Virtual Reality in Mobile Computing and Applied Ergonomics: A Bibliometric and Content Analysis

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Abstract Virtual Reality (VR) is a budding field in the realm of technology, and it also happens to be one of the main sub-topics entwined with the field of Artificial Intelligence (AI). The main idea of VR also revolves around Virtual Environments. Virtual Environments (VE) contribute to the creation of an out of the world experience for users, by allowing them to interact with the digital universe. Applied Ergonomics is a concept that involves designing for people and since VR is becoming a more mainstream technology being incorporated in various facets of people's lives, like mobile computing, it is only imperative that a bibliometric analysis is carried out to show the relationship between VR in mobile computing and applied ergonomics. This paper shows the connection between VR, Human Computer Interaction and ergonomics using software programs like MaxQDA, Harzing, VOSviewer, and Mendeley. The main keywords used in this bibliometric analysis were Virtual Reality, Artificial Intelligence, Human-Computer Interaction, and Ergonomics. These words were continuously repeated in the articles and chapters referenced in this paper.

Keywords: Virtual Reality, Artificial Intelligence, Bibliometric Analysis, Human-Computer Interaction, Ergonomics, Content Analysis.

1 Introduction and Background

1.1 Problem Statement

Technological advancements and innovative concepts in the world of Science Technology, Engineering and Mathematics (STEM), have led to a breakthrough and cutting-edge solution to various projects with AI, most especially the VR realm. The computational power derived from this breakthrough has created additional opportunities that support more human problem-solving opportunities and provide optimum expertise in the field of automation. Since ergonomics also deals with the efficiency of design for humans, it is necessary to show the relationship between new and innovative technologies such as virtual reality to the field of applied ergonomics. This paper aims to show the link and connection between VR and applied ergonomics through a bibliometric and content analysis. The analysis will be done through software programs including Mendeley, MaxQDA and Harzing. The main point of the analysis

will be to show the strong correlation between VR and ergonomics using keywords such as Virtual Reality, Artificial Intelligence, Human-Computer Interaction, and Ergonomics.

2 Research Methodology

2.1 Trend Data

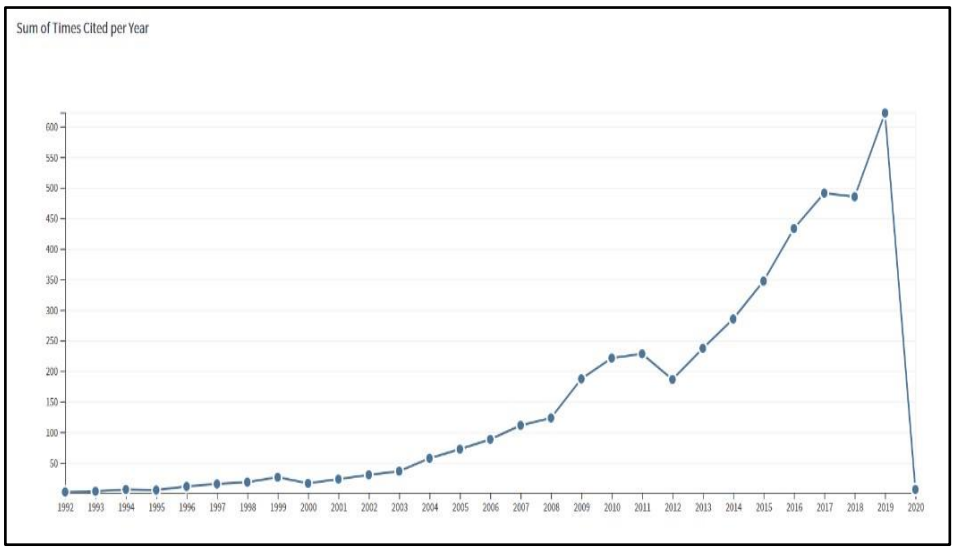

Fig. 1. Trend graph data of keywords "Artificial Intelligence (Virtual reality) and Applied Ergonomics" between the year 1992 up until 2019.

Figure 1 illustrates a trend graph data done through the report analysis on the Web of Science platform. The graph shows that the terms "Artificial Intelligence" and "Applied Ergonomics" have been cited multiple times in several articles. The term also shows a steady increase in the search of the keywords from the year 2012 up until 2018. These are the peak years that these terms became more acknowledged in the world.

2.2 Author Relationship Table

The author relationship table shown below was created through the search of Harzing. A search was done to see the authors that had more content related to Virtual Reality and Applied Ergonomics. The results from the search are laid out in the table below. Harzing also enables users to collect metadata that can be used to create an information visualization piece in the form of a linked graph.

Table 1. Author relationship table for key words "Artificial Intelligence" and "Applied Ergonomics"

Name of Author	Rank	Publisher
JR Wilson	1	Elsevier
PA Howarth	7	Elsevier
L Gamberini	14	Libertpub.com
VG Duffy	25	Taylorfrancis.com
F Biocca	64	MIT Press

2.3 Geographic Location

Fig. 3. Geographic locations for the keyword "Artificial Intelligence" generated with Author Mapper (https://www.authormapper.com/)

The geographic location search was done using Author Mapper. The Author Mapper search for the keywords "Virtual Reality" and "Applied Ergonomics" was also done, but the terms did not yield any results. Instead a search for "Artificial Intelligence" was completed.
(https://www.authormapper.com/search.aspx?q=artificial+intelligence&Facet=name)

3 Data Analysis and Procedures

3.1 Mendeley

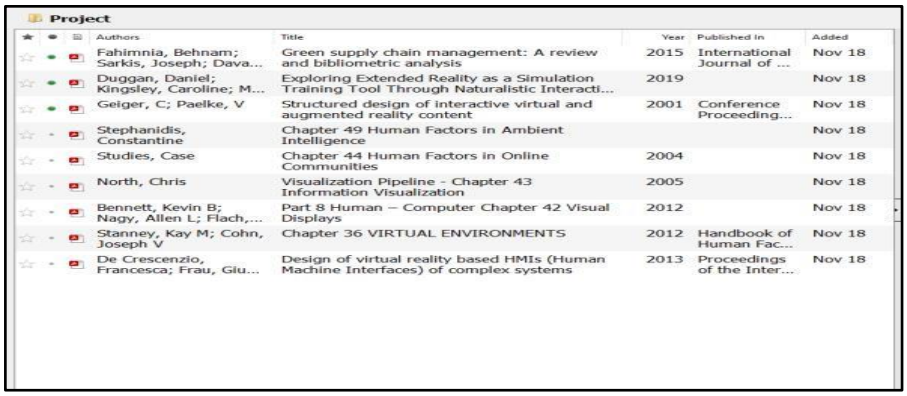

Fig. 4. The eight articles used for this content analysis organized in the Mendeley Software. (https://www.mendeley.com/?interaction_required=true)

Figure 4 shows the eight articles used for this content analysis organized in the Mendeley software program. These eight articles were used in the creation of this bibliometric and content analysis. Of the eight total articles, five of them used in this paper were acquired from the 4th edition of the *Handbook of Human Factors and Ergonomics* published by Gavriel Salvendy. The other three articles are from different sources, all listed in the references.

3.2 Harzing

Using the google scholar platform in the Harzing software program, the first search was done.

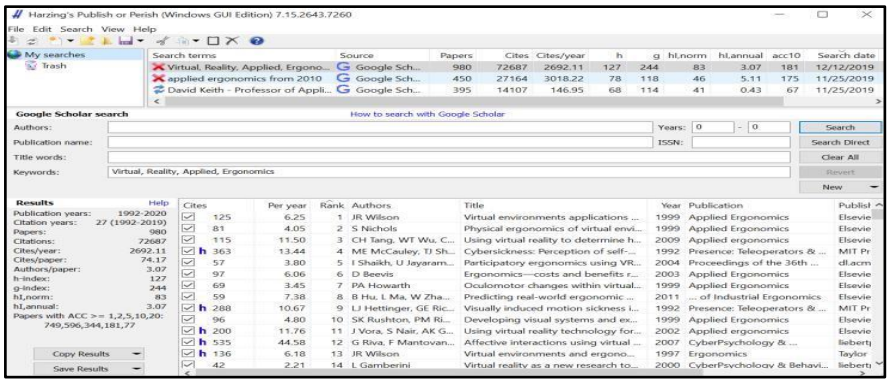

Fig. 5. Search is done in Harzing using the keywords "Virtual Reality" and "Applied Ergonomics"(https://harzing.com/resources/publish-or-perish)

The keywords used were “Virtual Reality” and “Applied Ergonomics”. Figure 5 below shows a visual representation of the platform.

3.3 VOS viewer

Metadata from the Harzing Software was used to create an information visualization piece in the form of a graph for the keywords “Virtual Reality” and “Applied Ergonomics”.

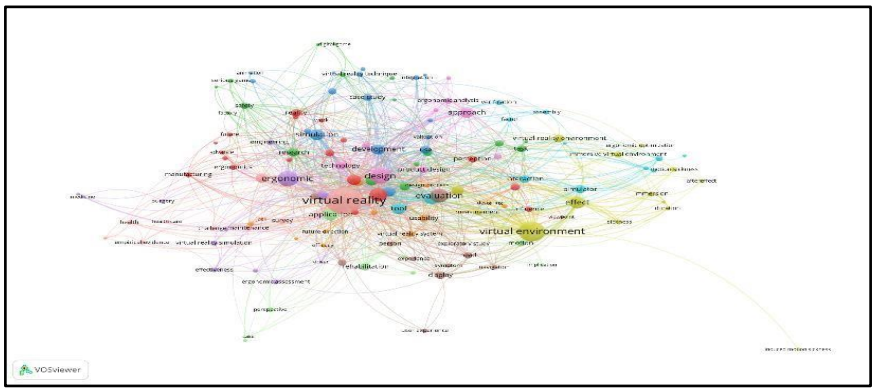

Fig. 6. VOSviewer visualization piece created with metadata from the Harzing search above. (https://www.vosviewer.com/)

Another search was done using the set of keywords, “Artificial Intelligence” and “Applied Ergonomics”. More details are provided in the results section.

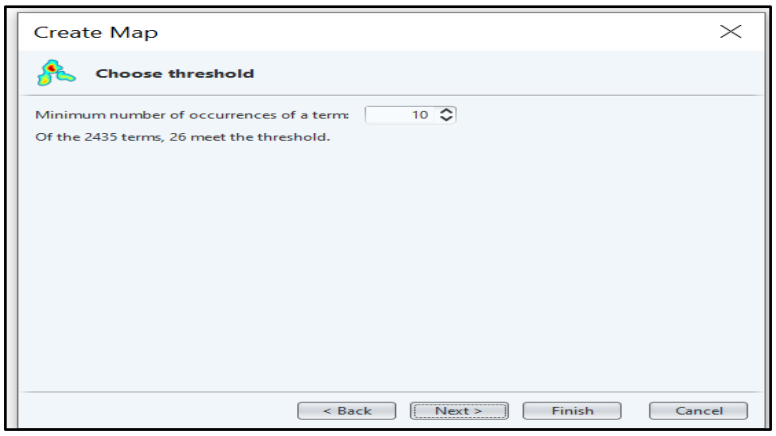

Fig. 7. minimum occurrence and threshold on VOSviewer. (https://www.vosviewer.com/)

As indicated on Figure 7 below, a minimum occurrence of 10 was used for this search, to obtain efficient results. A threshold of 26 was also used. The values used for the occurrence and threshold along with the metadata derived from the search on the Harzing software can be used to replicate the VOSviewer visualization pieces.

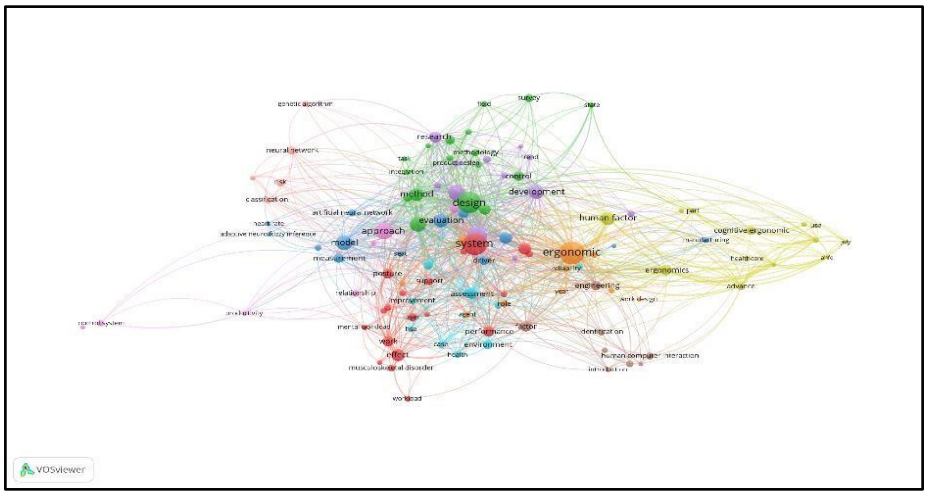

Fig. 8. VOS Viewer visualization piece with additional features selected (https://www.vosviewer.com/)

3.4 MaxQDA

Content Analysis was also completed with the MaxQDA version 2020. The eight documents were used to carry out that content analysis. A word cloud image (Fig 9) was produced.

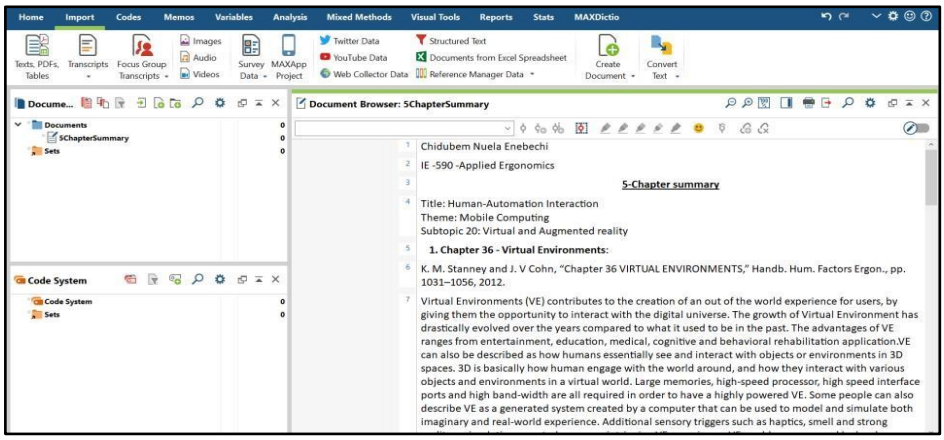

Fig. 9. MaxQDA 2020 Content Analysis Software (https://www.maxqda.com/qualitative-analysissoftware)

The word cloud image contains the common terms that can be found in the eight documents and it also shows how the terms are all connected to Applied Ergonomics.

Fig. 10. Bibliometric Analysis with MaxQDA (https://www.maxqda.com/qualitative-analysissoftware)

4 Co-citation and further analysis

A co-citation analysis was carried out on VOS Viewer to show a connection between lead papers and authors in the world of "Virtual Reality" and "Human Computer Interaction." The results yielded in the analysis are shown in Figure 11 below.

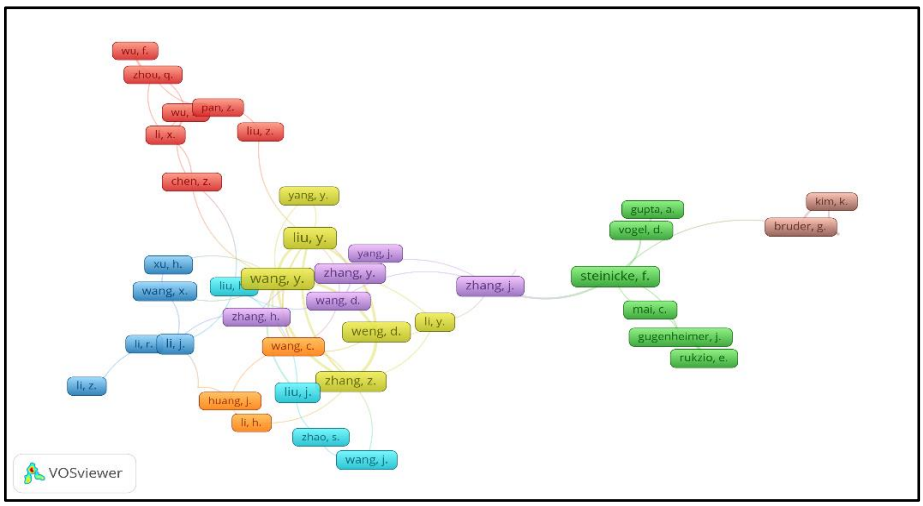

Fig. 11. Co-citation analysis of the terms "Virtual Reality" AND "Human Computer Interaction." (https://www.vosviewer.com/)

In results, the different colors represent the clusters. The search for the terms “Virtual Reality” AND “Human Computer Interaction” produced a total of eight different clusters. Each cluster contains three-seven nodes that are connected.

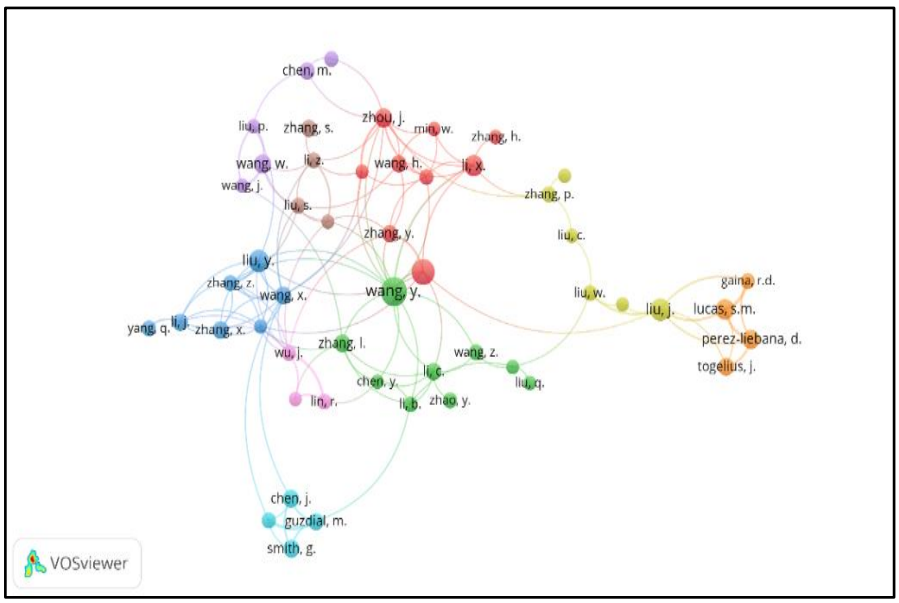

Fig. 12. Co-citation analysis of the terms “Artificial Intelligence” AND Human Computer Interaction. (https://www.vosviewer.com/)

The nodes in each cluster represent a publication. A link between two nodes indicates the publications have been cited together. Another co-citation analysis was also conducted for lead publications in the field of “Artificial Intelligence” and “Human Computer Interaction”. The results of this analysis are shown in the Figure 12 above.

The results from Figure 12 are not much different from the VOS viewer bibliometric results shown in Figure 11. Some popular authors are Guo J., Weng D., Zhang Z., Jiang H., Liu Y., Wang Y, Tarng S., Wang D., Hu Y. with publications such as “Mixed Reality Office System Based on Maslow's Hierarchy of Needs: Towards the long-term immersion in virtual environments” and “Estimating Cognitive Processes Related to Haptic Interaction within Virtual Environments”. These are a few publications that have a strong relationship between various facets of Artificial Intelligence, and they show a connection to the term Human Computer Interaction.

Figure 13 above shows some further analysis that was completed for the terms “Artificial Intelligence” AND “Virtual Reality” AND “Human Computer Interaction”.

The results also show the clear connection between authors and their lead publications in their various fields. This result depicts the authors whose publications are strongly entwined with the world of Human Computer Interaction.

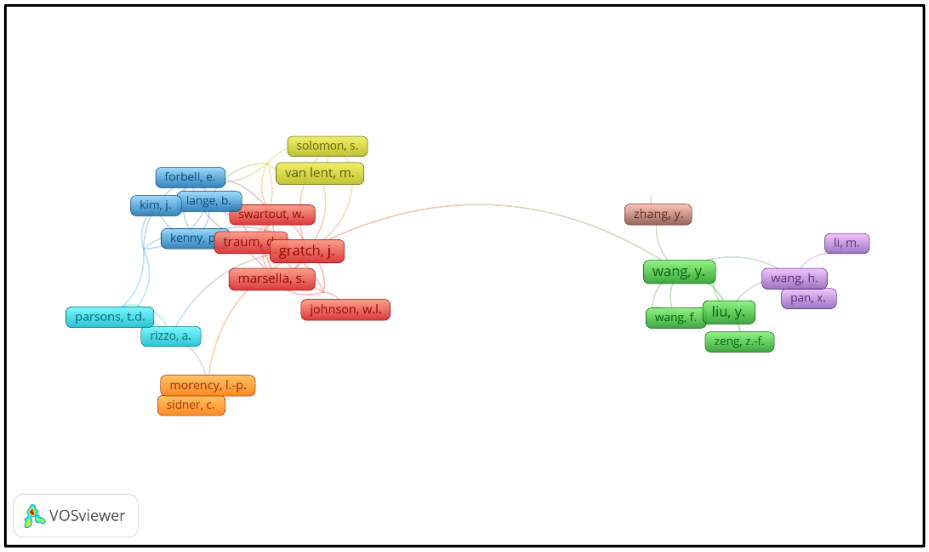

Fig. 13. VOS viewer Co-citation analysis of the terms "Virtual Reality", "Artificial Intelligence" and "Human Computer Interaction. (https://www.vosviewer.com/)

5 Results

While doing searches, the keywords "Cognitive Ergonomics", "Engineering Psychology", "Automation", "Human Computer Interaction", "Safety Ergonomics", "Contemporary Ergonomic", "Work design" and "Accident Performance" were quite redundant. The regular occurrence of these keywords depicts the fact that there is a correlation between applied ergonomics and AI, especially because VR is a subfield of AI. Therefore, it is safe to say that this was a successful bibliometric and content analysis.

6 Discussion

Terms like "Cognitive Ergonomics" came up on multiple occasions of searches with the keywords "Artificial Intelligence and "Applied Ergonomics". Therefore, there was more emphasis to focus this keyword. This is unsurprising considering that Cognitive Ergonomics is a field that deals with design systems and the environment, in conjunction with how humans interact with the design system and their cognitive abilities. It can be concluded that the two fields of AI and Applied Ergonomics overlap to birth the world of Cognitive Ergonomics.

7 Future Work

As the world keeps expanding so does the innovative technological advancement. Advanced technological innovation in AI and VR have led to groundbreaking solutions and troubleshooting of various problems in different facets of human life. For example, in the medical field, VR has played a has played a huge role in physical therapy for individuals with impaired limbs. AI has also come in very handy in the autonomous driving communities. AI has also been proven to make accurate predictions that provides solutions to propel business organizations forward.

There is also no gainsaying that the application of ergonomics has been effective in ensuring that the design of these advanced technologies is well suited for different objectives in the day-to-day life of a human. However, more research needs to be done in the realm of other areas of ergonomics. For example, Cognitive Ergonomics, which is a subfield of ergonomics whereby human thought processes are replicated to an automated system. Researchers and engineers need to collaborate in the future to create more advanced systems that can replicate the human mind, thoughts, and ideologies.

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