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# Issues and Challenges in Interactive Multimedia Systems: A Systematic Literature Review

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***Abstract*** *- Virtual Reality (VR) and Augmented Reality (AR) are the two most remarkably developing interactive multimedia systems. While these are being popularly used in numerous fields, several researchers predicted that these multimedia systems will face several businesses, social, political, communication, educational, technical, ethical, and legal issues. However, there were no empirical studies that explore these types of challenges in AR and VR. Using the methodology Systematic Literature Review, this paper explores and discusses the issues and challenges in AR and VR. The issues and challenges were categorized to the following: (1) business issues, (2) social and political issues, (3) communication and collaborative work issues, (4) educational and learning issues, (5) technological issues, and (6) ethical and legal issues. Technological issues were the most common challenges among the papers reviewed. The following additional challenges were also discovered that were not part from any category stated above: barriers imposed by physics, environmental challenges, usability issues and touchless interaction.*

**Keywords:** *solutions to issues and challenges in internet of things*

## 1 INTRODUCTION

Interactive multimedia was introduced to provide two-way information exchange. While interactive multimedia is mostly applied to education and learning [6][7][86][87][88], it is also seen to be utilized in interactive product training videos [1][2][3], interactive employee training videos [4][5], virtual reality [15][16][17] and virtual reality [15][16][17].

Virtual Reality (VR) and Augmented Reality (AR) are the two most notably growing interactive multimedia systems. Gartner, a leading technological and consulting firm, stated in its Hype Cycle, a guide to emerging technologies, that VR is close to being widely used and understood by the public. Augmented Reality (AR) aims to create the illusion that virtual images are seamlessly blended with the real world [22]. Virtual reality (VR), which can be referred to as immersive multimedia or computer-simulated reality, replicates an environment that simulates a physical presence in places in the real world or an imagined world, allowing the user to interact in that world. Both interactive multimedia systems are being used in medicine, entertainment, education, engineering and others.

The popularity of AR and VR in different application domains does not guarantee that these interactive multimedia systems are exempted from issues and challenges, that is according to several researchers [64][65], including the researchers from University of Lausanne and University of Arkansas [63]. These researchers predicted that AR and VR will have to face several businesses, social, political, communication, educational, technical, ethical, and legal issues in the near future. However, there were no empirical studies that explore these types of challenges in AR and VR. Thus, this paper aims to explore and discuss issues and challenges in AR and VR systems and categorize it according to certain type of issues.

The rest of the paper is organized as follows: section 2 discusses the methodology to be used. In addition, section 2 also discusses the six (6) specific issues and challenges in VR and AR. Then in section 3, results are discussed. Finally, section 4 concludes the paper.

## 2 METHODOLOGY

This paper uses the SLR method in undertaking a systematic literature review. By complying to the systematic procedure defined by the said research method, this paper can provide a more objective process in selecting relevant and note-worthy studies. The major steps in SLR include the following: (1) defining a research question, (2) search strategy for selecting studies and (3) management of studies.

Using the SLR methodology, the author should be able to define a research question that is anchored to the purpose of the literature review. The author should also be able to plan for the search strategy and specify the steps needed. Lastly, the author should be able to manage the studies, filtering the irrelevant studies and selecting the pilot studies to be evaluated. In order to properly manage the solutions introduced in the studies,

### 2.1 Defining a research question

This paper aims to identify the issues and challenges in AR and VR systems and defining a research question is the initial step. The research question will be the basis for the search strategy and the selection of the pilot studies to be evaluated.

### 2.2 Planning a search strategy

The initial step in planning a search strategy is selecting the input data source. In this paper, ACM Digital will be used as a source for the relevant studies. ACM Digital Library has been chosen as the main source because this is the most comprehensive database of full-text articles covering computing and information technology. The second step in our search strategy is to construct a query based on the research question. Keywords should be chosen carefully to maintain the proper balance between specificity and generality.

### 2.3 Managing the studies

After running the query in the ACM Digital Library, studies will be obtained. But there is a need for each of the study to be assessed for its actual relevance through inclusion criteria. Table 1 shows the inclusion criteria.

**Table 1: Inclusion Criteria**

| No. | Criterion | Description |
|---|---|---|
| 1 | It should be written in English. | There are some studies that are written in other language. They have provided English title and abstract so these papers will show up in the search results. Only studies written in English will be included. |
| 2 | It should be peer-reviewed. | To ensure the quality of this systematic literature review, only peer-reviewed studies will be included. |
| 3 | The publication date must not be earlier than 2013. | To ensure that only up-to-date energy-efficiency solutions are included, only studies that were published in the year 2013 onwards are selected. |

To furtherly filter the researches and articles, abstract and conclusion of each study are carefully examined. After selecting the pilot studies to be evaluated, the studies will be ordered and arranged according to the following type of issues, presented by [63]: (1) business issues, (2) social and political issues, (3) communication and collaborative work issues, (4) educational and learning issues, (5) technological issues, and (6) ethical and legal issues.

## 3 RESULTS AND DISCUSSION

This section will discuss the results of each step in the SLR methodology and later part will discuss the selected pilot studies according to type of issues.

### 3.1 Research question defined

This paper aims to answer the following question: What are the issues and challenges in AR and VR systems?

### 3.2 Results of the search strategy

Keywords were constructed from the research question. These keywords will be used in the search query in ACM Digital Library. The following search query will be used: "*issues and challenges in AR and VR*". Table 2 shows the number of search results per source:

**Table 2: Number of search results**

| Search query | Number of results (ACM Digital Library) |
|---|---|
| issues and challenges in AR and VR | 498,890 |

### 3.3 Managing the studies

The search result for the first query has been furtherly refined by publication year (>= 2014). Table 3 shows the number of search results for the given query.

**Table 3: Search result for the refined query**

| Search query | Number of results (ACM Digital Library) |
|---|---|
| issues and challenges in AR and VR | 126,037 |

To furtherly filter the results, advanced search feature has been used. The first where clause will be on the Title field that matches all (compared to matches any) of the following words or phrases: "issues and challenges in AR and VR". The next where clause will on the field of Publication Year, this is set to on or after (>=) 2014. The full query syntax is as follows:

*"query": { acmdlTitle:(+ issues+and+challenges+in+ AR+and+VR) }*

*"filter": {"publicationYear":{ "gte":2014 }}, {owners.owner=HOSTED}*

The above query resulted to fewer matches. From a total of 126,037 ACM Full-text Collection records, there were only 24 results found.

To furtherly filter the results and finally select the pilot studies, abstract and conclusion were read to verify and assess the paper's relevance to the research question. Table 4 shows the 20 final pilot studies to be evaluated.

**Table 4: Final list of researches with publication year**

| No. | Research Title | Publication Year |
|---|---|---|
| 1 | Visualizing Big Data with augmented and virtual | 2015 |

| | | |
|---|---|---|
| | reality: challenges and research agenda [66] | |
| 2 | Recollections on Presence Beginnings, and Some Challenges for Augmented and Virtual Reality [67] | 2016 |
| 3 | Towards Interconnected Virtual Reality: Opportunities, Challenges and Enablers [68] | 2017 |
| 4 | Virtual Reality Challenges in Education and Training [69] | 2017 |
| 5 | Empirical evidence, evaluation criteria and challenges for the effectiveness of virtual and mixed reality tools for training operators of car service maintenance [70] | 2015 |
| 6 | Grand challenges in virtual environments [71] | 2014 |
| 7 | Efficacy of virtual reality-based intervention on balance and mobility disorders post-stroke: a scoping review [72] | 2015 |
| 8 | Studying social interactions through immersive virtual environment technology: virtues, pitfalls, and future challenges [73] | 2015 |
| 9 | A Dose of Reality: Overcoming Usability Challenges in VR Head-Mounted Displays [74] | 2018 |
| 10 | Virtual, Augmented, and Mixed Reality for Human-Robot Interaction [75] | 2018 |
| 11 | On Building a Programmable Wireless High-Quality Virtual Reality System Using Commodity Hardware [76] | 2017 |
| 12 | Towards Perceptual Evaluation of Six Degrees of Freedom Virtual Reality Rendering from Stacked OmniStereo Representation [77] | 2018 |
| 13 | Virtual reality: A new track in psychological research [78] | 2018 |
| 14 | Location-based Mobile Augmented Reality Applications [79] | 2014 |
| 15 | The development of an augmented reality (AR) approach to mammographic training: overcoming some real world challenges [80] | 2018 |
| 16 | On the Networking Challenges of Mobile Augmented Reality [81] | 2017 |
| 17 | Touch-less Interactive Augmented Reality Game on Vision Based Wearable Device [82] | 2014 |
| 18 | Augmented Reality: Applications, Challenges and Future Trends [83] | 2015 |
| 19 | A Theoretical Model of Mobile Augmented Reality Acceptance in Urban Heritage Tourism [84] | 2018 |
| 20 | Augmented Reality needle ablation guidance tool for Irreversible Electroporation in the pancreas [85] | 2018 |

Additionally, the studies were categorized according to the type of issues and challenges. Table 5 shows the categorized studies:

**Table 5: Categorized researches**

| Type of Issue/challenge | Studies |
|---|---|
| business issues | [71] |

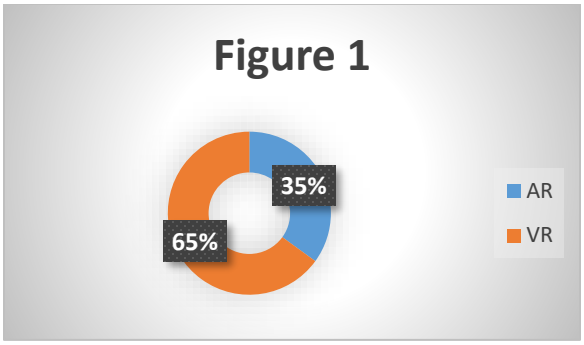
| | |
|---|---|
| social and political issues | [73][83] |
| communication and collaborative work issues | [73][75] |
| educational and learning issues | [69][70] |
| technological issues | [66][68][69][72][76][77][78][79][80] [81][82][83][85] |
| ethical and legal issues | [67][68][69] |

Furthermore, the researches have been classified by the type interactive multimedia system (AR or VR). Table 7 shows the studies by type of interactive multimedia system.

**Table 6: Categorized researches by Type of Interactive Multimedia System**

| Type of Interactive Multimedia System | Studies |
|---|---|
| AR | [79][80][81][82][83][84][85] |
| VR | [66][67][68][69][70][71][72][73][74][75] [76][77][78] |

Based from the table above, 65% of the pilot studies found are on VR systems while the remaining 35% researches are on AR systems.




In the business side, since VR and AR are becoming a mass consumer product, competition will rise. This will force businesses to sell their AR/VR devices and contents cheaper [71]. This will also drive them to make their SDKs open-source so developers can easily make content for their platform.

Communication has also been a prevalent issue. One of the biggest challenges in using virtual reality in social interaction is to achieve natural communication [73]. This issue is also presented by Williams, et. Al., [75], according to them virtual humans' responses might not be precisely adjusted to participants' utterances or to the tone of the conversation [75].

From the result of the categorization shown in Table 5, AR and VR commonly faced with technological issues. The paper of Olshannikova, et. Al. [60], which deals with Big Data visualization using virtual reality, says that visualization is the main challenge since this is dependent to human ability to manage the data, extract information and gain knowledge from it. Since Big Data is very complex to be visualized, the visualization in VR should be simple yet concise and that commercial Big Data platform companies should introduce new interactive platforms and supporting research in this area.

Another technological issue discussed was related to network infrastructure. Because AR and VR contents are data intensive, bandwidth requirements [76] should be taken into consideration. 5G network architecture can be seen as a solution to suffice to provide an aggregate of all camera feeds [68]. The use of modern technologies such as software defined networking (SDN), network function virtualization (NFV) and network slicing is needed to meet these demands. Mobile devices used for augmented reality is seen to suffer from network related challenges [81].

AR and VR also require intensive graphics capabilities. This imposes problems such that a standard computer equipment could not run AR/VR and it could take significant efforts to achieve smooth implementation [80], no delays in movements [78], accurate calculations [79][84][85] and worth immersion and interaction [68]. The paper [83] also agrees with this because AR system has to deal with vast amount of information in reality. Therefore, the hardware used should be small, light, and easily portable and fast enough to display graphics.

Compatibility is also an underlying problem. VR is often delivered as propriety solutions that could not be matched with similar environments from other developers. Many companies offer their own tools to create VR environments that are not compatible with the rest [68].

In the field of educational and learning, several issues have also been explored. Students tend to treat AR and VR applications as games but not a real learning process [69]. There is also a gap on the assessment of pre and post training understanding, recognition and retention [70].

A total of 3 papers were discussing ethical and legal issues and implications of VR and AR. In the paper of Sheridan [67], where AR is being used in driver training, legal implications should be taken into consideration when accidents happen while being engaged in AR-assisted driving. For the ethical issues, VR/AR is not always suitable for students from different cultures, religions, ethical [68] [69] groups and geographical regions. This is a serious consideration, which could significantly limit the successful distribution and adoption of even already proved implementations.

There were some papers that discuss underlying issues in AR/VR which were not covered by the categorization we made. The most significant issue that the researcher has explored is the barriers determined by physics [71]. There are no devices that can completely produce displays and feedbacks related physics. Another issue that was discovered is related to the environment. Examples of environmental challenges are low light, uneven terrain, external physical load, traffic, and obstacles. Another is usability issue, the use of AR/VR tends to be harder when compare to other interactive multimedia systems [74] [84]. Touchless interaction has also been tackled as one of the most important challenge of interaction for wearable devices [82].

## 4 CONCLUSION

In this paper, different issues and challenges of AR and VR were discussed. The papers were categorized according to the following type of issues: (1) business issues, (2) social and political issues, (3) communication and collaborative work issues, (4) educational and learning issues, (5) technological issues, and (6) ethical and legal issues.

Technological issues were the most common challenges among the papers reviewed. Specifically, networking infrastructure and graphics capability were the main concerns. Business issues were least discussed while there is moderate concerning with the issues related to

communication, education and learning, ethics and legal concepts.

It is also worth noting of the additional issues and challenges that were explored. These are: barriers imposed by physics, environmental challenges, usability issues and touchless interaction.

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