Chang, M. et al. (Eds.) (2019). Proceedings of the 27th International Conference on Computers in Education. Taiwan: Asia-Pacific Society for Computers in Education

Augmented reality research output from 1990-2018: A bibliometric analysis

Kaushal Kumar BHAGAT

Indian Institute of Technology Kharagpur, India
*kkntnu@hotmail.com

Abstract: This aim of this study was to analyze the research output of augmented reality (AR) using a bibliometric analysis. A total of 1737 related documents were published from 1990 to 2018. The results showed that the USA and the National University of Singapore were the most productive country and Institute publishing articles on AR, respectively. The most productive journal was IEEE Transactions On Visualization And Computer Graphics with the number of publications (22). This study provides an overview of the AR research and suggests future directions.

Keywords: Augmented reality (AR); bibliometric analysis; research trend

1. Introduction

Currently, AR has emerged as one of the most popular interactive technologies among the researchers. AR not only provides 3-D interactive visualizations in real time, but has other advantages (Chen, 2013):

- Multimedia and multisensory
- Portable and cost-effective
- User-friendly

AR is being used across many domains. It has several educational benefits that include better learning performance, motivation, and promotes active learning (Cai, Wang, & Chiang, 2014; Ferrer-Torregrosa, Torralba, Jimenez, Garcia, & Barcia, 2015; Yilmaz & Goktas, 2017). The present study attempted to present an overview of research conducted on AR by applying bibliometric analysis method.

2. Methodology

Scopus was used as a database using the following keyword syntax combination: (TITLE-ABS-KEY ("augmented reality") OR TITLE-ABS-KEY ("augmented learning") OR TITLE-ABS-KEY ("mobile augmented reality") AND TITLE-ABS-KEY ("learning") OR TITLE-ABS-KEY ("education") OR TITLE-ABS-KEY ("simulation") OR TITLE-ABS-KEY ("training") OR TITLE-ABS-KEY ("interactive learning environment")) to extract all the target publications. This study employed bibliometric method to analyze the research trend of AR research from 1990 to 2018. Data visualization was performed using VosViewer software.

3. Results

3.1 General trends

A total of 1737 documents were obtained. Figure.1 shows that there is an exponential growth in the publications related to AR. This suggests that the domain of AR research has got a lot of attention from the researchers, which is a good sign. This may be due to the low-cost and availability of AR technology compared to other available interactive technologies like virtual reality.

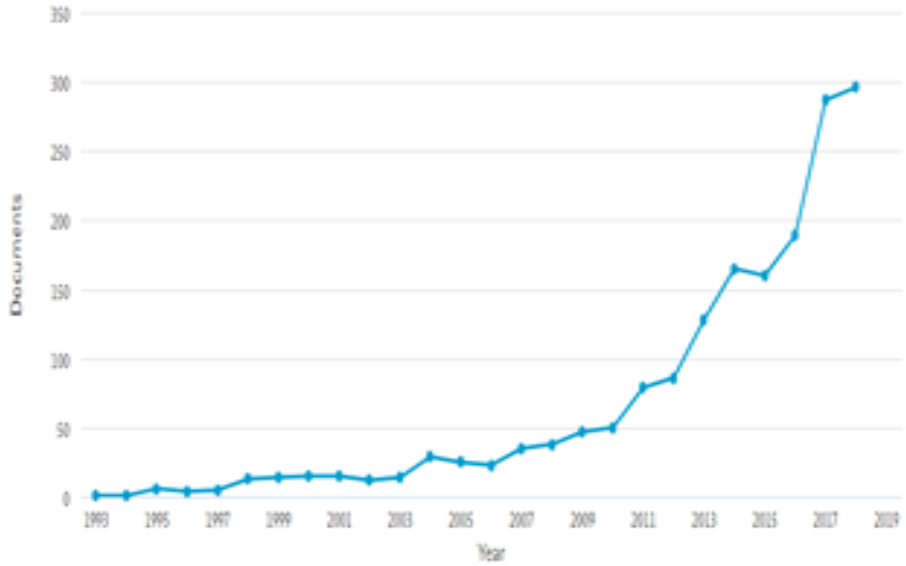

Figure 1. Number of publications per year

3.2 Document types and language of publication

Four different document types were identified that includes journal articles (1632), book series (65), trade publications (27), and conference proceedings (13).A total of 1626 (93.6%) publications were published in English language. This result indicates English is the dominating language in the domain of AR research. This analysis was restricted only journal articles because journal articles provide more detailed information compared to other document types.

3.3 Major journals and their publications

The top most productive journal is IEEE Transactions on Visualization and Computer Graphics with 22 publications (see Table 1.). Table 1 shows that AR is popular in computer science, medical field, and education.

Table 1. Top 10 productive journals based on total number of publications

Journal	Number of articles
IEEE Transactions on Visualization and Computer Graphics	22
Multimedia Tools And Applications	20
Virtual Reality	19
International Journal Of Computer Assisted Radiology and Surgery	18
IEEE Computer Graphics and Applications	17
Surgical Endoscopy	17
Computers and Graphics Pergamon	16
Eurasia Journal Of Mathematics Science And Technology Education	16
Computers in Human Behavior	15
Educational Technology And Society	14

3.4 Most-prolific authors

The most prolific author is *Andrew Y.C. Nee* from National University of Singapore, Singapore with 14 published articles (see Figure 2.).

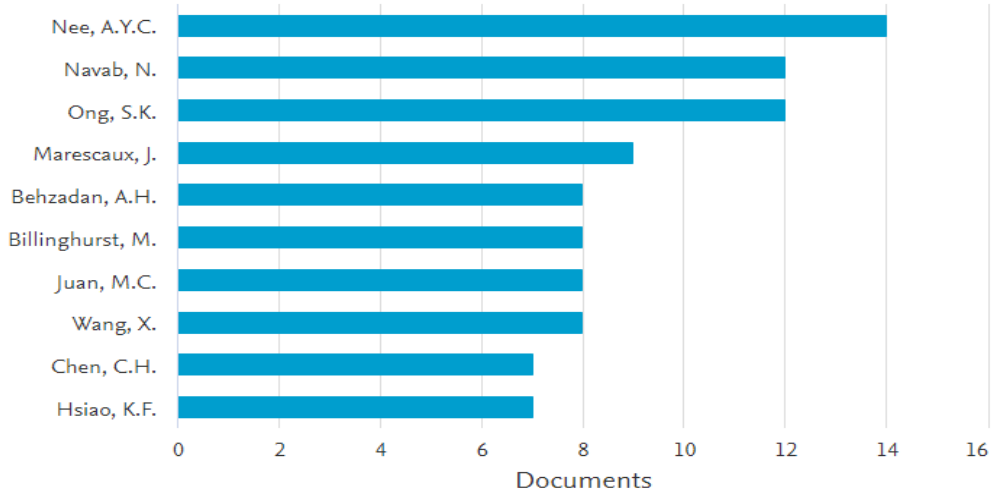

Figure 2. Top 10 most-prolific authors based on total number of articles published

3.5 Geographic distribution and international collaboration

USA is the most dominant country with 351 articles (see Table 2.) in AR research. All the top productive countries are developed countries except China. 3 out of the top 10 institutions are from Taiwan, and 5 out of 10 institutions are from Asia (see Table.3). National University of Singapore is the most productive institution with twenty three published articles. Figure.3 displays the network visualization between countries which are involved in AR research.

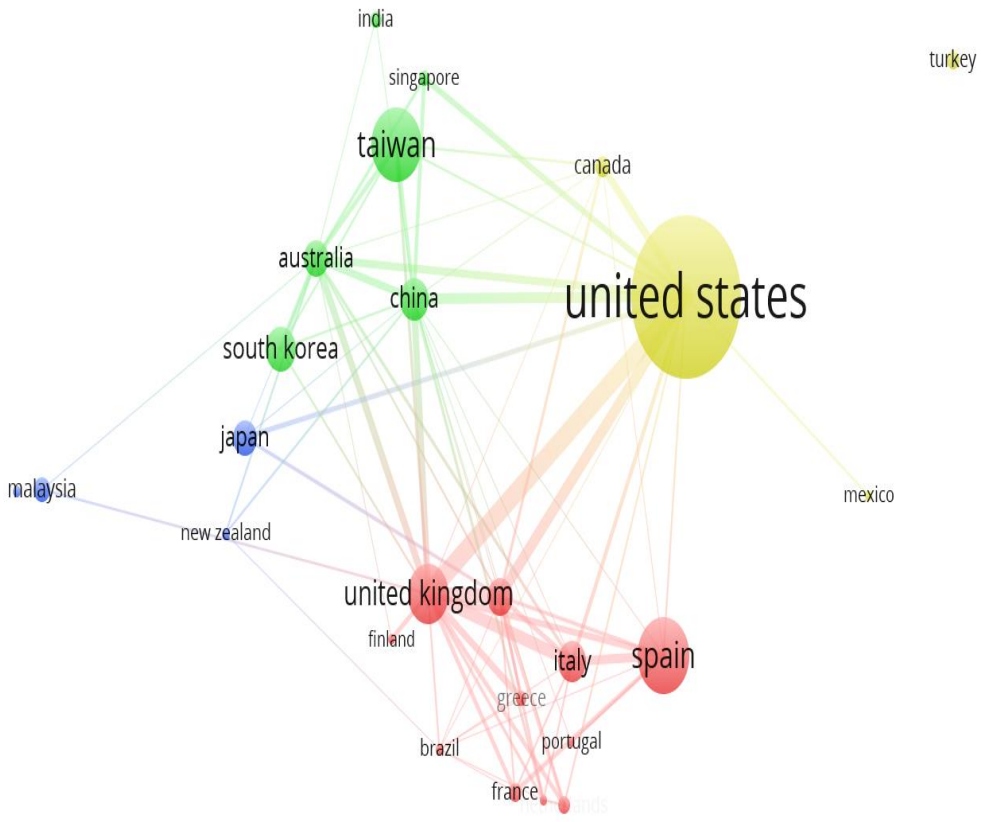

Figure 3. Network diagram showing collaboration between countries with a minimum number of fifteen articles

Table 2. Top 10 most productive countries based on total number of articles published

Country	Number of articles
USA	351
Spain	133
Taiwan	121
UK	114
Germany	99
South Korea	95
China	91
Italy	78
Japan	65
Australia	54

Table 3. Top 10 most productive institutes based on total number of articles published

Institute	Country	Number of articles
National University of Singapore	Singapore	23
Technical University of Munich	Germany	22
National Taiwan University of Science and Technology	Taiwan	21
University of Central Florida	USA	18
Imperial College London	UK	17
National Taiwan Normal University	Taiwan	16
Universitat Politècnica de València	Spain	14
Universiti Teknologi Malaysia	Malaysia	13
National Cheng Kung University	Taiwan	12
University of Wisconsin Madison	USA	12

3.6 Most frequently author keywords used

Table 4 lists the top 10 keywords used by the authors. The result indicates that AR has been used for teaching and training purpose. Only 9 keywords of the total occurred 20 or more than 20 times (see Figure 4.).

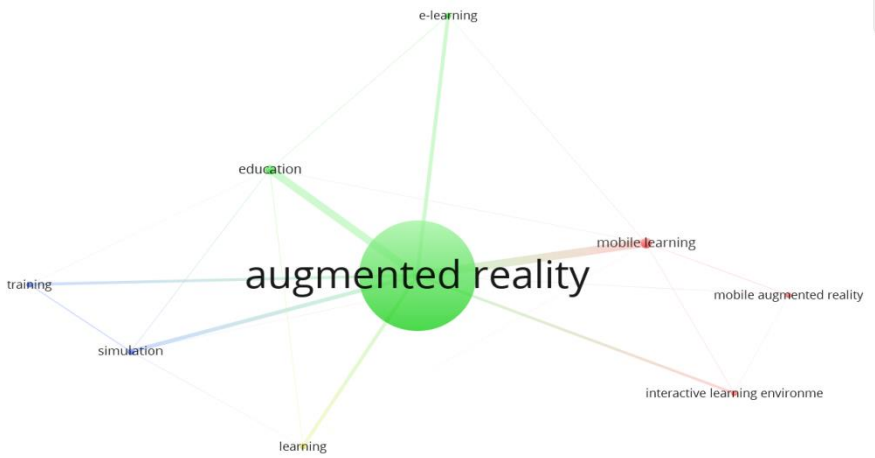

Figure 4. Network diagram 9 keywords that meet the threshold of occurrence at least 20 times

Table 4. Top 10 high frequency author keywords

Keywords	Frequency
Augmented reality	711
Mobile learning	57
Education	52
Simulation	34
Interactive learning environment	30
Learning	24
Mobile augmented reality	23
Training	23
e-learning	22

4. Conclusion and future directions

This study presented research trend of AR quantitatively using bibliometric analysis. Most of the studies were conducted in the developed countries. Asian countries are leading in AR research. More effort is needed in order to bring developing and under developing countries in the main stream of AR research.

References

Cai, S., Wang, X., & Chiang, F.-K. (2014). A case study of Augmented Reality simulation system application in a chemistry course. *Computers in Human Behavior, 37*, 31-40. doi: 10.1016/j.chb.2014.04.018

Chen, Y.-C. (2013). *Learning Protein Structure with Peers in an AR-Enhanced Learning Environment.* (Ph.D. thesis), University of Washington. Retrieved from https://www.learntechlib.org/p/124052

Ferrer-Torregrosa, J., Torralba, J., Jimenez, M. A., Garcia, S., & Barcia, J. M. (2015). ARBOOK: Development and Assessment of a Tool Based on Augmented Reality for Anatomy. *Journal of Science Education and Technology, 24*(1), 119-124. doi: 10.1007/s10956-014-9526-4

Yilmaz, R. M., & Goktas, Y. (2017). Using augmented reality technology in storytelling activities: examining elementary students' narrative skill and creativity. *Virtual Reality, 21*(2), 75-89. doi: 10.1007/s10055-016-0300-1