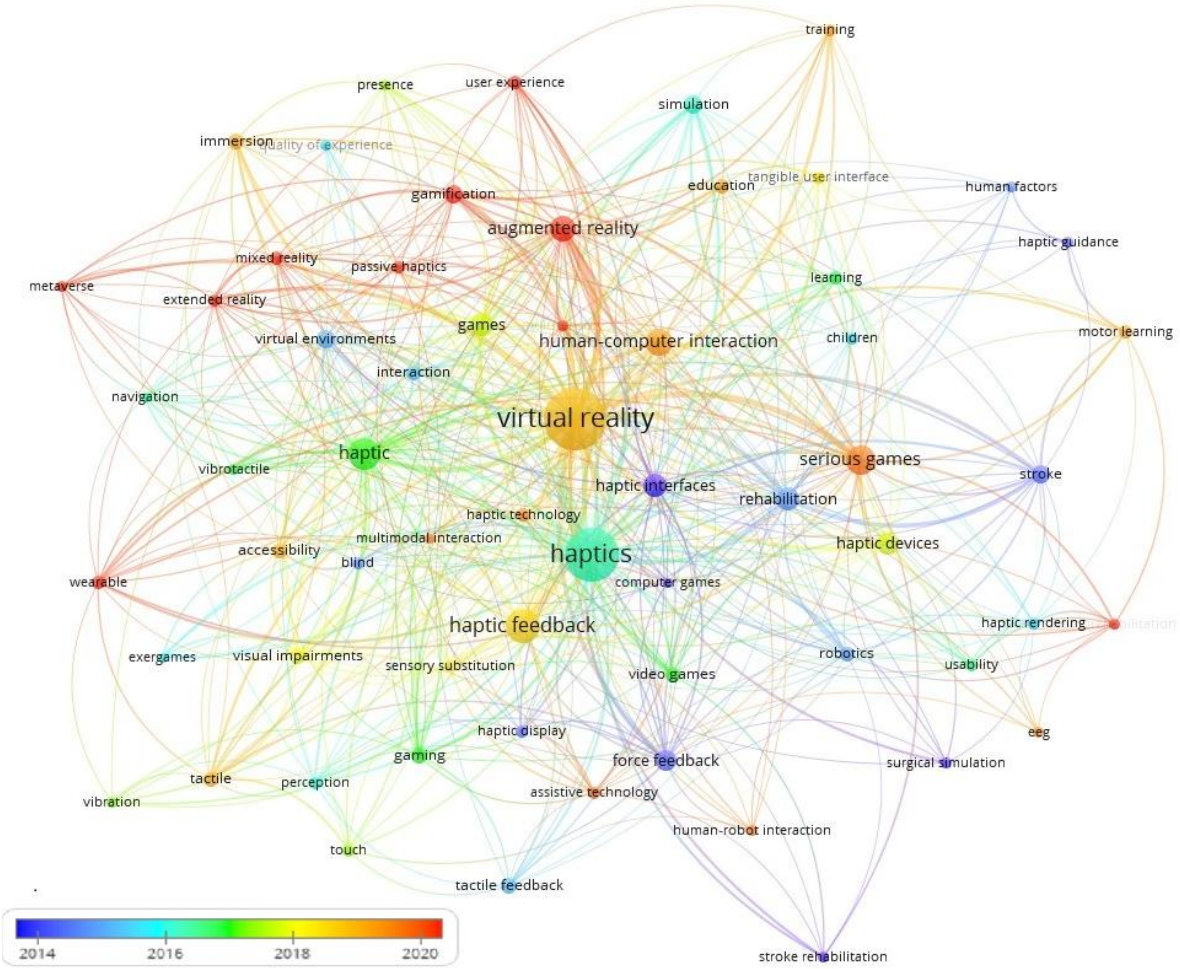


Figure 13: Co-occurrence Analysis - Overlay Visualisation Diagram[3].

The emerging themes we identified are: wearables, metaverse, extended reality, mixed reality, passive haptics, gamification, AR, neurorehabilitation, and user experience. Among these, metaverse and extended reality are the most recent, both carrying an average publication year of 2023 — reflecting the surge of research interest following commercial XR platform launches in 2021–2022. The emergence of user experience as a distinct theme deserves attention, this is because while user experience research in digital games is longstanding, its emergence as a newly identified co-occurring concept in this network reflects its growing association with extended reality, mixed reality, and gamification contexts specifically. Though this is encouraging, but our structural analysis in Section 4.5 confirms that this emerging user experience research is not yet connecting to video games or entertainment gaming contexts.

The declining or older themes — computer games (average publication year 2012), stroke rehabilitation (2013), and surgical simulation (2013) — can be best understood as terminological predecessors to broader current categories rather than abandoned research areas. Computer games has likely given way to the more inclusive video games framing. Stroke rehabilitation has probably been absorbed into the larger rehabilitation node (average publication year 2015). Surgical simulation has evolved into the serious games cluster's medical training applications. The persistence of their content under new labels

[3] The visualisation structure is similar to that of the network visualisation. The colours representing the various nodes are linked to a score determined by the average publication year. As per the VoSViewer manual (Waltman, 2023), the average publication year is described as “average publication year of the documents in which a keyword or a term occurs or the average publication year of the documents published by a source, an author, an organisation, or a country”. The colour ranges from blue to red, with deep blue representing an average publication year of 2014 and below, and red representing an average publication year of 2020 and above.

is indicated by the higher average publication years of their successor nodes, which suggests healthy conceptual evolution rather than the research being completely abandoned.

The results are summarised in Table 5.

Table 5: Summary of Results

Analysis Type	Key Finding	High Focus areas in research landscape	Low Focus areas in research landscape	Implication
Density Visualisation	Significant concentration around haptics and VR	Haptics, VR, Haptic Feedback, AR, Haptic Interfaces, Serious Games, Rehabilitation, HCI	Video Games, Quality of Experience	Research in entertainment digital games (video games) and quality of experience is underexplored
Network Visualisation (Overall)	62 items organized into 6 clusters identified	VR (largest node), Haptics (second largest)	Video Games, Quality of Experience (our point of interest)	VR and haptics are the most predominant research areas with link strength of 77
Network Visualisation - Serious Games Node Focus	Strong relationship between serious games and rehabilitation	Rehabilitation (link strength 9), VR (link strength 29), Stroke (link strength 16), haptic devices (link strength 5)	Haptic feedback, AR, Haptic interfaces (weak links to serious games)	Serious games research leans towards rehabilitation and VR applications, not entertainment
Network Visualisation - Force Feedback Node Focus	Force feedback closely associated with VR research	VR (link strength 15), Haptics, Serious Games, Rehabilitation	Weak links to games and computer games. No link to video games, quality of experience	Force feedback not well-researched in context of video games or quality of experience
Network Visualisation - HCI Node Focus	HCI research associated with VR and haptics equally	VR (link strength 17), Haptics (link strength 16), Haptic Interfaces	Interaction, Quality of Experience, Immersion, Presence (distant nodes) . Video games	Insufficient research linking HCI to granular aspects of user experience in digital games and haptics. Video games underexplored
Network Visualisation - Haptic Feedback Node Focus	Haptic feedback closely associated with VR applications	VR (link strength 34)	Video Games, Serious Games (distant nodes)	Emerging areas: wearable, neurorehabilitation, mixed reality, gamification, AR
Network Visualisation - Haptic Interfaces Node Focus	Haptic interfaces research closely tied to VR and AR	VR (link strength 10)	Video Games (link strength 1), Serious Games, No link to Haptics node	Research on haptic interfaces in context of digital games may be underexplored
Network Visualisation - AR Node Focus	AR research mainly associated with VR and haptics	VR (link strength 28), Haptics (link strength 9), Haptic Feedback (link strength 6)	Serious Games, video games	AR research not significantly related to serious games or gamification in haptics context. Video games underexplored
Network Visualisation - Video Games Node Focus	Video games node relatively small compared to other prominent nodes	VR (link strength 8)	Haptics, Haptic Interfaces (distant), HCI	Research in entertainment digital games has weak relationship with haptics research areas
Network Visualisation - Quality of Experience Focus	QoE node linked to VR, Haptics, HCI but with weak relationships	VR, Haptics, HCI, Haptic Interfaces	No link to Serious Games or Video Games nodes	Insufficient research on how haptics affects quality of experience for game users

Analysis Type	Key Finding	High Focus areas in research landscape	Low Focus areas in research landscape	Implication
Overlay Visualisation	Identified emerging and declining research areas by publication year	Wearable, metaverse, extended reality, mixed reality, passive haptics, gamification, AR, neurorehabilitation and user experience (avg publication 2020 and above)	Computer games (2012), stroke rehabilitation (2013), and surgical simulation (2013)	Older themes evolved into broader/specific areas; wearables and gamification are emerging trends

5. Discussion

The co-occurrence analysis that we have presented in this study maps the intellectual structure of research at the intersection of digital games and haptics across three decades of Scopus-indexed literature. In this section, we interpret these findings in relation to our two research questions, situate them within the broader bibliometric literature on haptics and games, and discuss their implications for the research community.

5.1 Research areas in the domain of digital games and haptics

The six research focus areas identified through our cluster analysis of the clusters from the network visualisation (Figure 3) namely haptic feedback and its applications, training and education, medical applications of haptics and digital games, medium of interaction, human perception in virtual settings, and medical rehabilitation and assistance reveal a field that has developed genuine internal differentiation while remaining concentrated around a narrow set of application contexts. The presence of six structurally distinct clusters within a corpus of 1,871 publications indicates that the haptics-games domain is not monolithic. These are communities that share keywords but engage in largely parallel conversations, as evidenced by the weak inter-cluster link strengths between, for instance, the haptic feedback cluster and the medical applications cluster.

When we compare these findings against prior bibliometric work in adjacent domains it reveals both continuities and important distinctions. Samanta et al. (2023), whose bibliometric analysis examined VR and haptics without distinguishing game contexts, identified haptic devices, haptic interfaces, and user experience as central research themes. Our analysis confirms these themes but reveals that, within the games-specific corpus, they are disproportionately concentrated in medical and rehabilitation application contexts rather than in entertainment or general interactive contexts. Wang et al. (2023), examining research on multimodal senses in virtual technology products, similarly found VR to be the dominant research orientation and haptic interfaces to be an identified future direction — a trajectory our analysis confirms is underway, but it is unevenly distributed. Martin (2018), in his bibliometric examination of the intellectual structure of game research more broadly, had identified a persistent gap between academic research communities and the game industry and opined that design serves as the primary bridge between otherwise disconnected research communities. Our findings extend this observation into the haptics domain specifically: not only does a gap between academia and industry exist, but the research communities within the academic landscape itself are weakly interconnected, suggesting that knowledge generated about haptic feedback technology is not influencing serious games application research, and vice versa.

The emerging themes identified through the overlay visualisation (Figure 13) — wearables, metaverse, extended reality, mixed reality, passive haptics, neurorehabilitation, gamification, and AR — indicate that the field is beginning to diversify beyond its focus on VR-rehabilitation. Notably, user experience has emerged as a distinct co-occurring theme in this corpus, associated primarily with extended reality, mixed reality, and gamification contexts. Though this is an encouraging signal, the network analysis also highlights that this emerging user experience discourse has not yet connected to entertainment digital games — a gap we examine in detail in Section 5.5.

5.2 Structural Biases in the Research Landscape

The most pervasive pattern in our findings is the gravitational pull of VR across every major node in the network. This is not simply a finding about VR research volume but is indicative of how the entire field is organised. Across haptic feedback (VR link strength = 34), haptic interfaces (10), force feedback (15), HCI (17), AR (28), serious games (29), and games (10), VR represents the strongest or second-strongest co-occurrence relationship in every case. The haptics-VR link strength of 77 is the single strongest pairwise relationship in the network and is more than double the next strongest inter-domain connection.

A secondary but related bias is observable in the dominance of serious game applications. When the serious games, games, and gaming nodes are examined collectively, their strongest links run toward VR and medical application contexts — rehabilitation, stroke, surgical simulation, learning — rather than toward entertainment gaming. Critically, neither the serious games node nor the gaming node carries any link to the video games node, indicating that these research communities are drawing no mutual insights from entertainment digital gaming despite the commercial ubiquity of haptic technology in that space.

Several structural factors plausibly account for the VR bias, even if establishing causality lies beyond the scope of this study. VR research has historically attracted medical, military, and industrial training funding — contexts where the performance stakes of haptic interaction are high and where quantifiable outcomes justify instrumented research programmes. Entertainment gaming, by contrast, has been primarily industry-driven, with haptic design decisions made through professional practice rather than published research. The consequence is a research landscape shaped by funding logics rather than user population size: VR haptics serves a relatively small but grant-accessible research base, while entertainment gaming haptics serves a vastly larger but commercially-funded one. This structural asymmetry, rather than any inherent difference in research complexity or importance, may account for the disproportion our analysis reveals — and it points to a clear opportunity for publicly-funded research investment in the entertainment haptics space.

5.3 Haptics, Haptic Feedback, and Haptic Interfaces: Distinct Concepts, Divergent Research Trajectories

A recurring ambiguity in the haptics-games literature is the interchangeable use of the terms haptics, haptic feedback, and haptic interfaces. Our network analysis reveals that these are not merely terminological variants but research constructs with structurally distinct co-occurrence patterns — a finding with substantive implications for how the field understands its own object of study.

Haptics, as the experiential dimension of touch-based interaction — the sensation, its perceived quality, and its contribution to immersion — is the largest and most connected node in the network (occurrences = 251, link strength = 317), and its strongest relationship is with VR (link strength = 77). This reflects the established finding that adding haptics to VR environments enhances user experience, immersion, and sense of presence (Singhal & Schneider, 2021; Zyda, 2005). Haptic feedback — the technology that transmits tactile or kinesthetic sensation to users (Chang, 2002; Stach & Graham, 2011) — carries a substantially lower link strength with VR (34), suggesting that the discourse on haptic experience is more developed than the discourse on haptic feedback technology within VR contexts. Haptic interfaces — the physical devices that deliver haptic feedback (National Research, 1995; Söderström et al., 2022) — carry the weakest link with VR (10) and, distinctively, have no direct link to the haptics node at all despite spatial proximity in the network. This absence suggests that research on haptic delivery hardware has become so embedded in VR application discourse that it is rarely regarded independently in terms of haptic experience.

The implication is that the field currently researches these three layers in largely separate conversations. Research on what haptics contributes to experience is dominated by VR presence studies. Research on haptic feedback technology is advancing in parallel, with emerging connections to AR and wearables. Research on haptic interface hardware is proceeding within VR application and simulation contexts. What is absent is integrative research that connects all three layers — from interface capability through

feedback design to experiential outcome — within a single coherent framework. It is also notable that research on quality of experience is linked to haptics and VR but not to haptic feedback or haptic interfaces, suggesting that even the experiential discourse has not yet engaged with the design and hardware dimensions of haptic systems.

For entertainment digital games specifically, this three-layer disconnect carries direct design consequences. A player's haptic experience of a sword impact, a car collision, or a weapon recoil is simultaneously a hardware event (the controller's actuator), a feedback event (the vibrotactile or adaptive trigger signal), and an experiential event (the felt sensation and its contribution to immersion and player experience). A research agenda adequate to this context would need to integrate all three layers within a player-centred evaluative framework. Our findings map the current absence of such integration and thereby we identify the theoretical space it would need to occupy.

5.4 HCI in the Research Landscape of Digital Games and Haptics

The HCI node occupies a structurally important position in our network as it is large, well-connected, and equidistant between the VR and haptics nodes (link strengths of 17 and 16, respectively). This near-equal weighting indicates that HCI research in the haptics-games domain treats VR and haptics as co-equal concerns, consistent with the field's established understanding that haptics enhances VR-mediated human-computer interaction. The connections between HCI and haptic interfaces (link strength = 4) and haptic feedback (4) further confirm that HCI's engagement with haptics in this corpus extends, modestly, beyond the experiential level to include technological and hardware dimensions.

However, the HCI node's connections to the granular aspects of player experience — interaction, quality of experience, immersion, presence — are structurally weak, with these nodes appearing at considerable spatial distance despite their conceptual centrality to HCI concerns. Prior bibliometric work confirms that HCI's engagement with gamification, game-based learning, and serious games has been substantial (Behl et al., 2022; Hallinger et al., 2020; Schöbel et al., 2021), but our analysis reveals that this engagement has not been carried into the haptic dimensions of those contexts. HCI's link to video games carries a link strength of only 1 — the lowest meaningful connection in the network — indicating that the discipline most directly concerned with human experience of computational systems has largely overlooked entertainment gaming as a context for haptic investigation.

This absence carries a methodological consequence that deserves explicit attention. HCI has developed a rich toolkit for evaluating user experience in interactive systems — usability protocols, experience sampling, physiological measurement, and validated questionnaires. Within the haptics domain, these methods have been applied predominantly to VR and serious games contexts calibrated to controlled, task-oriented, and often clinical settings. Whether these methods transfer meaningfully to the affectively-driven, open-ended, entertainment-oriented context of video gaming is a substantive open question. Our network analysis suggests it is also an unanswered question, as there is no co-occurring research literature in this corpus that has brought HCI methodology, haptic design, and entertainment gaming together as a unified research problem. This methodological gap is not just a topic gap but a tools gap as well, and is among the most practically significant findings of this study. This methodological gap has been identified at the level of research practise as well in the field of GUR (Games User Research). Samanta et al. (2025) in their critical review of existing GUR methods found that several existing methods can partially assess the effects of haptic interaction on player experience. However, none were designed with the haptic modality as the primary variable being evaluated. This indicates that most of the widely used tools in the field may produce haptic experience evaluation data as a byproduct of their player experience and interaction evaluation rather than as a primary research outcome.

5.5 Extent of research in entertainment digital games in the research landscape of digital games and haptics

Our second research question asked about the extent of research in entertainment digital games within the broader haptics-games landscape. The answer that emerges from all three visualisations is

unambiguous: entertainment digital games are structurally peripheral to the research domain, and this peripherality is not incidental but deeply embedded in the field's organisational logic.

The video games node is small relative to the major nodes of the network (occurrences = 19, compared to VR's 341 and haptics' 251), and its strongest link to VR, at link strength 8, is still relatively modest. More revealing than its absolute size is its pattern of connections. The research areas that co-occur with video games are rehabilitation, stroke, learning, accessibility, visual impairments, and assistive technology — all serious game application contexts. Entertainment digital gaming, the commercially dominant form of video game consumption worldwide, does not appear as a research context in its own right within the video games node's immediate neighbourhood. The computer games node reinforces this picture: with an average publication year of 2012, it represents the terminological predecessor of current video games research and has receded from the network's active discourse.

The quality of experience node provides the most direct evidence of what is missing. This node carries no link to either video games or serious games, despite being conceptually important for both. Research on how haptics shapes the quality of what a player feels — the immediate perceptual and affective dimensions of haptic interaction — has not formed a co-occurring research conversation with either entertainment gaming or serious game application in this corpus. The node's weak links to VR, haptics, HCI, and haptic interfaces suggest it is an emerging concern at the periphery of the field rather than an established research focus.

Recent research has begun to address aspects of this gap. The growing body of work on vibrotactile embellishments and player experience (Singhal & Schneider, 2021) represents an important step toward understanding how haptic feedback design choices affect experiential outcomes in game contexts. Research on haptic rendering and feedback in display contexts, including recent work examining feedback haptics in interactive media (Sobchyshak et al., 2026), has begun to connect hardware and experiential dimensions more directly. However, as our analysis demonstrates, these efforts remain weakly integrated into the broader haptics-games research landscape, as evidenced by the low link strengths between the quality of experience, haptic feedback, and video games nodes. The gap identified in this study is therefore not the absence of any relevant research, but the absence of a coherent, interconnected research community organised around the problem of haptic experience design for entertainment gaming.

This disconnect between academic priorities and commercial practice is striking when considered against the scale of haptic technology deployment in entertainment gaming. Nintendo introduced vibrotactile haptic feedback in game controllers in 1997 (Söderström et al., 2022)and haptic feedback has been standard in most commercially available game controllers for nearly three decades. The DualSense controller, introduced with the PlayStation 5, represents a significant advance in haptic expressivity, with adaptive triggers and high-definition vibrotactile actuators capable of communicating granular gameplay information through touch (Gao & Spence, 2025). Gao and Spence (2025) also observe that there is a limited availability of consistent empirical evidence that demonstrates the benefits of tactile feedback for player immersion and experience. Moreover, most existing studies are constrained by small sample sizes, novelty effects and controlled laboratory environments, conditions that run counter to the natural settings of entertainment digital gaming. Our analysis aligns with the observation of Gao and Spence (2025). We observe that force feedback carries no link to the video games node, and that haptic feedback's link strength with video games is negligible. This shows that commercial development of haptics experience design in entertainment digital games has proceeded largely without the benefit of a sustained academic research foundation, and the academic study of haptics has proceeded largely without engagement with the context where haptic technology reaches its largest user population.

Martin (2018) identified a persistent knowledge gap between game research and the game industry. Our findings extend and specify this observation for the haptics domain: the gap is not simply between academia and industry in general, but between the haptic research communities that have developed robust methodological and theoretical frameworks and the entertainment gaming context that most urgently needs them. Since existing research methods for evaluating haptic player experience were

developed primarily for VR and clinical serious games contexts, they may not be adequate for the entertainment gaming context without significant adaptation. The lack of haptic experience evaluation tools in GUR (Samanta et al., 2025) also confirms the deficit of methods to evaluate the haptic experience of players in the entertainment digital gaming context. Thus, there is a need to develop evaluation instruments and design frameworks specifically calibrated to how haptic events function within the affective, narrative, and moment-to-moment interaction structures of entertainment digital games.

The quality of experience node's structural isolation points to where this work needs to begin. No validated instrument currently exists for evaluating haptic experience quality in entertainment digital game contexts as a primary research variable. The present study provides the bibliometric foundation for that research agenda: a mapped landscape in which the missing territory is now clearly delineated, and the conceptual distance between existing research clusters and the needed framework is made visible and measurable.

5.6 Limitations

Our study has four limitations that need to be taken into consideration when interpreting its findings.

First our analysis is based on a dataset drawn exclusively from the Scopus Database. We selected Scopus as the sole database based on the insights we drew from Schöbel et al. (2021) who cautioned against cross-database comparisons, and the inability of VOSViewer in combining data from different sources is explicitly documented in the manual of VOSViewer (Lim et al., 2024; Waltman, 2023). However, single-database analyses carry coverage biases (Mongeon & Paul-Hus, 2016). For the focus area of our study, we observed that Scopus provides a significantly broader coverage of HCI literature than WoS because it does index ACM and IEEE peer-reviewed conference proceedings, and these two publication groups are home to relevant haptics and games research (Meho & Rogers, 2008). Scopus does index conferences selectively rather than exhaustively which may result in some proceedings from CHI, CHI Play and IEEE Haptics Symposium being partially represented. We acknowledge this as a residual limitation.

To assess whether this residual gap affected our study's core findings, we conducted a supplementary review of 1,460 records which we had retrieved from the IEEE Xplore database using the same search keyword search string that we had used in our study. We used the same co-occurrence threshold of 10 here as well. From the results of the co-occurrence analysis in VOSViewer we observed that the keyword frequency distribution of the data from the IEEE corpus replicated the pattern we had identified from our study using the Scopus database. The research landscape was dominated by haptic interfaces (777 occurrences), virtual reality (332 occurrences), and training (211 occurrences). Conversely, video games (23 occurrences), player experience (1 occurrence), and game controller (1 occurrence) remained peripheral which is consistent with our findings of a VR dominated, training oriented structure from the Scopus database. Our cross-database validation confirms the existence of a gap in the form of inadequate research in entertainment digital games and haptics and is a structural feature of the research landscape of digital games and haptics. It also validates that the identified gap is not an artefact of resulting from single-database coverage.

Second, the wildcard search string "gam* AND (haptic* OR haptics)" can theoretically retrieve terms such as gamma, gamete, or gamut through the gam* operator. However, in practice, we have set the recommended minimum co-occurrence threshold of 10 in our analysis using VOSViewer which eliminates chances of such noise. However, the potential presence of the theoretical variants of "gam*" at the level of individual records in the initial retrieval of 1,871 records cannot be entirely ruled out and we acknowledge this as a residual retrieval limitation.

Third, co-occurrence analysis measures the frequency with which terms appear together across publications and not on the depth or nature of the conceptual relationship between them. It is not necessary for two terms frequently co-occurring together to share an intellectual dialogue linking the

terms. The cluster labels and thematic interpretations assigned in this our study represents our analytical reading of the co-occurrence patterns and carry the interpretive limitations that are inherent in any qualitative labelling exercise applied to quantitative network data.

Fourth, though the use of a minimum co-occurrence threshold of 10 is a standard practice in VOSViewer based co-occurrence analysis (van Eck & Waltman, 2014), it might result in the elimination of low-frequency terms which point towards emerging fields of research. This another limitation of our study and may need a separate study without any threshold limits to identify the emerging fields of research in this domain.

6. Conclusion and future work

Bibliometric analysis methods are instrumental in helping researchers understand the intellectual structure of a research field in any domain. Although bibliometric analysis methods have been in use for some time, their application in digital games-related research is a relatively recent phenomenon. To the best of our knowledge, no comprehensive study has previously applied bibliometric methods to investigate the intellectual structure of research at the intersection of digital games and haptics.

We employed co-occurrence analysis on a corpus of 1,871 Scopus-indexed publications spanning 1995 to June 2025, identifying six overarching research focus areas within this domain: haptic feedback and its applications, training and education, medical applications of haptics and digital games, medium of interaction, human perception in virtual settings, and medical rehabilitation and assistance. The overlay visualisation further identified wearables, gamification, metaverse, extended reality, mixed reality, passive haptics, augmented reality, and neurorehabilitation as emerging research themes.

The analysis reveals that the field is organised around a strong gravitational pull toward VR, with serious games and healthcare applications dominating the application landscape. Most significantly, entertainment digital games — despite constituting the largest commercial deployment of haptic technology, reaching hundreds of millions of players through vibrotactile and adaptive trigger controllers — remain structurally peripheral to the research domain. The weak co-occurrence links between the video games node and all major haptic research themes, combined with the complete absence of a link between quality of experience and video games, point to a systematic gap between academic research priorities and commercial industry practice.

This gap has a methodological dimension that extends beyond topic coverage. The instruments and frameworks currently available for evaluating haptic experience in game contexts were developed primarily for VR and clinical serious games settings. No validated framework exists for evaluating haptic experience quality in entertainment digital games as a primary research variable. Closing this gap requires not only more research in the domain, but the development of purpose-built evaluation instruments calibrated to the affective, narrative, and moment-to-moment interaction structures of entertainment gaming.

Our future work addresses this directly. We are currently investigating the factors that contribute to haptic experience quality in entertainment digital game contexts, developing and validating an evaluation instrument suited to this domain, and examining the research methods available within game user research for measuring haptic experience. The present bibliometric study provides the foundational mapping that motivates and frames this agenda — a landscape in which the missing territory is now clearly delineated.

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References

Aguilar-Cuesta, Á. I., Colomo-Magaña, E., & Ruiz-Palmero, J. (2024). El papel de la tecnología educativa en las ciencias sociales: análisis bibliométrico [Article]. *Texto Livre*, *17*, Article e46791. https://doi.org/10.1590/1983-3652.2024.46791

Al Ardha, M. A., Nurhasan, N., Ridwan, M., Wijaya, A., Moh. Fathur Rohman, M. F., Pandhadha Putra, N. S. R., Bikalawan Bikalawan, a. S., Mubarak, J. A., Putra, K. P., & Yang, C. B. (2024). The Development of Esports Research and Technology in the Last 3 Decades [Article]. *TEM Journal*, *13*(2), 1537-1547. https://doi.org/10.18421/tem132-67

Aliu, J. O., Omoregie Aghimien, D., Emmanuel Oke, A., Ebekozien, A., & Aigbavboa, C. (2025). Gamification as a Catalyst for Effective Construction Management Education [Article]. *International Journal of Human–Computer Interaction*, 1-22. https://doi.org/10.1080/10447318.2025.2526588

Behl, A., Jayawardena, N., Pereira, V., Islam, N., Giudice, M. D., & Choudrie, J. (2022). Gamification and e-learning for young learners: A systematic literature review, bibliometric analysis, and future research agenda [Article]. *Technological Forecasting and Social Change*, *176*, Article 121445. https://doi.org/10.1016/j.techfore.2021.121445

Callon, M., Courtial, J.-P., Turner, W. A., & Bauin, S. (1983). From translations to problematic networks: An introduction to co-word analysis. *Social Science Information*, *22*(2), 191-235. https://doi.org/10.1177/053901883022002003

Carbonell, X., Guardiola, E., Beranuy, M., & Belles, A. (2009). A bibliometric analysis of the scientific literature on Internet, video games, and cell phone addiction [Article]. *J Med Libr Assoc*, *97*(2), 102-107. https://doi.org/10.3163/1536-5050.97.2.006

Centre for Science and Technology Studies, L. U., The Netherlands. (2020). VOSviewer - Visualizing scientific landscapes. In: https://www.vosviewer.com/.

Chang, D. (2002). Haptics: gaming's new sensation. *Computer*, *35*(8), 84-86. https://doi.org/10.1109/mc.2002.1023794

Chen, P.-Y., Hwang, G.-J., Yeh, S.-Y., Chen, Y.-T., Chen, T.-W., & Chien, C.-H. (2021). Three decades of game-based learning in science and mathematics education: an integrated bibliometric analysis and systematic review [Article]. *Journal of Computers in Education*, *9*(3), 455-476. https://doi.org/10.1007/s40692-021-00210-y

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines [Article]. *Journal of Business Research*, *133*, 285-296. https://doi.org/10.1016/j.jbusres.2021.04.070

Gao, Y., & Spence, C. (2025). What role does touch play in active entertainment? A narrative review of tactile feedback in gaming [Article]. *i-Perception*, *16*(3), Article 20416695251336117. https://doi.org/10.1177/20416695251336117

Halevi, G., Moed, H., & Bar-Ilan, J. (2017). Suitability of Google Scholar as a source of scientific information and as a source of data for scientific evaluation—Review of the Literature [Review]. *Journal of Informetrics*, *11*(3), 823-834. https://doi.org/10.1016/j.joi.2017.06.005

Hallinger, P., Wang, R., Chatpinyakoop, C., Nguyen, V.-T., & Nguyen, U.-P. (2020). A bibliometric review of research on simulations and serious games used in educating for sustainability, 1997–2019 [Review]. *Journal of Cleaner Production*, *256*, Article 120358. https://doi.org/10.1016/j.jclepro.2020.120358

Hogle, N. J., Widmann, W. D., Ude, A. O., Hardy, M. A., & Fowler, D. L. (2008). Does training novices to criteria and does rapid acquisition of skills on laparoscopic simulators have predictive validity or are we just playing video games? *J Surg Educ*, *65*(6), 431-435. https://doi.org/10.1016/j.jsurg.2008.05.008

Hsu, M. H., & Chang, Y. C. (2023). Haptic and Force Feedback Technology in Dental Education: A Bibliometric Analysis [Article]. *Int J Environ Res Public Health*, *20*(2), Article 1318. https://doi.org/10.3390/ijerph20021318

Hu, L., Chen, Y., Cao, E., & Hu, W. (2024). User Experience & Usability of Wearable Health Device: A Bibliometric Analysis of 2014–2023 [Article]. *International Journal of Human–Computer Interaction*, *41*(8), 5100-5119. https://doi.org/10.1080/10447318.2024.2357905

Kanade, S. G., & Duffy, V. G. (2020). A systematic literature review of game-based learning and safety management. In V. G. Duffy (Ed.), (Vol. 12199 LNCS, pp. 365-377): Springer.

Lim, W. M., Kumar, S., & Donthu, N. (2024). How to combine and clean bibliometric data and use bibliometric tools synergistically: Guidelines using metaverse research [Article]. *Journal of Business Research*, *182*, Article 114760. https://doi.org/10.1016/j.jbusres.2024.114760

Ma, M., & Zheng, H. (2011). Virtual Reality and Serious Games in Healthcare. In *Advanced Computational Intelligence Paradigms in Healthcare 6. Virtual Reality in Psychotherapy, Rehabilitation, and Assessment* (pp. 169-192). https://doi.org/10.1007/978-3-642-17824-5_9

Malone, T. (1981). What Makes Things Fun to Learn? A Study of Intrinsically Motivating Computer Games. *Pipeline*, *6*.

Malone, T. W. (1982). Heuristics for designing enjoyable user interfaces: Lessons from computer games. Conference on Human Factors in Computing Systems - Proceedings,

Marín-Suelves, D., Esnaola-Horacek, G., & Donato, D. (2022). Videojuegos y educación: análisis de tendencias en investigación [Article]. *Revista Colombiana de Educacion*, *1*(84), 1-17. https://doi.org/10.17227/rce.num84-12125

Martin, P. (2018). The intellectual structure of game research [Article]. *Game Studies*, *18*(1). https://www.scopus.com/inward/record.uri?eid=2-s2.0-85047547446&partnerID=40&md5=3b2ab17e09fe4536a645c9c09721d718

Meho, L. I., & Rogers, Y. (2008). Citation counting, citation ranking, and h-index of human-computer interaction researchers: A comparison of scopus and web of science [Article]. *Journal of the American Society for Information Science and Technology*, *59*(11), 1711-1726. https://doi.org/10.1002/asi.20874

Min, W., Mott, B., Rowe, J., Taylor, R., Wiebe, E., Boyer, K. E., & Lester, J. (2017). Multimodal goal recognition in open-world digital games. Proceedings of the 13th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment, AIIDE 2017,

Ming, O., Jiann-Rong, W., Wu-Nan, T., Tzong-Jer, Y., & Chung-Hsi, H. (1995). *A Force Feedback Joystick and Its Use in PC Video Games* Proceedings of International Conference on Consumer Electronics, https://www.scopus.com/inward/record.uri?eid=2-s2.0-0029235615&partnerID=40&md5=8f862c34636cceb4fc3faf22eb69e58b

Mongeon, P., & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics*, *106*(1), 213-228. https://doi.org/10.1007/s11192-015-1765-5

Nadi-Ravandi, S., & Batooli, Z. (2022). Gamification in education: A scientometric, content and co-occurrence analysis of systematic review and meta-analysis articles [Article]. *Educ Inf Technol (Dordr)*, *27*(7), 10207-10238. https://doi.org/10.1007/s10639-022-11048-x

National Research, C. (1995). *Virtual Reality*. The National Academies Press. https://doi.org/10.17226/4761

Ouhyoung, M., Tsai, W. N., Wu, J. R., Huang, C. H., Yang, T. J., & Tsai, M. C. (1995). A low-cost force feedback joystick and its use in PC video games [Article]. *IEEE Transactions on Consumer Electronics*, *41*(3), 787-794. https://doi.org/10.1109/30.468083

Padasinavik. (2017). History of Haptic Technology in Video Game Industry. https://teslasuit.io/blog/history-haptic-technology/

Pek, L. S., Yob, F. S. C., Nallisamy, V., Mee, R. W. M., Camara, J. S., & Anwar, C. (2025). Play, Learn, Grow: A Decade of Insights into Gamified Socio-Emotional Learning [Article]. *International Journal of Learning, Teaching and Educational Research*, *24*(6), 432-455. https://doi.org/10.26803/ijlter.24.6.20

Sabri, Z., Remaida, A., Benyoussef, A., Qostal, A., Sellamy, K., Fakhri, Y., & Moumen, A. (2024). Engineering Education Using Serious Games: The Current State, Trends and Future Using a Bibliometric Study. In H. El Fadil & W. Zhang (Eds.), (Vol. 1141 LNEE, pp. 113-127): Springer Science and Business Media Deutschland GmbH.

Saikia, S., Gul, S., & Verma, M. K. (2023). Are libraries ready to serve gamification tools for teaching and learning? A review based on computational mapping [Article]. *Global Knowledge, Memory and Communication*, *74*(5-6), 1381-1399. https://doi.org/10.1108/gkmc-04-2023-0114

Salkini, M. W., Doarn, C. R., Kiehl, N., Broderick, T. J., Donovan, J. F., & Gaitonde, K. (2010). The role of haptic feedback in laparoscopic training using the LapMentor II. *J Endourol*, *24*(1), 99-102. https://doi.org/10.1089/end.2009.0307

Samanta, S., Banerjee, S., & Upadhyay, P. (2023). A Bibliometric Analysis of Research in VR and Haptics. Design in the Era of Industry 4.0, Volume 1, Singapore.

Samanta, S., Banerjee, S., & Upadhyay, P. (2025). How Does Games User Research Measure and Guide Haptic Experience Design? A Critical Review. Communications in Computer and Information Science,

Schöbel, S., Saqr, M., & Janson, A. (2021). Two decades of game concepts in digital learning environments – A bibliometric study and research agenda [Article]. *Computers & Education*, *173*, Article 104296. https://doi.org/10.1016/j.compedu.2021.104296

Sharma, W., Lim, W. M., Kumar, S., Verma, A., & Kumra, R. (2024). Game on! A state-of-the-art overview of doing business with gamification [Article]. *Technological Forecasting and Social Change*, *198*, Article 122988. https://doi.org/10.1016/j.techfore.2023.122988

Singhal, T., & Schneider, O. (2021). Juicy haptic design: Vibrotactile embellishments can improve player experience in games. 2021 CHI Conference on Human Factors in Computing Systems: Making Waves, Combining Strengths, CHI 2021,

Sobchyshak, O., Berrezueta-Guzman, S., & Wagner, S. (2026). Pushing the boundaries of immersion and storytelling: A technical review of Unreal Engine. *Displays*, *91*, 103268. https://doi.org/https://doi.org/10.1016/j.displa.2025.103268

Söderström, U., Larsson, W., Lundqvist, M., Norberg, O., Andersson, M., & Mejtoft, T. (2022). Haptic feedback in first person shooter video games.

Stach, T., & Graham, T. C. N. (2011). Exploring Haptic Feedback in Exergames. In *Human-Computer Interaction – INTERACT 2011* (pp. 18-35). https://doi.org/10.1007/978-3-642-23771-3_2

Sun, S., Nan, D., Che, S., & Kim, J. H. (2024). Investigating the knowledge structure of research on massively multiplayer online role-playing games: A bibliometric analysis [Article]. *Data and Information Management*, *8*(1), Article 100024. https://doi.org/10.1016/j.dim.2022.100024

Trinidad, M., Ruiz, M., & Calderon, A. (2021). A Bibliometric Analysis of Gamification Research [Article]. *IEEE Access*, *9*, 46505-46544, Article 9369392. https://doi.org/10.1109/access.2021.3063986
Tuttle, M., & Carter, E. W. (2022). Systematic Review of Studies Addressing Computer-Assisted Instruction for Students with Visual Impairment. *Journal of Special Education Technology*, *38*(3), 274-287. https://doi.org/10.1177/01626434221088026
Tyni, J., Tarkiainen, A., Lopez-Pernas, S., Saqr, M., Kahila, J., Bednarik, R., & Tedre, M. (2022). Games and Rewards: A Scientometric Study of Rewards in Educational and Serious Games [Article]. *IEEE Access*, *10*, 31578-31585. https://doi.org/10.1109/access.2022.3160230
van Eck, N. J., & Waltman, L. (2014). Visualizing Bibliometric Networks. In Y. Ding, R. Rousseau, & D. Wolfram (Eds.), *Measuring Scholarly Impact* (pp. 285-320). Springer International Publishing. https://doi.org/10.1007/978-3-319-10377-8_13
Wallin, J. A. (2005). Bibliometric methods: pitfalls and possibilities [Short survey]. *Basic Clin Pharmacol Toxicol*, *97*(5), 261-275. https://doi.org/10.1111/j.1742-7843.2005.pto_139.x
Waltman, N. J. v. E. a. L. (2023). *VOSviewer Manual (Version 1.6.20)* [Manual]. Universiteit Leiden. https://www.vosviewer.com/documentation/Manual_VOSviewer_1.6.20.pdf
Wang, Q., Wang, J., & Pan, L. (2023). Research Status and Trend Analysis of Sensory Interaction of Virtual Technology Products. Proceedings of SPIE - The International Society for Optical Engineering,
Waters, E. L., & Johnson, M. J. (2024). Motor Learning in Robot-Based Haptic Dyads: A Review [Review]. *IEEE Trans Haptics*, *17*(4), 510-527. https://doi.org/10.1109/TOH.2024.3379035
White, H. D., & McCain, K. W. (1998). Visualizing a discipline: An author co-citation analysis of information science, 1972–1995. *Journal of the American Society for Information Science*, *49*(4), 327-355. https://doi.org/10.1002/(sici)1097-4571(19980401)49:4<327::Aid-asi4>3.0.Co;2-4
Wu, X., Chen, Y., & Guo, M. (2025). Game Design for Older Adults: A Bibliometric Review of Trends and Future Directions [Article]. *International Journal of Human–Computer Interaction*, 1-33. https://doi.org/10.1080/10447318.2025.2506508
Xu, S., Yu, X., Chen, J., & Jing, Y. (2023). Advances in electronic skin research: a bibliometric analysis [Article]. *Frontiers in Materials*, *10*, Article 1188662. https://doi.org/10.3389/fmats.2023.1188662
Yu, X., Xie, Z., Yu, Y., Lee, J., Vazquez-Guardado, A., Luan, H., Ruban, J., Ning, X., Akhtar, A., Li, D., Ji, B., Liu, Y., Sun, R., Cao, J., Huo, Q., Zhong, Y., Lee, C., Kim, S., Gutruf, P., . . . Rogers, J. A. (2019). Skin-integrated wireless haptic interfaces for virtual and augmented reality. *Nature*, *575*(7783), 473-479. https://doi.org/10.1038/s41586-019-1687-0
Zhang, X., Huang, X., Ding, Y., Long, L., Li, W., & Xu, X. (2024). Advancements in Smart Wearable Mobility Aids for Visual Impairments: A Bibliometric Narrative Review [Review]. *Sensors (Basel)*, *24*(24), Article 7986. https://doi.org/10.3390/s24247986
Zhao, F., Alsagoff, S. A., Abdullah, K., & Wu, X. (2023). The Dynamics and Frontiers of Video Game Social Research in Communication Studies-A Scientometrics Analysis Based on CiteSpace and VOSviewer [Article]. *Studies in Media and Communication*, *11*(7), 328-343. https://doi.org/10.11114/smc.v11i7.6423
Zyda, M. (2005). From visual simulation to virtual reality to games [Article]. *Computer*, *38*(9), 25-32. https://doi.org/10.1109/mc.2005.297