

# Role of Augmented Reality to enhance consumer experience: A Bibliometric Study

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***Abstract: Technology helps companies stand out in the crowd, by providing the latest goods and services to serve their customers better. If we look at technological advancements, there are a number of technological tools that affect us and one of them is Augmented Reality (AR). From Virtual Reality to Augmented Reality and Mixed Reality, consumers have witnessed an amazing experience. This paper aims at reviewing and discussing the research studies on the role of augmented reality across various industries to enhance customer experience on a global level which were published in Peer Review Journals and indexed for the period 1999-2019 on the Web of Science Core Collection. The analysis examines, how the technology has been adapted by various industries by taking into consideration the publication volume, authors and countries that have collaborated together. This study takes detailed evaluation at current trends in AR and the future potential areas for smarter consumer experiences. The study will be useful for AR and Mixed Reality practitioners to create customized solutions for customers; for academics as it adds to the literature on technology adoption across different sectors; and for society as a whole to benefit as customers gain better knowledge of the applications of AR to make an informed choice whenever they engage in purchase of products and services which will maximise their user experience.***

***Keywords: Bibliometric analysis; augmented reality; customer experience; mixed reality; technology, web of science.***

## **Introduction**

The term Augmented Reality traces its origins back to 1901 in Lyman Frank Baum's well received work 'The Wonderful Wizard of Oz,' although the real application first appeared in 1968 when Ivan Sutherland, Computer scientist and a Harvard professor, designed the first ever head-mounted display of VR and AR called 'The Sword of Damocles' (Isberto, 2018). People observed computer-generated graphics which enhanced their perception of the world sensory. This technology has since been used across diverse industries. It was used in the production of theatre in 1994 where the show featured acrobats dancing on the physical stage alongside projected virtual objects (Poetkar, 2019). In 1998, this technology was used by NFL game to improve the viewer's experience by adding the virtual yellow line on playground to make them realize which team was advancing to get the first down (Poetkar, 2019). NASA has also used AR to help ensure better navigation during its test flights (Poetkar, 2019). Esquire Magazine has used this to improve social user engagement for the first time in print media (Poetkar, 2019). Volkswagen used AR within the service manual via a mobile application which gave technicians step-after-step repair instructions. In 2014, Google also launched 'Google Glass devices' which helped users immerse themselves in a pool of exceptional experiences as they accessed a variety of applications such as Gmail,

Google Maps, and more (Poetkar, 2019). Popular game 'Pokemon Go' reached masses with AR technology at the core of its design (Poetkar, 2019). Sephora, a leading beauty company, used the technology to minimize the amount of makeup lost in trials by using Dynamic Augmentation with the invention of their AR mirror, which is just like a real-world mirror showing the user's face on the screen, and by using on-screen markers / pickers, the user can try to see how they look in real life by trying different Sephora products in AR mirror (Marr, 2018).IKEA has helped consumers overcome the issue of making a wrong purchase of furniture, as the application let customers to digitally preview their home decor choices before making a purchase actually (Gochhait, 2020). Converse, a famous shoe brand has also helped customers to make better buying decision by simply angle the back camera to their feet and see how their intended shoes are look like in their AR enabled application. In 2020, a consumer start-up named 'Homingos' has enhanced the user experience of preserving memories in the form of photo albums by introducing the concept of ViBo (VideoBook) that helps users to print their videos as photos that can be scanned by their AR-enabled application to playback that video. (Mali, 2020). Many such benefits or applications of Augmented Reality across different fields has been published in numerous records over the years. The analysis of these records can help us understand how much Augmented Reality has progressed, and how the world is applying the concept of technology to increase the user experience (Naqvi and Soni, 2019).

A bibliometric analysis is used to examine the knowledge structure and the research development based on the analysis of related publications, which includes analysis based on quantitative indicators such as number of citations, most ranked authors, prime publication and so on (Leena and Gochhait, 2020).. This is a very useful strategy to track the growth and productivity of any field within any period or place. Similarly, the aim of this paper is to explore how much the Augmented Reality paradigm has evolved in terms of enhancing customer experience by solving various problems.

## **Objectives**

The main objective of this analysis is to find the growth of Augmented Reality Literature published in 1999-2019 as per the Web of Science database and to carry out a quantitative and qualitative evaluation by analyzing various characteristics of research production such as the growth of publications, quotations, core research areas, active countries, languages, authorship patterns, highly cited journals etc(Fatima and K S,2019).

## **Design/Methodology/approach**

The data is the study was collected from the Web of Science database covering the 1999-2019 period.A total of 9574 articles records were retrieved with the terms "Augmented Reality" or "Mixed Reality."The data was further analyzed to reveal various trends that prevail in Augmented Reality research including most productive countries, pattern of authorship, most cited papers, etc(Fatima and K S,2019).

## **Analysis and Result**

### **Core Areas**

The keywords used for this study are 'Augmented Reality' and 'Mixed reality' All records within the years 1999-2019, that has the above-mentioned keywords in their title has been

considered for the analysis. The top 10 research areas for this study has been collated in the table below:

| S.no | Core Areas                      | Total Count |
|------|---------------------------------|-------------|
| 1    | COMPUTER SCIENCE                | 2635        |
| 2    | ENGINEERING                     | 2113        |
| 3    | EDUCATION RESEARCH EDUCATIONAL  | 954         |
| 4    | SURGERY                         | 446         |
| 5    | PSYCHOLOGY                      | 394         |
| 6    | TELECOMMUNICATIONS              | 393         |
| 7    | BUSINESS ECONOMICS              | 376         |
| 8    | OPTICS                          | 289         |
| 9    | NEUROSCIENCES NEUROLOGY         | 264         |
| 10   | SCIENCE TECHNOLOGY OTHER TOPICS | 256         |

**Table 1:** Key research areas for the analysis

Other areas researched apart from above are Robotics, Communication, Healthcare Sciences Services, Materials Science, Physics, Social Sciences Other Topics.

### Country wise

According to the analysis, USA has the highest number of records published, that is 2280. USA is followed by England with 797 records and China with 769 records.

| S.no | Countries/Regions | Total Count |
|------|-------------------|-------------|
| 1    | USA               | 2280        |
| 2    | ENGLAND           | 797         |
| 3    | PEOPLES R CHINA   | 769         |
| 4    | GERMANY           | 695         |
| 5    | SPAIN             | 679         |
| 6    | SOUTH KOREA       | 509         |
| 7    | ITALY             | 484         |
| 8    | JAPAN             | 468         |
| 9    | CANADA            | 441         |
| 10   | FRANCE            | 425         |

**Table 2:**Top 10 countries with highest publications

### Languages

English is the language used for 8857 records, which is 92.51% of the total published records collected. The rest of the records are published in other 9 languages, which is depicted in the table below.

| S.no | Row Labels | Total Count | % of 9574 |
|------|------------|-------------|-----------|
| 1    | ENGLISH    | 8857        | 92.51%    |
| 2    | SPANISH    | 323         | 3.37%     |
| 3    | RUSSIAN    | 77          | 0.80%     |
| 4    | PORTUGUESE | 72          | 0.75%     |
| 5    | FRENCH     | 65          | 0.68%     |
| 6    | GERMAN     | 64          | 0.67%     |
| 7    | ITALIAN    | 39          | 0.41%     |
| 8    | CHINESE    | 12          | 0.13%     |
| 9    | POLISH     | 12          | 0.13%     |
| 10   | TURKISH    | 10          | 0.10%     |

**Table 3:** Record count of Top 10 Languages

### Authors

The top authors and their publication details have been tabulated and shown below. Navab N. has the highest number of record publications with a count of 64 which accounts to 0.668% of the total collected set. Most of the Authors have a record count ranging from 37 to 31 which constitutes a minor percentage of the total set.

| S.no | Author         | Record Count | % of 9574 |
|------|----------------|--------------|-----------|
| 1    | NAVAB N        | 64           | 0.668%    |
| 2    | ONG SK         | 56           | 0.585%    |
| 3    | NEE AYC        | 52           | 0.543%    |
| 4    | BILLINGHURST M | 37           | 0.386%    |
| 5    | KIM H          | 37           | 0.386%    |
| 6    | KIM J          | 37           | 0.386%    |
| 7    | LIU Y          | 32           | 0.334%    |
| 8    | LEE S          | 31           | 0.324%    |
| 9    | SCHMALSTIEG D  | 31           | 0.324%    |
| 10   | WANG XY        | 31           | 0.324%    |

**Table 4:** Record count of Top 10 Authors

## Organisations Enhanced

The table shows that total of all organisations constitutes a very low percentage of total records i.e. less than 10%.

| S.no | Organisation-Enhanced                                      | Record Count |
|------|--|--------------|
| 1    | STATE UNIVERSITY SYSTEM OF FLORIDA                         | 154          |
| 2    | UNIVERSITY OF LONDON                                       | 132          |
| 3    | UNIVERSITY OF CALIFORNIA SYSTEM                            | 131          |
| 4    | CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS          | 128          |
| 5    | NATIONAL UNIVERSITY OF SINGAPORE                           | 116          |
| 6    | TECHNICAL UNIVERSITY OF MUNICH                             | 110          |
| 7    | UNIVERSITY OF CENTRAL FLORIDA                              | 92           |
| 8    | HARVARD UNIVERSITY   | 79           |
| 9    | PENNSYLVANIA COMMONWEALTH SYSTEM OF HIGHER EDUCATION PCSHE | 79           |
| 10   | JOHNS HOPKINS UNIVERSITY                                   | 75           |

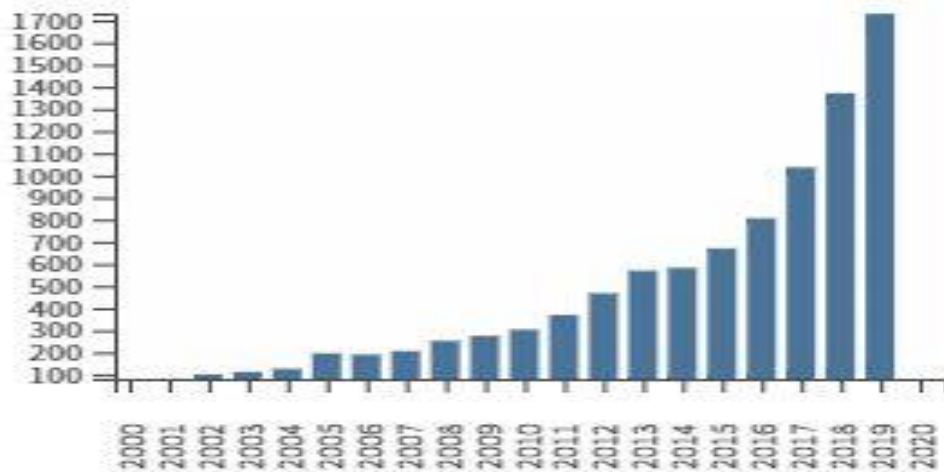
*Table 5: Record count of Top 10 Enhanced Organisations*

## Annual Publication output

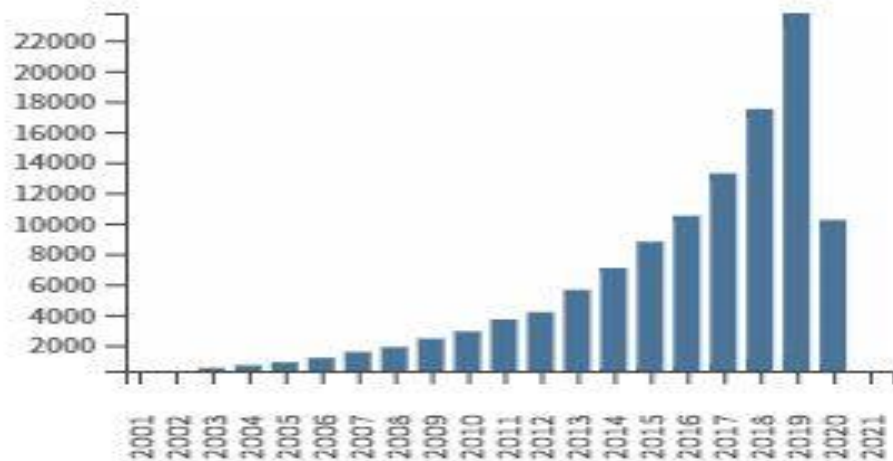
The block-wise period, number of publications and quotations received in each block year are shown in Table 6. The number of papers published is increasing positively in line with each block year. A record number of papers with 4137 papers and 54553 total citations (13.19 citations per paper) is released in the 2017-19 block year, followed by the 2014-16 block year with 2058 articles and 26341 total citations (12.80 citations per paper). Average citation per paper is determined by dividing the number of quotes with no. articles (Fatima and KS, 2019). There were overall 9574 articles with an average of 11.17 citations per article. There were overall 9574 articles with an average of 11.17 citations per article. Work on Augmented Reality was least in the 1999-2001 period, i.e. just 213 papers, but the reason for the growth of work is the advancement of information and communication technology year after year.

| Block years | Total Citation | Total Papers | ACPP  |
|-------------|----------------|--------------|-------|
| 1999-2001   | 257            | 213          | 1.21  |
| 2002-2004   | 1515           | 339          | 4.47  |
| 2005-2007   | 3613           | 592          | 6.10  |
| 2008-2010   | 7210           | 830          | 8.69  |
| 2011-2013   | 13500          | 1405         | 9.61  |
| 2014-2016   | 26341          | 2058         | 12.80 |
| 2017-2019   | 54553          | 4137         | 13.19 |
| Total       | 106989         | 9574         | 11.17 |

**Table 6:Year Wise Output**



**Figure 1:Total Publications per year**



**Figure 2:Sum of Citations per year**

**Most Cited Records**

The table represents the top 10 highest cited records published within the 9574 data collected. It also includes the information on the authors of the publications, the country and the year they were published in.

Further results of the study are as follows(including results of 2020):

- According to the analysis of 9574 records, overall number of citations (sum of citations of all records under analysis) is **117,214**
- Overall number of citations without self-citations (external citations in the paper) is **98,984**.
- The total number of citing articles, that have cited any of the records under the analysis is **82,206**.
- The total number of citing articles without self-citations (external citations in the paper) is **77,736**.
- The H-index of all 2495 collected record is **115**.
- The average citation per article is **12.24**. This value is given by the total number of cited times divided by the total number of collected records.

| S.no | Title  | Authors  | Year of Publication | Total Citations | Per Year Average |
|------|--|--|---------------------|-----------------|------------------|
| 1    | Affordances and Limitations of Immersive Participatory Augmented Reality Simulations for Teaching and Learning         | Dunleavy, Matt; Dede, Chris; Mitchell, Rebecca   | 2009                | 369             | 30.75            |
| 2    | 5G: A Tutorial Overview of Standards, Trials, Challenges, Deployment, and Practice                                     | Shafi, Mansoor; Molisch, Andreas F.; Smith, Peter J.; Haustein, Thomas; Zhu, Peiying; De Silva, Prasan; Tufvesson, Fredrik; Benjebbour, Anass; Wunder, Gerhard | 2017                | 348             | 87               |
| 3    | Reconceptualising the 'policy mix' for innovation  | Flanagan, Kieron; Uyarra, Elvira; Laranja, Manuel  | 2011                | 340             | 34               |
| 4    | A physically-based treatment of elemental carbon optics: Implications for global direct forcing of aerosols            | Jacobson, MZ   | 2000                | 332             | 15.81            |
| 5    | Use of a Low-Cost, Commercially Available Gaming Console (Wii) for Rehabilitation of an Adolescent With Cerebral Palsy | Deutsch, Judith E.; Borbely, Megan; Filler, Jenny; Huhn, Karen; Guarrera-Bowlby, Phyllis   | 2008                | 330             | 25.38            |

|    |   |   |      |     |       |
|----|---|---|------|-----|-------|
| 6  | Lessons in modelling and management of marine ecosystems: the Atlantis experience     | Fulton, Elizabeth A.; Link, Jason S.; Kaplan, Isaac C.; Savina-Rolland, Marie; Johnson, Penelope; Ainsworth, Cameron; Horne, Peter; Gorton, Rebecca; Gamble, Robert J.; Smith, Anthony D. M.; Smith, David C. | 2011 | 306 | 30.6  |
| 7  | Mobile Phone Sensing Systems: A Survey  | Khan, Wazir Zada; Xiang, Yang; Aalsalem, Mohammed Y.; Arshad, Quratulain  | 2013 | 289 | 36.13 |
| 8  | Motion tracking: No silver bullet, but a respectable arsenal                          | Welch, G; Foxlin, E   | 2002 | 289 | 15.21 |
| 9  | Ultra-Dense Networks: A Survey  | Kamel, Mahmoud; Hamouda, Walaa; Youssef, Amr  | 2016 | 283 | 56.6  |
| 10 | Impact of an augmented reality system on students' motivation for a visual art course | Di Serio, Angela; Blanca Ibanez, Maria; Delgado Kloos, Carlos   | 2013 | 280 | 35    |

**Table 7:**Top 10 Most Cited Records

## Conclusion

This paper tries to identify the research trends in the discipline of Augmented Reality during 1999-2019. Based on Web of Science data, authors analyzed Year-Wise Output, Most Productive Countries, Most Common Languages, etc. There is a positive growth in literature. Number of papers were fewer in initial years but steadily they increased year over year. It is clear that USA and England have the highest publications. The most cited articles are majorly after the year 2007. The core research areas have been Computer Science and Engineering. English has been the main language for more than 92% of publications. Also, the top authors collectively form a minor part of total collected records. Most enhanced organisations are State University system of Florida and University of London.

The technology has been progressively gaining importance and various use cases have been beneficial for enhancing consumer experience in various ways by driving customer engagement. Problems of time, less information of the product are solved by using of AR. Almost across major industries, technology has gained popularity although in the education sector, use of technology may pose some As students, psychological challenges would be cognitively swamped by the vast amount of knowledge they receive, the various applied



devices they need to use and the complex tasks they have to perform.(Wu;Lee ; Chang and Liang, 2013). There are many areas which can be explored further to apply the technology to enhance user experience or solve the business problems likedoctors can use it to have guides during surgeries that require immense accuracy(Islam,2018). It can be used forenhancing indoor and outdoor navigation. Augmented Reality is most certainly a big thing(Islam, 2018).

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