Chapter

The Interactive Applications (IAs) in Academic Libraries: Challenges and Opportunities

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Abstract

Presentation tools of academic content are increasing in popularity for educators in Higher Education Institutions (HEI) who want to share ideas and information in a more creative and interactive environment using more effective tools and demand to involve. Interactive Applications are becoming lot more common and is more integrated into our everyday activities, like using mobile apps. The features of the Fourth Industrial Revolution (4IR) began to emerge through Interactive Applications (IAs) such as the applications of Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR). Information resources development is no longer restricted and residing within the realm of speculative fiction. By using AR, VR and MR, academic libraries could already deliver a massive revolution in information retrieval. However, the biggest challenge that need to be tackled perhaps remains in how we could tune between these resources and the users so that the greatest possible benefit could be achieved in the light of accelerated technological development. This chapter uncovers the challenges and opportunities in using Interactive Applications (IAs) technologies and should be an eye opener for academic libraries that Interactive Applications technology are important to transform the use of traditional resources to interactive resources.

Keywords: Interactive Application, Virtual Reality, Augmented Reality, Mixed Reality, Academic Library, Open Science, Interactive Information Resources

1. Introduction

Interactive Applications (IAs) are becoming lot more common and is more integrated into our everyday activities. The ability of IAs to enhance what already exists is what makes it an ideal fit for libraries, educational institutions, museums, and similar institutions. It can be used for resources wayfinding, shelf-reading, upgrade services, technological integration, and community engagement. New technology services are making it easier than ever for libraries to create their own free or low-cost IA content without having to download a Software Development Kit (SDK) or transact with complicated Application Programming Interface (API) codes [1]. In addition, the development of open science (OS) movement and methods has supported scientific research data and has managed to make its information accessible to the scientific society and to the overall public. This wide global recognition towards OS has made the demand of making data more open

through important aspects such as open data, open access, open material, and open educational resources to sustain sharing scientific information easily. And by IAs such as AR, VR and MR, this type of information can be experimented easily and used firsthand by users in academic libraries.

2. The concept of interactive applications (IAs)

An Interactive Apps (IAs) is an application that allows users to interact with audiovisual information via gamification, visualization, and even Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR). The origin of Interactive Applications such as AR, VR came way back in 1838, when Charles Wheatstone invented the stereoscope [2]. **Figure 1** shows the timeline of Interactive Applications by checking out this infographic, which details not only the technology's past but also its present and future [3–13].

2.1 Augmented reality (AR)

Augmented reality (AR) can be defined as *"an enhanced version of the real physical world that is achieved through the use of digital visual elements, sound, or other sensory stimuli delivered via technology"* [14]. Furthermore, AR is a system that fulfills three basic features: a combination of real and virtual worlds, real-time interaction, and accurate 3D registration of virtual and real objects (see **Figure 2**).

2.2 Virtual reality (VR)

Virtual reality is one of the most popular technologies currently, which can allow experiencing things that may be difficult to happen in the real world. VR can be defined as *"an artificial environment that is created with software and presented to the user in such a way that the user suspends belief and accepts it as a real*

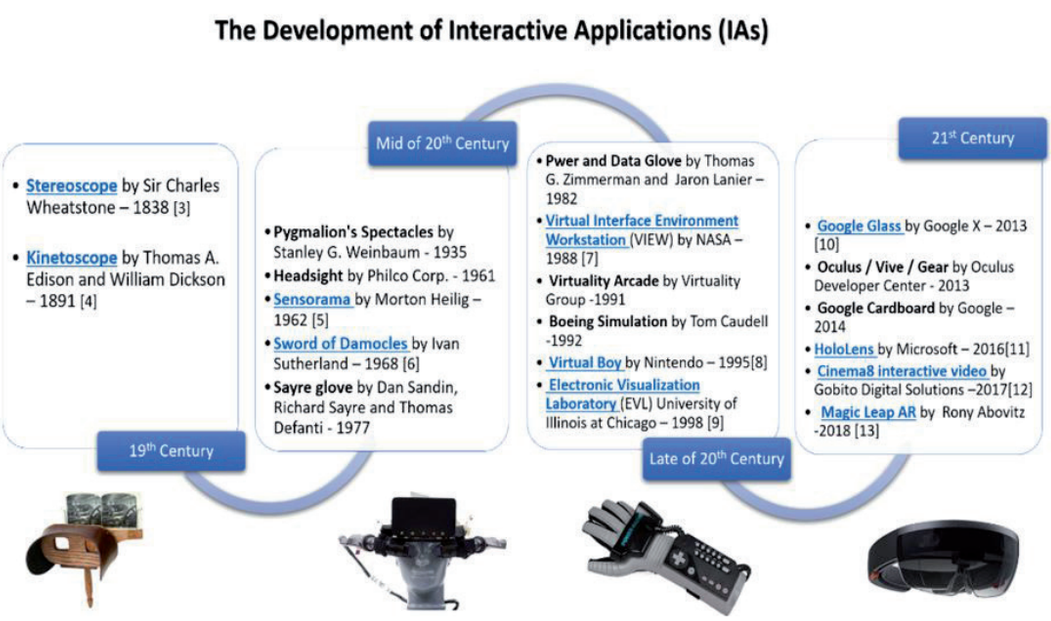

Figure 1.
The development of interactive applications (IAs) [3–13].

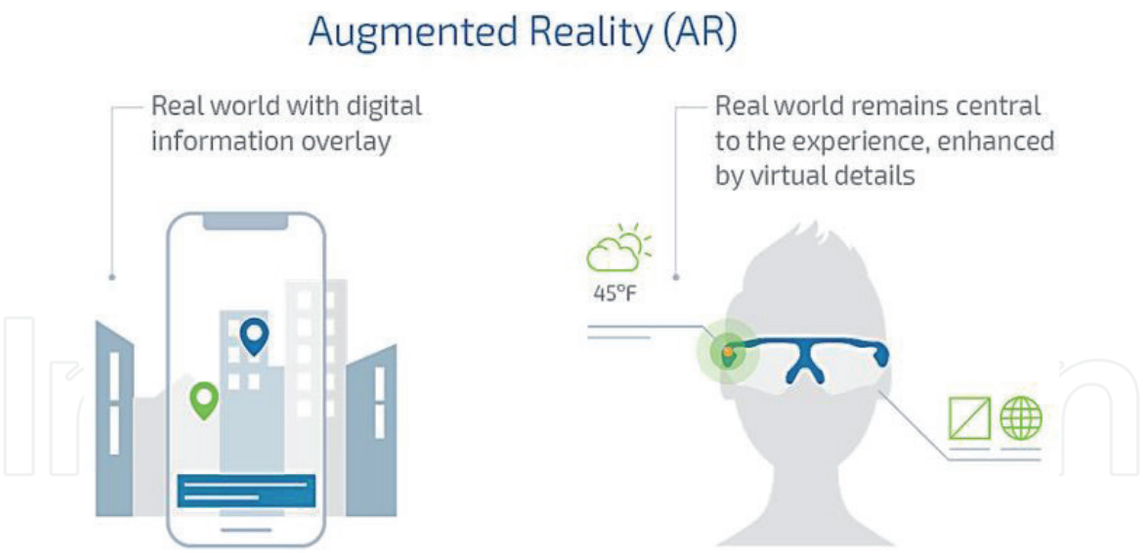

Figure 2.
The concept of augmented reality [15].

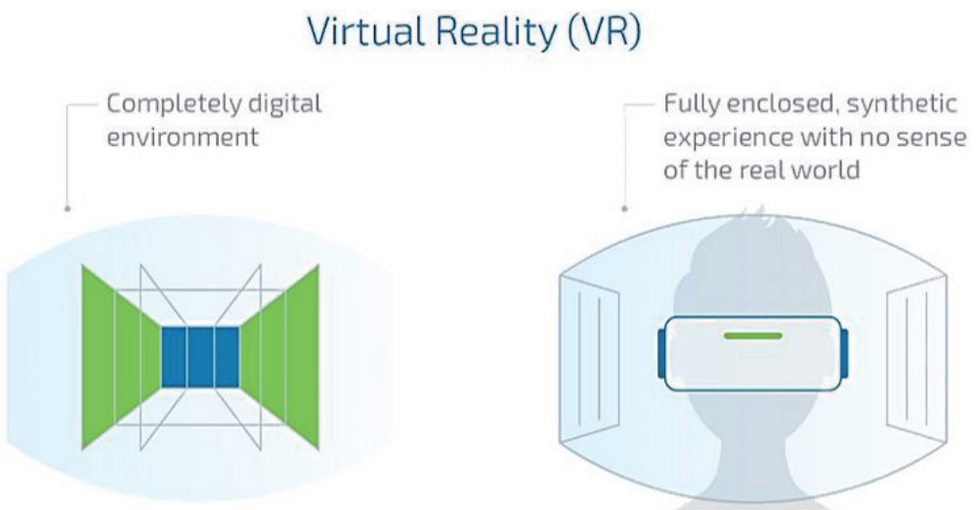

Figure 3.
The concept of virtual reality [15].

environment" [14]. Furthermore, it is the computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors (see **Figure 3**) [15].

2.3 Mixed reality

Mixed Reality, also called the merged reality, is a term coined by technology giants Intel and Microsoft to describe their proprietary VR project. MR is defined as *"the merging of real and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real-time"* [16]. **Figure 4** indicates Mixed reality takes place not only in the physical world or the virtual world but is a mix of reality and virtual reality [15]. Simply, Mixed reality is a hybrid of VR and AR and aims to offer the best of both worlds. For instance, while it uses a headset just like VR, seeing through a translucent viewport or glass, it also projects visuals on top of our environment.

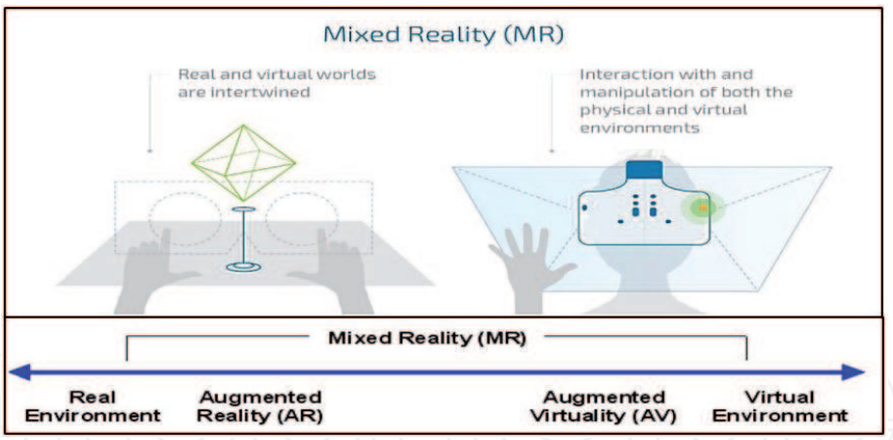

Figure 4.
The concept of mixed reality [15].

3. Interactive applications (IAs) in academic libraries in the digital age

Forty years and more the future of the library has been questioned by people, in addition it has been predicted by some the end of the library. This is due to being incapable to deal with the digital and social transformation, unsustainable by the classic Gutenberg era; having made a dead end, they "may disappear like the dinosaurs" [17]. But one thing is for sure, which is the development of the modern world of information technologies and digital developments, connectivity has changed the future advancement of libraries, and libraries must offer advanced solutions if they want to exist. Integrating IAs, such as VR, AR, and MR into higher education institutions and their libraries, are essential to the advancement of learning in the digital age. Advanced learning platforms through technology are already available and in higher education, their use is catching on. In fact, the use of IAs is already becoming more popular in higher education. Since 2015, for instance, first-year medical students at Case Western Reserve University have been learning from home using an MR app called HoloLens and Holo-Anatomy, created by Case Western Reserve University and Cleveland Clinic in cooperation with Microsoft. Through 3D learning, medical students are learning about the human body in a way that would otherwise not be possible [18]. Similarly, San Diego State University Instructional Technology Services has used virtual immersive teaching and learning since 2017. Students' learning is enhanced through the opportunity to interact with 3D graphics in what appears to be a real-world environment. Instead of placing the student or a camera within a physical learning environment, virtual reality places the student in a simulated environment where senses such as vision, hearing, and touch foster learning.

In 2015, the University of North Texas (UNT) Media Library began offering access to VR and AR devices. This collection is growing as new technology, games, and devices evolve to support students, faculty, and staff interested in research and recreation. IA's in UNT Media Library can be used for various forms of simulations and entertainment, for instance, by using VR headsets such as HTC Vive to let students walk around 3D visualizations or reconstructions of archeological sites. Moreover, museum visits, view artwork from different angles or up close, or view designs in 3D and gain a better understanding of how they work [19].

Two years later, in 2017, Harvard University Library opened the AR/VR studio to further the growth of the ventures being built at Harvard using inspiring AR, MR, and VR tech, as well as, to give students from across the university a space to experiment with and create projects and ventures in the virtual, augmented,

and mixed reality spaces [20]. In the same year, North Carolina State University (NCSU) Libraries launched the Virtual Immersive Teaching and Learning (VITaL) initiative, providing a variety of VR, AR, MR, and 360°-video immersive tools for use across the NCSU pedagogical spectrum. Today, "VITaL serves as an incubator to enable experiences that would be out of reach, if not impossible in a traditional learning environment, including low-frequency, high-risk scenarios simulating life-threatening medical conditions, celestial events in outer space, and scientific phenomena occurring at the micro scale" [21]. Thus, there are many university libraries around the word have used these technologies to enhance their services and functions. Hence, information resources development is no longer restricted and residing within the realm of speculative fiction. By using IAs academic libraries and learning centres could already deliver a massive revolution in information retrieval. However, according to Rotolo, Hicks, & Martin, (2015) the biggest challenge that needs to be tackled perhaps remains in how we could tune between these resources and the users so that the greatest possible benefit could be achieved in the light of accelerated technological development. Given the perceived lack of available research material regarding the impact of emerging technologies in real-life application since they are new and still developing [22]. This development of information resources leads the researchers to introduce a new term titled Interactive Information Resources (IIR).

3.1 The definition of interactive information resources (IIR)

Ghuloum, Allamki, and Alhabashi, during the Digital Transformation Conference in the State of Kuwait in 2018, presented a new concept of IIR which is;

"a type of electronic resource that is faster and more flexible in information retrieval than both the traditional and the electronic information resources due to the wearable form-devices and its complex algorithms. It is used to instantly map your information environment to create photorealistic, shareable, and collaborative 3-D digital models of the contents" [23].

The wearable devices and software incorporate digital and holographic data into the real-physical environment and streamline existing use of the information resources processes in a collaborative context to enhance and empower the experience of the beneficiaries. In other words, it is a way to simulate the content of traditional resources into an augmented electronic environment, where the new shape of the content could be interactively browsed using the physical hand-waving of users. Information resources, over the time has gone through many changes, starting with Traditional Information Resources (TIR), then Electronic Information Resources (EIR), and finally Interactive Information Resources (IIR). **Table 1** clarifies the comparison criteria between the different types of information resources.

3.2 Open science and IAs

The importance of the resources is determined by contribution and sharing. In other words, sharing of information is part of the basic principles of libraries, therefore, librarians and other information specialists must provide access to information in any medium or format for library users. They also encourage the concepts of open access, open source, and open licenses [24].

Throughout history, scientists develop the best research by building on the work from others. The essential role of accessible information in the development of science and technology naturally gives growth to the Open Science (OS) movement that aims at disregarding access barriers to scholarly communications (Open Access,

Information resources (IR) criteria	Traditional information resources (TIR)	Electronic information resources (EIR)	Interactive information resources (IIR)
Multimedia	Static	Dynamic	Interactive
Browsing Speed	Slow	Fast	Instant
Collaboration	Not Supported	Not Supported	Supported
Content	Printed	Electronic	Photorealistic
Sharing	Not Possible	Possible	Possible
Accessibility	During working hours.	24/7	24/7
Update	Slow/Easy	Fast/Easy	Fast/Hard
Space	Require large physical space.	Require reasonable electronic storage.	Require large electronic storage.
Information Literacy	Knowledgeable	Widely knowledgeable	Lack of knowledge
Cost	Reasonable	Reasonable – Expensive	Very Expensive
Maintenance	Low	Medium	High

Table 1.
Comparison IR criteria between TIR, EIR and IIR [23].

OA), research data (Open Data), and the proprieties and other software tools that gather and process the data (Open Source) [25].

Research contributions are recognized in the age of OS by the way how technologies have changed [26]. For instance, scientific literature contains acknowledgments and comments that are a form of peer reviews on the cited work. Even, software and datasets are cited work too and not only articles.

OS is a movement to make scientific research, data, and spreading accessible at all levels of an investigative society. It is also a transformation of an approach of how research performed, documented, and distributed. The goal of OS is to make research outputs; methods and software are openly accessible. It can be well-defined as a sequence of procedures that, under the proper requirements, it improves the quality of research by making results shared and accessible. One of the main qualities of OS is sharing research data among researchers. Therefore, the advancement of OS affects various strategic, theoretical, and technical disputes to numerous scientific societies that carry out data-driven research [27].

3.2.1. Open science researchers

There are career-driven essential reasons to apply and promote OS methods. Besides there are benefits that specifically involve those who perform the research that are known as Early Career Researchers (ECRs). Generally, OS methods are expected to address concerns around duplication, are progressively expected, and ECRs can gain from being involved early on [28]. Thus, the OS movement provides opportunities to access unrestricted high-quality data. During the past years, the world has witnessed outstanding technological developments, specifically in the field of artificial intelligence (AI) power-driven by the access to big data and cloud computing [29, 30].

OS methods is known that it could improve the quality and consistency of scientific work. Such methods that are developed become extensively recognized, in addition ECRs who adopt OS early, the progress of the research should reflect confidently in the quality.

An important aim of the OS movement is to make science more reliable and trustworthy. Sharing of procedures and data leads to repetition, reproduction of analyses, and exploration. This increased exploration can also be an influence to guarantee good quality data and analyses [28]. In addition, in an educational prospective, once code and data presented the researcher replicate results presented in papers, which simplifies understanding of the study. Scientists and public at all levels can benefit when replication of results found, as it is crucial to OS and vital in increasing trustworthiness.

Furthermore, for researchers to promote collaboration among them, configurations must be established around OS. These configurations include a variety of software tools, and publishing mechanisms. OS software such as web-based, version-controlled repositories like GitHub archivist [31] can help with maintaining and sharing code. In other words, ECRs can form well-documented and strong code where libraries that may use over again for impending studies and for educational purposes [28]. Therefore, new open tools can help with strong data analysis in a manageable manner.

Placing more research and data in an unrestricted domain is fundamental to OS and increases ECRs' opportunities for recognition, interchange, collaboration, and development. Moreover, articles that are published and share open data by researchers obtain more citations than articles that do not share data [32], thus, ECRs can obtain citations for their work when deposited at unrestricted open repositories such as the OS Framework. Setting research and data in the public domain is essential to OS and increases ECRs' opportunities for recognition, exchange, and cooperation [33].

Early implementation of OS practices encourages and drives career advantages for researchers in the future. With open data, it is open to everyone, therefore, OS can expedite wide contribution for ECRs and to the public in general. And therefore, early OS implementation will have equal benefits for science and to the public.

3.2.2. IAs platform as a tool for open science in academic libraries

Cloud-based technologies have become an important tool and are extensively used by scientists all around the world to perform their research. The European Open Science Cloud (EOSC) is supported by the European Commission as a source for advocating OS and research. Cloud resources are raised according to different usage patterns, and decreased costs for individual groups of scientists to sustain their own foundation, therefore, they can be delivered up on request [34].

In Europe experts outlined the basic principles of the cloud of OS for the European Open Science Cloud (EOSC) [35]:

1. Other electronic infrastructures and projects are needed to be combined with EOSC by establishing organized system of services and information that suits the centralized standard.

2. The accessibility of services and data in agreement with applicable and non-biased policy describes the term "open" (although not all data and tools may be open nor the existence of free data and services).

3. EOSC-hub should include academic fields in its cloud.

4. The term "cloud" should relate to worldwide access to scientific data, software, standards, expertise, and policy frameworks and not to ICT structure.

Most participants for the European Open Science Cloud (EOSC) agree in the fact that this cloud needs [36]:

1. Different suppliers should provide the system of services.

2. The developer efforts should concentrate on the integration of cloud services, therefore, depend on current electronic infrastructure.

3. New services should be freely distributed to users developing and incorporating new services and tools when they are available.

4. To make it a primary motive for the development of the European cloud of open science by prioritizing the needs of users.

To solve research difficulties, modern science need support from computing societies, consequently many European and national associations deal with cloud-based infrastructures. One of them is the European Network Infrastructure (EGI). European Network Infrastructure (EGI) is an innovative computing engine for research designed to improve computing services for research. The state primarily funds the EGI and has over 300 data centers and cloud providers all around the world. Open academic community is its basic principle, open results for research and research infrastructures is its mission and that is by establishing and providing openness through combining digital abilities, resources, and knowledge between communities and across national limits. EGI structural design is organized in platforms [32]:

1. Managed distributed infrastructure is a basic Infrastructure Platform.

2. Managing the merging of Cloud infrastructure and regional infrastructure.

3. Easy access to large and distributed data sets is provided by an open data platform.

4. It is a platform for the exchange of information, collaboration, and community coordination.

5. Cooperative platforms and specialized service are designed for certain academic communities.

The most common area of OS in many academic and research institutions have actively engaged is Open Access (OA). OA to scientific peer-reviewed publications has led the trend of OS, which is now also expanding to original research data. Still, there are some difficulties to OS, which now impede the full understanding of its benefits. In theory, OS includes the public spread of all aspects engaged in scientific investigation, ranging from lab journals and research notes to publications, materials, data, methods/protocols, models, code, and software [37]. Although not all these aspects may be freely available in all cases, a commitment to enable the sharing of these resources reinforces the OS movement. OS is new to all academic institutions even in one of the world's foremost research performing academic institutions which is UCL (University College London), nevertheless, this structure supports the leadership role of the Library [38].

- **UCL's Open Science Policy Platform**

Open Science is a growing area, and it is a challenge in how universities and research institutions can co-operate with it. A new role for the academic library has been developed in sharing research and informative outputs. In other words, the academic Library is now more than a supervisor and a cataloger of information. The Library provides access to data and information, which allows for the integration and creation of new knowledge. This new role of the academic library is also played in part by the research coordination office and places it directly in the frontlines of these developments at an institutional level to create new methods to the delivery of OS such as UCL (University College London) experience [38].

University College London (UCL) has initiated an OS Policy Platform. It is directed by the Pro-Vice-Provost (UCL Library Services). The purpose of the Platform is to look at the institutional approach and to distinguish areas which would promote from configuration with the concept for OS. In terms of application, the Platform has found 6 main sections for preliminary action and implementation:

- Open Access and OA Publishing
- Bibliometrics
- Research Data Management
- Recognition, Promotion and Reward Structures
- Open Education
- Citizen Science

The Pro-Vice-Provost works with existing committee structures in UCL to promote open methods and to utilize the applicable e-structures to convey open pursuits in each of these sections [38].

4. Challenges and opportunities of IAs in academic libraries

To implement a new technology in academic libraries such as IAs, we need to understand the strength and weakness aspects in this type of technology. Hence, **Figure 5** presents the challenges and opportunities of IAs in academic library.

4.1 Challenges

- *Security and Privacy*:

Although the development of IAs provide great benefits, the practical use of it in academic libraries require user acceptance. One issue with respect to user acceptance is preserving ethical issues such as security and privacy. Privacy and security strategies need to consider different aspects, including the ability to gather user information, using IAs information provided by third parties, the ability to share these systems, and providing security in the environment of these applications.

- *Network Issues*:

The network is an important part of IAs architecture in academic libraries, which provide a connection between the users and the server via a configuration

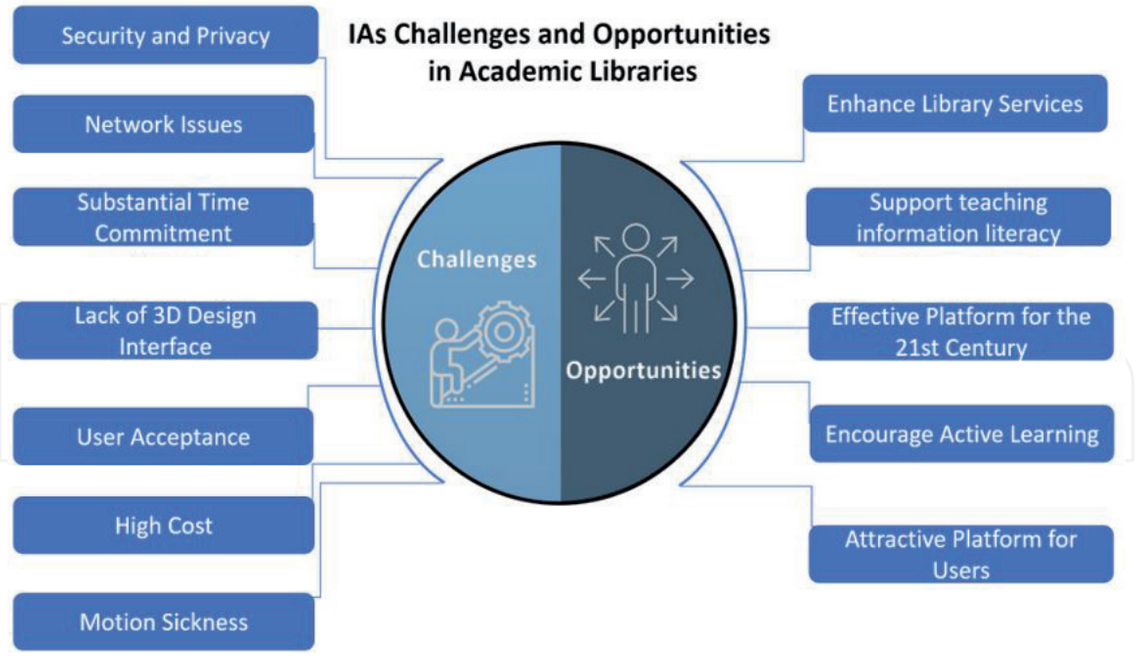

Figure 5.
IAs challenges and opportunities in academic libraries.

mechanism. When the IP of the network is achieved, each user can communicate with others and the server to access the IAs package containing the virtual model [39]. Hence, network issues may be an obstacle to implement IAs in Academic Libraries.

- *Substantial Time Commitment*:

Substantial time is required in using IAs technology and related hardware/software and creating services for academic library users. Many librarians may find this process too time consuming and lacking in added value [40]. Towards OS, there are theoretic reasons why OS methods could save time. Nevertheless, these reasons hardly come to completion in the existing system. The additional requirements for research that use the OS method often take more time, this all goes back to the traditional procedures like Archiving, documenting, and quality controlling of code and data [28].

- *Lack of 3D Design Interface*:

The biggest barrier to wide adoption of immersive IAs in academic libraries is the lack of good user experience design. 3D interface design is difficult and expensive, and there are few people with the necessary design skills to overcome these issues [41].

- *User Acceptance*:

Getting people to use IAs such as AR and VR may be more challenging than expected, and many elements play a role in use acceptance of IAs ranging from unobtrusive fashionable appearance (gloves, helmets, etc.) to privacy concerns [42].

- *High Cost*:

The market indicates that, IAs equipment and devices are costly, which is hard for the academic library to balance between the number of equipment and user

demand. Furthermore, the IAs such AR, VR and MR industry are developing fast, which leads libraries to keep up to date with these changes. In addition, maintenance and repair cost can be another challenge for libraries as some of them have limited budget to afford acquiring this type of technology [40].

- *Motion Sickness*:

Several studies confirm that, some people experience motion sickness in VR and MR which means when they put on a headset and enter a virtual world, they feel dizzy or nauseous. This challenge makes decision-makers in academic libraries hesitant to acquire IAs [40, 42].

4.2 Opportunities

- *Enhance Library Services*:

IAs contribute to improving the quality of services provided by academic libraries to users. For instance, Indiana's Premier Urban Public Research University (IUPUI) believes in the power of transformation. They are committed to providing educational opportunities that transform the lives of students, community, and the changing world. Therefore, the IUPUI University Library provides a Virtual and Augmented Reality Lab (VR/AR Lab) that has been provided through a generous federal grant from the Library Technology Services Act. The VR/AR lab includes two HTC Vive HMD's, an MSI VR One backpack PC, and one META 2 developer kit. The lab is available to all students, faculty, and staff of IU to experience and gain a better understanding of this emerging technology [43].

- *Support Teaching Information Literacy*:

IAs such as VR, AR, and MR are valid additions to the toolkit that may be used by Academic libraries to engage its users, not only with the latest technology but also with the goal in mind of ensuring a proper approach to teaching information literacy. Users such as students will gain immeasurably from the enhanced delivery of information on a particular topic through IAs and the multiple means by which the student can become proficient in the basic information literacy skills culminating is successful search for information, using every tool at his or her disposal to complete their academic assignments [44].

- *Effective Platform for the 21st Century*:

There are many opportunities for implementing IAs technologies into today's and future academic libraries which closely match the life and education styles of Generation Z users. That lead several academic institutions to acquire IAs equipment and devices in their libraries such as Harvard university library, Cleveland state university library, and others [40].

- *Encourage Active Learning*:

IAs technologies support the active learning style in academic libraries which is becoming popular among the current academics in most disciplines. For example, Microsoft is showing again how HoloLens can help engineering designers via collaboration with the University of Cambridge's construction IT lab. "We have never been able to bring 3D models from buildings and bridges off our screens and onto

the real structure," says Cambridge's Ionnis Brilakis. Using the HoloLens, however, engineers can overlay a design onto a real-world bridge or building (or vice-versa), making inspections simpler and safer [45].

- *Attractive Platform for Users*

Several Studies indicate that, integrating IAs such as AR, VR, and MR in academic libraries are increase the number of users and make academic Library more Attractive. In fact, via IAs library users can learn, play, share, collaborate in an attractive environment [ref]. David King, Digital Services Manager, Topeka & Shawnee County Public Library say that "a lot of people they think of the library as the place to go to learn about emerging technology, [so] people will come to check out the new equipment maybe they can't afford, or they want to know or don't know what it is." [46].

5. Conclusion

IAs in academic libraries has become necessary and considered a new norm to enhance academic activity in research whether through traditional ways of research or if considering sharing research data through OS. For these activities to succeed, the academic library should recognize the challenges and opportunities of this type of technology before going through the process of implementation and adoption. Academic libraries need to establish policies, processes, and guidelines to promote IAs and OS usage in the academic institution and this would begin by recognizing the challenges and promoting its opportunities. This transformation may not be easily made. However, taking the first step would begin to change the whole academic environment and by understanding the users' needs from this technology.

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