The Intersection of Virtual Reality and Art: Hotspots Analysis Based on Computer Science Clustering Algorithm

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Abstract. VR art has received attention as the intersection of virtual reality and art. In order to understand the current research hotspots in VR art, we built a panorama of current research hotspots through a keyword co-occurrence analysis study based on topic modelling and computer science clustering algorithms. The data analysis resulted in three maps: Network Visualization, Overlay Visualization and Density Visualization. these three views allowed us to see how keywords are coupled, how keywords or hotspots change over time, how often they appear and how hot they are. In summary, the current research focus and direction of VR art is deep learning, machine learning and algorithms. Secondary directions relate to health and psychotherapy. the future of VR art depends on advances in virtual reality technology. Art exists as a secondary topic in the field of VR art, appearing more as an auxiliary tool.

Keywords: VR Art · Virtual Reality · Topic Modelling · Clustering Algorithm · Hotspots

1 Introduction

The immersive feeling of the present is emphasized by the fictional sense of the present, which replaces reality regarding reality [14]. VR gives a virtual (spatial) presence to the topic of the experience because the VR space is virtual [5], and the subject of the experience is real.

As time goes on, more and more types of engagement become available to the general population. From the most straightforward vibration-sensitive switches [17] and infrared-sensitive [15] to today's somatic interactive devices [8], modalities of engagement have progressed and expanded in lockstep with technological advancements. Motion capture technology [11], for example, can be utilized to create CG special effects [10] in movies and can even replace animation in some circumstances. Computers can also create new characters for movies.

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Table 1. Specific search information records.

Databases	Search Method	Search Terminology	Number of Search Results	Search Time	Record Content	Export Records to
Web of Science Core Collection	Topic	VR Art	1,014	24 April 2022. Time: 18:05 Lisbon Local Time GMT+1	Full Record and Cited References	TXT File

Note: Form information was collated by Yiyuan Ding and recorded in real time.

Updates and advancements in algorithms, neural networks, and external devices are critical to the growth of virtual reality [6][20]. However, art has also been used as a tool to assist VR in creating scenes.

This paper focuses on the data base of the literature within the field of VR art. It is tested using the topic modeling, bibliometric methods, and a clustering algorithm based on VOSviewer keyword analysis. The keywords of 1,014 articles in the Web of Science core repository under the topic of VR art were studied. A total of 142 keywords were found to be of interest. The network relationships, frequency, timing and hotness of keyword occurrences were mined. Research hotspots for Virtual Reality Art (VR Art) were identified, which also helped to capture the overall academic macro trends in the subject. The final results show that virtual reality dominates research in the field, with art taking a secondary position. Alternatively, art is a secondary aid to developing computer technology and artificial intelligence.

2 The Specific Data Collection Processing

This keyword co-occurrence analysis was based on the software VOS viewer 1.6.18. This software was developed by Leiden University in the Netherlands and is widely used for data analysis of bibliometrics and the creation of clustered view graphs [9]. This search was conducted employing a Topic search. The search term was "VR art". For specific search information, please refer to Table 1.

Data retrieved from the Web of Science core collection. We used a subject search for the term "VR Art".

3 Methodology and Experimental Procedures

The most prominent theoretical approaches are bibliometric [21] and keyword co-occurrence analysis. Word frequency analysis is based on Zipf's law [1][7][13][18][19]. If all of the terms in the database are sorted by decreasing frequency of occurrence, the product of the serial number x and the frequency f, fx, is approximately constant i.e., $fx = a$, $(x = 1, 2, 3, 4, ...)$.

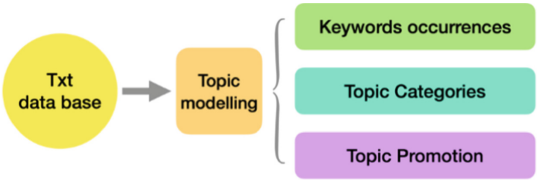

Fig. 1. The process of applying Topic modeling in this study.

In contrast, the theme modelling technique uses LDA technology [2][4]. The text collection is mapped using topic modeling approaches to a low-dimensional topic subspace, where a topic is a group of words. Topic models are statistical models that reveal the text data's hidden structure [12]. Refer to Fig. 1 for the process of topic modelling techniques.

Formula $\beta_{k,j}^{(g)} \propto \Sigma_{d \in g} \#(z = k \wedge w = j)$ using the current point assignment or counts associated with each z for a document group g's usage of subject k word j [12]. Also, VOSviewer's clustering technique was used to merge the keyword word frequency data with Topic modeling together. We gathered a set of data sets pertaining to the frequency distribution of keywords across various clusters (see Table 2).

The method of testing the data and deriving the final results is based on the keyword co-occurrence clustering algorithm of VOSviewer. VOSviewer's clustering algorithm is based on the strength of association, and its core concept is to minimize the weighted sum of squared distances between all pairs of items, representing research hotspots, avoiding tag name overlap and map artifact problems, and clearly presenting each element, which can reflect the connection between each object [16].

The strength of association approach and the fractionalization nomalization are the two main standardised analysis methods included in VOSviewer [3]:

Association normalization: $S_{ij} = \frac{C_{ij}}{C_i C_j}$.

Fractionalization nomalization: $S_{ij} = \frac{1}{2}\left(\frac{C_{ij}}{C_i} + \frac{C_{ij}}{C_j}\right)$.

We imported data into VOSviewer 1.6.18, choosing Co-occurrence as the type of analysis and selecting All Keywords in the Unit of analysis, selecting Full counting in the Counting method. Then set the Minimum number of occurrences of a keyword to 5. There were 142 proper keywords out of a total number of 3,829. The two duplicated keywords were removed further to ensure the data's accuracy. The result was 140 useful keywords. The Network Visualization, Overlay Visualization and Density Visualization were obtained.

The Network Visualization is a graphical representation of the keyword clustering relationships in the field of VR Art. The Overlay Visualization shows the occurrence of keywords at different times. Finally, the Density Visualization shows how hot the keywords are.

Table 2. Keywords occurrences and clustering.

Keyword	cluster	Occurrences	Keyword	cluster	Occurrences
visualization	1	31	Model	5	25
deep learning		22	Impact		10
machine learning		14	antiretroviral therapy		8
algorithm		10	head-mounted display		8
image		10	eeg		7
quality assessment		10	serious games		7
solid modeling		10	adults		6
three-dimensional displays		10	communication		6
virtual environments		10	hiv		6
feature extraction		9	human-computer interaction		6
quality of experience		9	augmented reality	6	82
virtual reality	2	346	vr		51
environments		39	art		42
immersion		21	tracking		12
reality		19	models		11
experience		17	reconstruction		10
performance		16	photogrammetry		9
rehabilitation		16	motion		8
embodiment		11	motion capture		7
empathy		11	animation		6
body		10	gis		6
design	3	29	mobile		6
ar		17	time		6
			cultural heritage	7	14
augmented reality (ar)		15	perception		12
5g		12	human-centered computing		11

(*continued*)

Table 2. (*continued*)

Keyword	cluster	Occurrences	Keyword	cluster	Occurrences
optimization		11	artificial intelligence		8
systems		9	gamification		8
internet		8	computer graphics		7
networks		8	human computer interaction (hci)		7
architecture		7	interaction design		7
challenges		7	museum		7
framework		7	computer vision		6
simulation	4	30	user experience		6
technology		25	computing methodologies		5
education		24	interactive art		5
children		18	system	8	36
training		11	mixed reality		26
anxiety		9	cave		9
environment		9	tool		6
therapy		9	3d		5
immersive virtual reality		7	classification		5
fear		6	database		5
safety		6	games	9	5
students		6			
surgery		6			

Note: The authors got the data for each cluster in this table after processing it using the VOSviewer clustering algorithm. Due to space constraints, only the top ten most commonly occurring keywords in each cluster are given below. The keywords are arranged in descending order of Occurrence and classified according to the distinct clusters. If a cluster's number of keywords falls short of ten, as many as are added to Table 2.

4 Cluster Analysis of Keywords

This analysis yielded nine clusters, with Cluster 1 containing 28 words. Cluster 2 contained 24 words. Cluster 3 contained 22 words. Cluster 4 contains 17 words. Cluster 5 contains 14 words. Cluster 6 contains 14 words. Cluster 7 contains 13 words. Cluster 8 has seven words, while Cluster 9 has only one. For each cluster, refer to Fig. 1. Figure 2 shows the Network Visualization, with different colours representing different clusters. The greater the weight of the keyword, the larger the node in the graph. The stronger

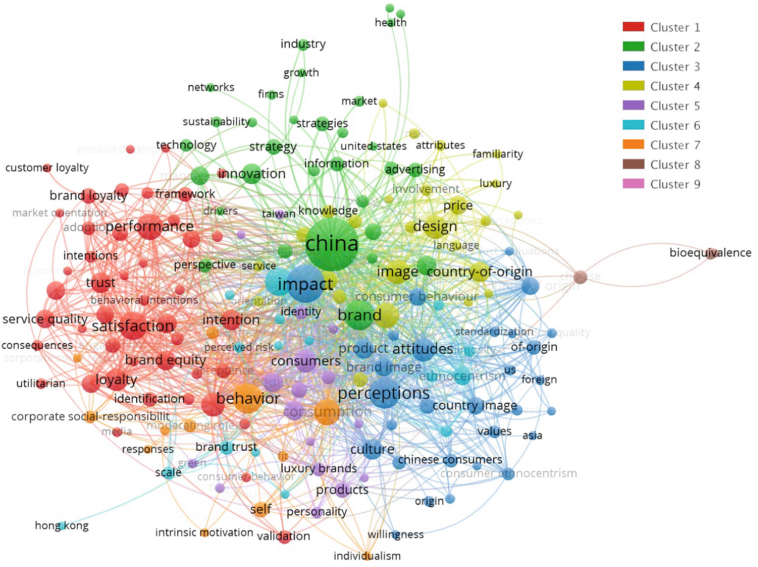

Fig. 2. The Network Visualization.

the connection, the thicker the line between the node. Only the eight larger clusters are analysed here.

Cluster 1 radiates other keywords like deep learning, machine learning, algorithm, image, quality assessment, solid modelling, three-dimensional displays, virtual environments, etc. The keyword visualisation is the core. The cluster is centred on visualisation, with the radiating areas being mainly deep learning and machine learning, closely linked to computer science. The hotspots are mainly concerned with the working principles and raw technology behind VR technology.

Cluster 2 is centred on virtual reality, radiating hotspots such as environment, immersion, reality, experience, performance, healing, experience, empathy and the body etc. The hotspots in this group revolve around virtual reality technology in health, experience and behaviour, and psychotherapy. Of course, the field is still seeking keywords like art therapy, digital art, etc. Scene building and art design in VR can assist in the smooth running of these works.

Cluster 3 focuses on the design and radiates the terms design, of-the-art, augmented reality (AR), 5g optimization, systems and the Internet. Therefore, it is mainly concerned with the design, system structure, external hardware, information transmission technology, etc.

Cluster 4 is related to children's education and children's mental health. It is a subdivision of cluster 2. Cluster 5 is associated with VR's external device technology and brain-computer interaction. Cluster 6 crosses the hot spots in augmented reality, virtual reality, art and animation.

Cluster 7 focuses on cultural heritage preservation, cluster 8 on mixed reality, and cluster 9 has only one keyword alone, games.

The analysis of keyword clustering shows that research within the field of VR art is still mainly focused on VR technology support, such as deep learning, algorithms, etc. Art appears more as an auxiliary tool.

5 Annual Statistics of Keyword Co-occurrence

The keywords vary from year to year; please refer to Fig. 3. Starting with the year 2012 and continuing up to 2020, the top five terms with the highest frequency are picked in this graph. If a year has fewer than five keywords, a few are listed when they are accessible. If the frequency of keywords is the same, but the overview includes five more, the keywords are retained.

The keywords show different changes from year to year as the technology evolved. For example, deep learning emerges in 2019, machine learning and 5g in 2020, etc. Based on the above keyword analysis, it can be seen that art does not appear as frequently in VR art science. However, keywords related to computer science appear very frequently.

See Fig. 4 for another look at the changing research hotspots over time. Blue indicates an earlier time; green is a medium time, and yellow is an earlier time. The same can be seen in the changes in the direction of VR art research due to advances in computer technology, AI algorithms and other areas.

Through technological advancements, the mix of VR and art will likewise experience new modifications. Art aids in forming the constituent parts within the VR environment. But it also provides beauty and warmth to the VR technology itself, from image digital art in the past to the development of interactive, experiential art paired with VR technology today.

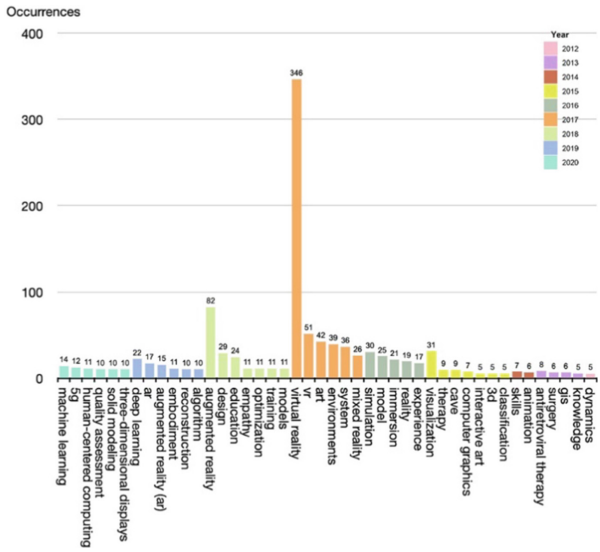

Fig. 3. The Network Visualization.

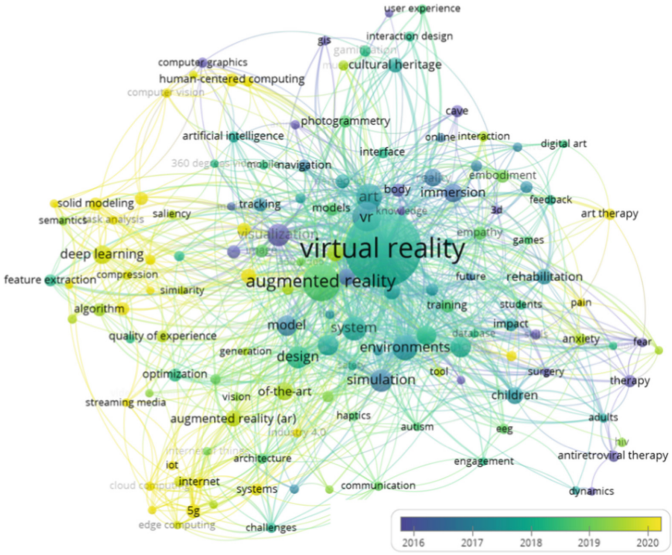

Fig. 4. The Overly Visualization.

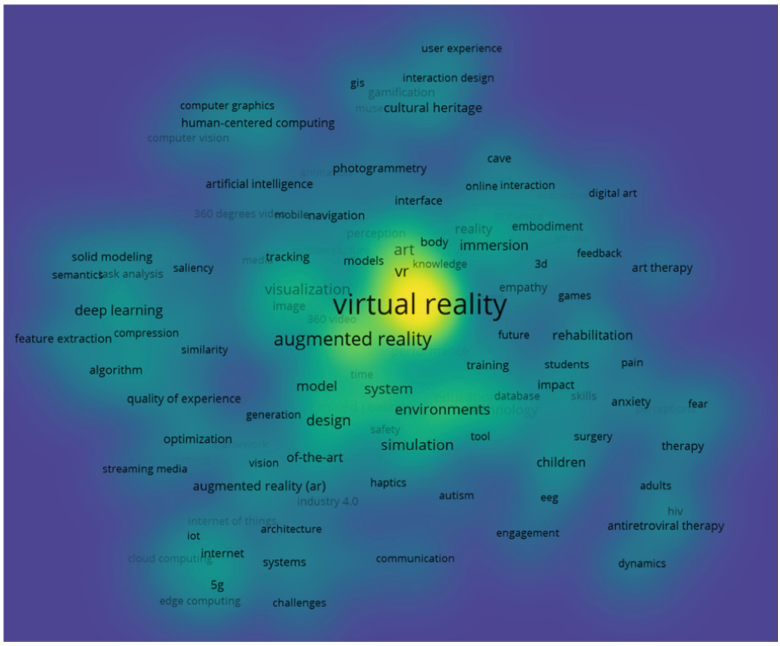

Fig. 5. The Density Visualization.

The keyword hotspot view, however, still shows the core of the field's development (see the Fig. 5). The most popular keyword remains virtual reality, while Art in VR Art has not received sufficient attention.

6 Conclusion

The following conclusions can be drawn as a result of the above analysis of the keywords.

(1) The clustering analysis reveals that deep learning, machine learning, algorithms, and other directions are the current research emphasis and direction in the field of VR Art. In addition, VR technology is used in health therapy (primarily mental health) to a second extent, with art therapy methods involved.

(2) With developments such as algorithms and artificial intelligence techniques, the hotspots for VR Art research change each year. And the integration with artificial intelligence technology will become closer and closer.

(3) However, most of the research is focused on the theme of virtual reality and less on artistic research. Art exists as a secondary subordinate in the field of VR Art.

If the correlation between VR and Art needs to be clarified, it is suggested that further analysis is needed concerning specific cases. Also, bibliometrics is limited by the speed of updating the database, and further analysis and additions to the updated data will be necessary for the future.

References

1. Bornmann, L., Haunschild, R., & Hug, S. E. (2018). Visualizing the context of citations referencing papers published by Eugene Garfield: A new type of keyword co-occurrence analysis. Scientometrics, 114(2), 427–437.
2. Chauhan, U., & Shah, A. (2021). Topic modeling using latent Dirichlet allocation: A survey. ACM Computing Surveys (CSUR), 54(7), 1–35.
3. Eck, N. J. v., & Waltman, L. (2009). How to normalize cooccurrence data? An analysis of some well-known similarity measures. Journal of the American society for information science and technology, 60(8), 1635–1651.
4. Gabaix, X. (1999). Zipf's law for cities: an explanation. The Quarterly journal of economics, 114(3), 739–767.
5. Grabarczyk, P., & Pokropski, M. (2016). Perception of affordances and experience of presence in virtual reality. Avant. The Journal of the Philosophical-Interdisciplinary Vanguard, 7(2).
6. Hambli, R., Chamekh, A., & Salah, H. B. H. (2006). Real-time deformation of structure using finite element and neural networks in virtual reality applications. Finite elements in analysis and design, 42(11), 985–991.
7. Moreno-Sánchez, I., Font-Clos, F., & Corral, Á. (2016). Large-scale analysis of Zipf's law in English texts. PloS one, 11(1), e0147073.
8. Núñez Pacheco, C., & Loke, L. (2017, March). Tacit narratives: Surfacing aesthetic meaning by using wearable props and focusing. In Proceedings of the Eleventh International Conference on Tangible, Embedded, and Embodied Interaction (pp. 233–242).
9. Pradhan, P. (2017). Science mapping and visualization tools used in bibliometric & scientometric studies: An overview.
10. Prince, S. (2011). Digital Visual Effects in Cinema. In Digital Visual Effects in Cinema. Rutgers University Press.

11. Rahul, M. (2018). Review on motion capture technology. Global Journal of Computer Science and Technology.
12. Ramage, D., Rosen, E., Chuang, J., Manning, C. D., & McFarland, D. A. (2009, December). Topic modeling for the social sciences. In NIPS 2009 workshop on applications for topic models: text and beyond (Vol. 5, pp. 1–4).
13. Rana, M. S. (2015, January). Content analysis and application of Zipf's Law in Computer Science literature. In 2015 4th International Symposium on Emerging Trends and Technologies in Libraries and Information Services (pp. 223–227). IEEE.
14. Ryan, M. L. (1999). Immersion vs. interactivity: Virtual reality and literary theory. SubStance, 28(2), 110–137.
15. Teutsch, M., Sappa, A. D., & Hammoud, R. I. (2021). Computer vision in the infrared spectrum: challenges and approaches. Synthesis Lectures on Computer Vision, 10(2), 1–138.
16. Van Eck, N.J., & Waltman, L. (2007). VOS: a new method for visualizing similarities between objects. In H.-J. Lenz, & R. Decker (Eds.), Advances in Data Analysis: Proceedings of the 30th Annual Conference of the German Classification Society (pp. 299–306). Springer.
17. Xie, X., Diao, J., Xu, Y., & Zhang, Z. (2018). Performance of a low-frequency hybrid vibration isolation platform for vibration-sensitive devices. Journal of Low Frequency Noise, Vibration and Active Control, 37(4), 1164–1175.
18. Xu, J. (2019). Knowledge Graph of Design Science. China Science and Technology Press. (p. 16)
19. Zhang, Z. K., Lü, L., Liu, J. G., & Zhou, T. (2008). Empirical analysis on a keyword-based semantic system. The European Physical Journal B, 66(4), 557–561.
20. Židek, K., Piteľ, J., Pavlenko, I., Lazorík, P., & Hošovský, A. (2022). Small Parts Recognition by Convolutional Neural Networks with Implementation to Virtual Reality Devices for Assisted Assembly Tasks. In 5th EAI International Conference on Management of Manufacturing Systems (pp. 185–196). Springer, Cham.
21. Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. Organizational research methods, 18(3), 429–472.