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Building Immersive Library Environment to Access Virtual Reality Content - A Proposed Framework Model

Samrat Guha Roy[#,*], Uma Kanjilal[$], B. Sutradhar[#], and S.K. Jalal[#]

[#]*Central Library, IIT Kharagpur, Kharagpur - 721 302, India*

[$]*School of Social Sciences, Faculty of Library and Information Science, IGNOU, New Delhi - 110 068, India*

[*]*E-mail: samrat@library.iitkgp.ac.in*

ABSTRACT

Immersive environments refer to a computer-simulated 3-dimensional virtual world. Libraries worldwide have been adopting and implementing new immersive technologies to enhance users' experience and learning. The Central Library of IIT Kharagpur offers (i) web-based augmented reality (WebAR), (ii) virtual reality (VR), and (iii) data visualisation immersive services. This research investigates the users' perceptions on factors that influence their satisfaction with WebAR/VR services. The study surveyed 135 random users to note their immersive library experience; out of them, only 100 users responded to our survey. The results show that 90 per cent of the respondents were satisfied with our services. Secondly, the respondents revealed that data privacy, health, and safety were some of the critical factors that influenced their satisfaction. Further, 14 per cent were apprehensive in terms of their health & safety. In fact, these users reported vision problems, disorientation, dizziness, sweating, and nausea. Based on the data collected, we prepared a framework, using The DELOS DL reference model for information delivery, along with educational and research activities. We believe that this study would lend crucial insights to academic libraries that may be planning to adopt and implement AR/VR as part of their immersive environment.

Keywords: Augmented reality; Virtual reality; Visualisation; User experience; Immersive technology; DELOS DL reference model

1. INTRODUCTION

Emerging technologies like augmented and virtual realities (AR & VR) are being used for various educational and training purposes. According to a report by Cicek, the market size of both VR and AR is expected to grow exponentially between 2019 and 2025[1]. Companies like Google, Apple, HTC, Facebook, Microsoft, and Samsung have already started working and developing various hardware and software kits for VR applications. Thus, as may be noted, these emerging technologies are already leaving their impact on every industry, including academia (libraries). This study aims to understand the factors that affect user satisfaction for the newly developed AR/VR space.

1.1 Background

Academic libraries today are creating an immersive environment, using emerging technologies, so that its users get to explore and experience new knowledge. Emerging technologies like AR and VR do provide a wide range of engaging experiences that users' possibly cannot experience practically. For example, a user may safely experience a live volcano, using VR[2]. In his seminal study, Li mentions this 'facility' as "Immersive Library Environment" (ILE)[3]. It's a space within the library, where users get absorbed in virtual content. Effectively, such facilities transform the learners' perspective, while providing them a platform for more innovation. In other words, ILE facilitates[4] library users' access to VR content. This study captures the users' experiences of the AR/VR space at the Central Library of IIT Kharagpur. In the process, this study aims to find the critical factors that influence their satisfaction. We also try to enlist some of the hardware and software required for setting up such a facility in libraries.

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1.2 What is Immersive Technology?

It is the technology that integrates virtual content with the physical environment, while completely immersing users in a computer-simulated virtual world. Augmented reality (AR) being part of immersive technology is a process of displaying virtual information overlayed onto physical objects[5]. When AR is implemented using web technologies, it is known as Web-based AR (WebAR)[6]. Virtual reality (VR) on the other hand, is a computer-simulated 3D environment, where users effectively experience a virtual world, while remaining physically connected with the 'real world'[7]. Mixed reality (MR) combines both the natural and virtual worlds, whereby the user interacts, using various controllers and haptic devices that produce a new interactive visual environment[8]. Further, in MR, both physical and digital objects co-exist. Hence, the user effectively interacts in real-time. Extended reality (XR) is an universal term that includes all AR/VR/MR[9] technologies. It encompasses the entire spectrum (i.e. from no immersion to complete immersion). Lastly, data visualisation is the graphical representation of 3D data on large display screens for collaborative study[10].

1.3 The Spectrum of Immersive Technology

The shift from real to the virtual world aided by a computer-simulated environment is what defines the spectrum. Milgram and Kishino proposed that shifting from the real to a purely virtual environment is called "Virtuality Continuum"[11] (Fig. 1). Further, it may be noted that in the virtual world, users become unaware of their natural surroundings with an increase of "computational graphical display." Augmented virtuality is displaying virtual information overlaid on mobile devices[12], while the mixed reality spectrum is in-between AR and VR. The spectrum's entire set of virtual environments is called Extended Reality (XR).

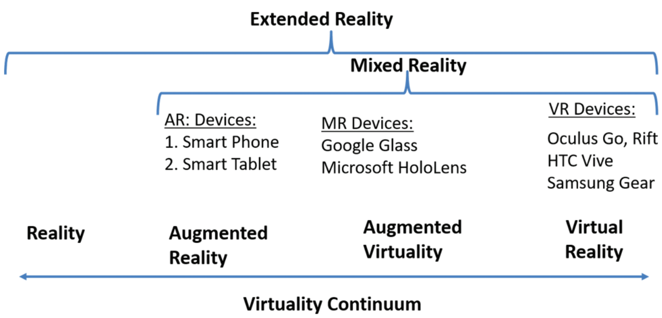

Figure 1. Virtuality continuum and spectrum of immersive technology.

1.4 Scope and Limitation

We conducted the survey study at the Central Library of IIT Kharagpur, wherein, we aimed to capture the users' experience with regard to factors that tend to influence users' satisfaction with AR/VR services. Specifically, we used Oculus Go, a common standalone VR device that is used in many libraries. One of our major limitations was that owing to the ongoing Covid-19 pandemic, we could only include users, who were vaccinated and following Covid protocols. They were allowed to enter the library, and access the AR/VR space.

2. LITERATURE REVIEW

2.1 AR/VR Timeline

Human civilisation has always been fascinated by the concept of 3D models and sculpture. Figure 2 shows the important milestones of the AR/VR timeline. The concept of virtual reality (VR) dates back to 1838, when Charles Wheatstone invented stereoscope technology. The stereoscope shows a two-dimensional image in a three-dimensional space, when viewed with naked eyes. In 1960, Ivan Sutherland introduced a head-mounted display (HMD) unit that was used to design a 'Sketchpad' system, enabling a person to communicate with the computer by drawings blended fine wireframe lines onto the real world[13]. However, it was Jaron Lanier, who first coined the term 'virtual reality' in 1985. About six years later, in 1991, the Sega VR system brought an unprecedented concept of VR headset devices. Although in the later stage, the Sega VR headset was canceled and never launched. The term augmented reality (AR) on the other hand, was coined in 1993 by Tom Caudell[14]. Tom used a blended mesh virtual image onto physical objects, while assembling aircraft electrical cables at the Boeing lab. Since 1999, with breakthrough developments in networks and smartphone technology, many companies now do provide varied AV/VR services.

2.2 Library Applications

VR in effect, collapses the outer space, and provides a more vibrant learning environment for higher education. Frost stated that services like 360-degree virtual galleries, VR and AR, along with CAVE Automatic Virtual Environment (CAVE™) simulation were going on to become common in library services[15].

This literature review shows some exciting AR/VR space/applications designed for various library services. They include:

- myLibrARy, an AR app developed by the University of Applied Sciences Potsdam; it is used to find book information and its location within a library[16]
- ShelvAR was developed by Miami University to display bibliographic information of the books present on the shelf[17]
- The SCARLET (Special Collections using Augmented Reality to Enhance Learning and Teaching) project was developed by the University of Manchester and Mimas. It is a marker-based AR application that uses QR codes and book covers to consult rare books, historical manuscripts, and archives within the John Rylands library[18]
- The University of North Florida Carpenter Library had opened its Virtual Learning Center (VLC) in March 2021. VLC supports both its students and faculty members for accessing VR services (e.g. a virtual tour, library orientation, VR-based education, etc.)[19]

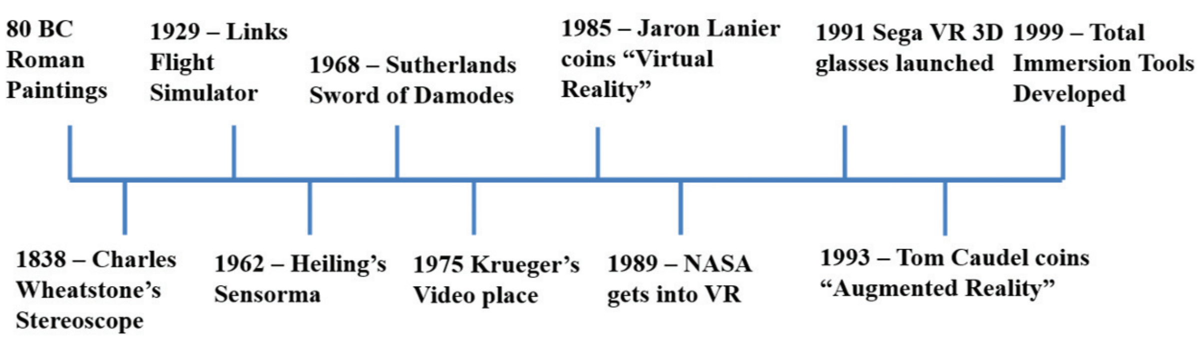

Figure 2. AR/VR Timeline.

- The Binghamton University Science Library organised VR-based outreach programs as a pilot project[20].

3. PROBLEM STATEMENT

In today's digital world, immersive technological innovations have gradually changed how we deliver/ display information. From the literature review, we see proof of the implementation of AR/VR in library services and simulation-based training. However, we note a significant gap in factors affecting user satisfaction for AR/VR services within an academic library.

3.1 Research Objectives

The main objectives of the study are:

- To find the critical factors that affect users' satisfaction with AR/VR services
- To determine the percentage of users who report health issues like blur vision, headache, dizziness, and nausea using the VR system
- To propose a framework model for building an immersive library environment.

4. METHODOLOGY

4.1 Method

The study followed a survey methodology to capture the users' experience of the library's immersive services. We manually distributed the survey questionnaire to 135 users, out of which 100 users agreed to respond. We conducted the survey during Aug–Nov 2021, and Jan–Feb 2022. We designed the sample population (n=100 respondents) into two groups, comprising 50 users each. Users of group I shared their experience with WebAR services, while group II for VR services. Once this exercise was completed, we conducted our quantitative data analysis using MS Excel software.

4.2 Tools and Techniques

The survey questionnaire had three parts: (a) personal information/ demographies, (b) measuring factors for WebAR Service, and measuring factors for VR Service, and (c) contact details. We asked the respondents to share their experience with WebAR/VR services, and specify the level of agreement on a Likert scale (5-Strongly Agree, 4-Agree, 3-Neutral, 2-Disagree, 1-Strongly Disagree) [21].

4.3 Variables

We considered five factors for the WebAR user survey; they include satisfaction, comfort, fun, data privacy, and content delivery. On the other hand, the VR user survey considered five measuring factors that include auditory learning, visual learning, fear, health, and fun. Lavoie, documented the negative side effects of VR, which can cause users to experience vertigo, nausea, or dizziness[21]. Notably, the 'fear' factor refers to 'health and safety' related issues, due to which many users actually avoid using the VR systems. We specifically chose to use this factor to understand what health and safety-related issues users usually face, due to which they're apprehensive of using this system.

4.4 User Experience

User Experience (UX) concept with reference to library services, refers to capturing the users' opinion about a particular system/service, i.e., ILE, and then analyzing the data to find the critical factors[22] that affect the user satisfaction.

4.5 Data Collection

We had initially approached 135 users, out of which, 100 agreed to participate, from which, 45 students responded to the WebAR information delivery services, while the other 45 users responded to the VR service. It may be noted that 5 users accessed both the services, and preferred to respond for both. In addition, five users' forms were rejected because they were incomplete as shown in Fig. 3.

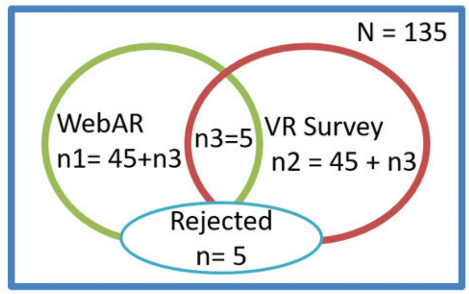

Figure 3. Sample population.

Table 1. About WebAR users' experiences

Question	Factor	Likert rating (Survey count)				
		5	4	3	2	1
How satisfied are you with the WebAR Services?	Satisfaction	19	27	3	1	1
How comfortable are you to use the WebAR services?	Comfortability	14	27	6	3	0
Is it fun to access the WebAR services?	Fun	17	24	7	1	1
Did you observe any potential breach of your private data?	Data Privacy	1	4	13	14	18
Did you notice any delay in content delivery on your smart device?	Content Delivery	37	9	3	1	0

5. RESULT ANALYSIS

5.1 Web-based AR Services

The results show that 92 per cent of the users agreed that they were satisfied with the WebAR information delivery services (Table 1). Further, data analysis shows that 82 per cent mentioned that they do feel comfortable and enjoy (fun) accessing augmented information.

When asked, "Did you observe any potential breach of your private data?" – 10 per cent of users mentioned that they did feel unsafe. When we further explored the reasons for the same, we found that it was because of the WebAR program that accessed the mobile camera, whereby the phone's user had to permit scanning the AR marker. Thus, users felt 'unsafe', as they apprehended that the application program would track the phone location or the user's confidential phone data.

When asked, "Did you notice any delay in content delivery on your device?" – we noted from our data analysis that 26 per cent of users agreed that at times there was a short or even a long 'time lag' for content delivery. Thereby, the users felt disappointed when the information was not displayed promptly.

The bar and line chart in Fig. 4 shows that the users' satisfaction and comfortability actually depend on two critical factors (i.e. data privacy and content delivery). Technically, content delivery per se, further depends on two critical issues (i.e network speed & phone calibration). When the phone is not calibrated correctly, the program's AR marker cannot read, resulting in content delivery failure.

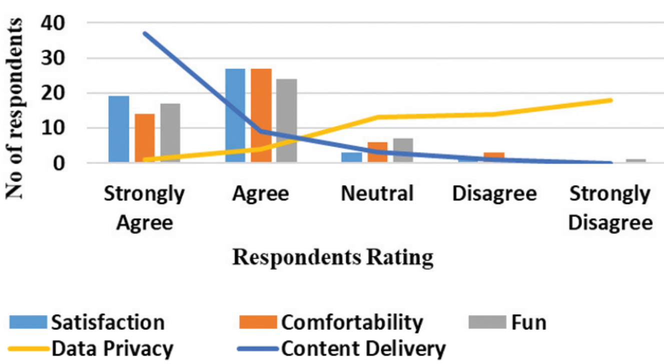

Figure 4. Users' opinion about WebAR services.

5.2 VR Services

Data analysis showed that 88 per cent of users agreed that VR is useful for auditory learning. In fact, the users specifically talked about gaining knowledge from both visual and auditory VR content.

When asked, "Did you experience any fear/scary while accessing the VR system?" – data analysis showed that 14 per cent of users mentioned that they were indeed apprehensive. A further analysis of users' feedback revealed that this apprehension/fear was due to the following reasons (i) health, (ii) safety, (iii) data privacy, and (iv) scary virtual content. Herein, the users categorically mentioned that they feared if they use VR systems frequently, their vision may be impaired. Additionally, they were also apprehensive about the safety of their private data in the virtual world.

When asked, "Did you experience any health issues while using the VR system?" - 72 per cent of respondents mentioned they never experienced any health issues, while 14 per cent did acknowledge that they felt disoriented and had some vision-related problems. Notably, the remaining participants responded neutrally.

The bar and line chart in Fig. 5 shows that 90 per cent of users mentioned that they were indeed satisfied with auditory and visual learning, using the VR system. Interestingly, the feedback analysis revealed that users were more interested in the VR game program.

Table 2. About VR users' experiences

Question	Factor	Likert rating				
		5	4	3	2	1
Did you gain any knowledge from auditory VR content? e.g., VR interview	Auditory learning	33	11	2	1	3
Did you gain any knowledge from visual VR content? e.g., VR 360-degree Video.	Visual learning	38	8	1	1	2
Did you experience any fear/scare while accessing the VR system?	Fear	3	4	2	7	34
Did you experience any health issues while using the VR system?	Health	0	7	7	5	31
Did you experience fun while accessing the VR content?	Fun	40	9	1	0	0

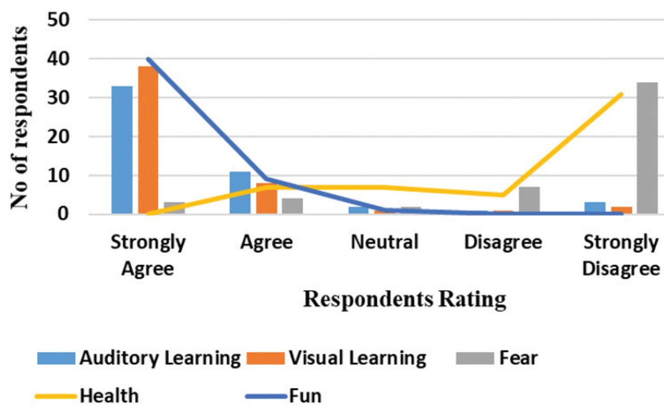

Figure 5. User opinion about VR services.

5.3 Requirements Analysis

Hardware and software are two components of an 'immersive environment'. VR systems are generally classified under three categories that include non-immersive, immersive, and semi-immersive.

5.3.1 Hardware

Non-Immersive system includes a Desktop VR system (like three-dimensional games). In such environments, the software plays a significant role in immersion, whereby the users interact with the 3D environment, using a joystick, mouse, monitor, and keyboard.

An immersive VR system on the other hand, provides the highest level of immersion to its users. Herein, users use VR headsets to experience the virtual world, and feel like a part of the virtual environment[22]. Headset devices like the HTC

VIVE system, Oculus Go/ Rift, Gear VR are commonly used for experiencing virtual reality[1,14]. Google cardboard[23] is a do-it-yourself VR viewer kit that anyone can build or buy.

The semi-immersive VR system is a hybrid system like AR, CAVE (Cave Automatic Virtual Environment), or driving simulators. Such infrastructures are very costly and used for specific purposes, like pilot training simulators.

5.3.2 Software

Software is an essential component that constructs the virtual environment (VE). Carmo found that the virtual three-dimensional (3D) models of a physical object are used for exhibition in virtual museums[24-25]. Some widely used 3D models/VE development tools include Unity, Unreal Engine, Vuforia, and Adobe Creative Cloud. Open-source softwares like A-Frame[6], three.js, Blender, and OpenSpace3D are also commonly used to design and develop AR/VR applications.

6. PROPOSED FRAMEWORK MODEL

Prof. S. R. Ranganathan rightly mentioned that a library is a 'growing organism'. Libraries adopt all the necessary tools to provide better services to their patrons; and 'immersive 26 services' are a new addition to the library's service list. This study proposes a framework for an immersive library environment (ILE)[2-3] to access VR content. The conceptual framework is developed based on the DELOS Digital Library Reference Model[27].

The DELOS Digital Library Reference Model is a three-tier framework:

6.1 Digital Library

DL collects, preserves, and manages the digital VR content for access. The users, staff, and the digital contents comprise the digital library. The digital library functions for AR/VR services, and defines the usage policy for its users.

6.2 Digital Library System

DLS is the middle-tier software system. Hereby, the immersive services are delivered to the users with the other sub-systems. Figure 6 depicts the framework model.

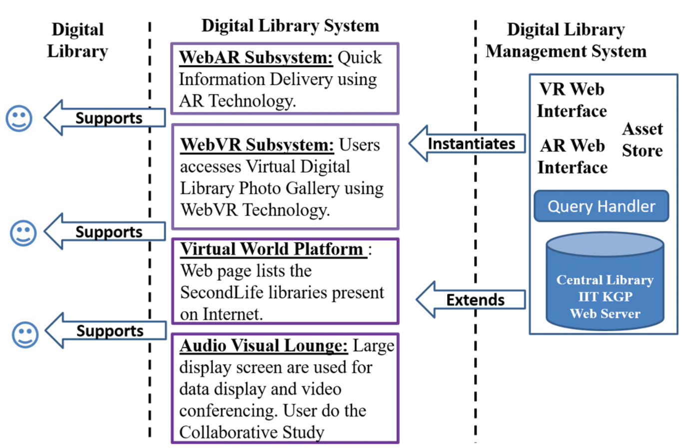

Figure 6. Immersive library environment – A Three-tier framework model.

6.2.1 The WebAR Subsystem[6]

It is an information delivery service developed, using the A frame JavaScript libraries. AFrame is an open-source web framework used for building both AR and VR experiences. As the user focuses its camera on the AR marker, the query handler triggers the video information displayed on the user's mobile phone.

6.2.2 WebVR Subsystem

This sub-system provides a game-like virtual world environment[14]. Users herein, may access the portal, using a desktop computer, and then browse through the gallery in 360-degree mode. Notably, when the content is accessed using a VR headset, we get the feel of the virtual world; and when the content is accessed using a desktop computer, it is a 2D experience.

6.2.3 Virtual World Platforms

SecondLife platforms have features like creating an avatar and leading a second life in the virtual online world. An Avatar represents an user[28]. Users can then interact with others with voice and text messages in real time. Many libraries around the world have subscribed to the virtual world's SecondLife platforms. Notably, the virtual worlds and galleries are accessible from desktop systems and VR devices.

6.2.4 Audio-Video Lounge

Data visualisation represents 'innovation' in library services. Large screens, Wacom computers, Dolby audio speakers, and video conferencing cameras are used to build such facilities. Users need to book this facility for presentations, group discussions, collaborative study, and video conferencing with peer researchers. Herein, HD screens are used to display high-definition images[16]. Softwares like Tableau, Microsoft Power BI, R stat package, among others are used for data visuals and presentations.

6.3 Digital Library Management System

DLS belongs to the 'system software' class. It is the tier that comprises the server infrastructure that supports ILE[2] activities. Herein, web servers process HTTPS query requests from an AR client program, while storage servers stores the 3D assets, and the database servers store user profiles.

7. DISCUSSION

This study examined the users' experiences with a library's AR/VR space 29, and identified some of the critical factors that go on to affect their satisfaction. The present study is undertaken for WebAR[6]/VR services delivered by the digital library. Results show that 90 per cent of users were satisfied using the AR/VR facility. We evaluated their VR experiences to find why 10 per cent of users hesitated to access the VR headset unit. We found that users with vision problems like farsightedness and shortsightedness are worried about their vision. Data reveals that 14 per cent of the users reported health-related issues and vision problems. These users were advised to view data in 2D mode, using the library's audio-visual lounge facility. The most encouraging statistic is that 98 per cent of users said they enjoyed using the VR system.

8. CONCLUSION

This study presented some of the critical factors that influence the users' satisfaction level. We identified internet network and phone calibration as two critical issues that affect content delivery in WebAR service. Further, the data analysis revealed that the 'content delivery' factor was directly proportional to satisfaction. However, with good wifi signals within the Central Library of our study location (i.e. IIT Kharagpur), the users did appreciate using the WebAR services. Significantly, 10 per cent of the users did express health concerns in using the VR/VE systems[30]. The central library of IIT Kharagpur implemented the WebAR service to deliver library e-resource information, while the VR facility has been extended for educational use. This study affirms that both AR and VR technologies are indeed beneficial for effective learning and information delivery, involving minimal risks[4]. However, setting up an AR/VR space does have several challenges, which include infrastructure cost, staff training, and technology integration with the existing system. Based on our findings and literature review, we recommend that further research on open access hardware and software technologies is needed to overcome some of the existing challenges in order to make it more feasible for academic libraries to adopt AR/VR technologies.

REFERENCES

1. Cicek, I.; Bernik, A. & Tomicic, I. Student thoughts on virtual reality in higher education-A survey questionnaire. *Information*, 2021, **12**(4), 151. doi: 10.3390/info12040151
2. Ruggiero, A. Volcano VR: watch eruption in immersive 8k drone video. Gearjunkie. https://gearjunkie.com/technology/drone-vr-iceland-volcano. (Accessed on February 20, 2022)
3. Li, X. Library as incubating space for innovations: Practices, trends and skill sets. *Library Management*, 2006, **27**(6/7), 370–378. doi: 10.1108/01435120610702369
4. Yavarkovsky, J. Editorial board thoughts: The promise of immersive libraries. *Inform. Technol. Libr*, 2013, **32**(4), 5. doi: 10.6017/ital.v32i4.5267
5. Dalili Saleh, M.; Salami, M.; Soheili, F. & Ziaei, S. Augmented reality technology in the libraries of universities of medical sciences: Identifying the application, advantages and challenges and presenting a model. *Libr. Hi. Tech*, 2021. doi: 10.1108/LHT-01-2021-0033
6. Roy, S.G. & Kanjilal, U. Web-based augmented reality for information delivery services: A performance study. *DESIDOC J. Libr. Inf. Technol*, 2021, **41**(3), 167–174. doi: 10.14429/djlit.41.03.16428
7. Suen, R.L.T.; Chiu, D.K.W. & Tang, J.K.T. Virtual reality services in academic libraries: Deployment experience in hong kong. *Electron. Libr*, 2020, **38**(4), 843–858. doi: 10.1108/EL-05-2020-0116
8. Marshall, D.H.; DuBose, J. & Archer, P. Mixed reality lab at mississippi state university libraries. *Public Serv. Q*, 2019,**15**(1), 51–58. doi: 10.1080/15228959.2018.1554466
9. Döllinger, N.; Wienrich, C. & Latoschik, M.E. Challenges and opportunities of immersive technologies for mindfulness meditation: A systematic review. *Front. Virtual Real*, 2021, **2**. doi: 10.3389/frvir.2021.644683
10. Finch, J.L. & Flenner, A.R. Using data visualisation to examine an academic library collection. *Coll. Res. Libr*, 2016, **77**(6), 765–778. doi: 10.5860/crl.77.6.765
11. Milgram, P. & Kishino, F. A taxonomy of mixed reality visual displays. *IEICE T. Inf. Syst*, 1994, **E77-D**(12),1321-1329.
12. Hahn, J. Mobile augmented reality applications for library services. *New Libr. World*, 2012, **113**(9/10), 429-438. doi: 10.1108/03074801211273902
13. Sutherland, I.E. Sketchpad a man-machine graphical communication system. *In* AFIPS Conf. Proc.-Spring Joint Comp. Conf. 1963. doi: 10.1145/1461551.1461591.
14. Caudell, T.P. & Mizell, D.W. Augmented reality: An application of heads-up display technology to manual manufacturing processes. *In* Proc. of the 25th Hawaii Inter. Conf. on Sys. Sci, 1992, pp. 659-669. doi: 10.1109/HICSS.1992.183317
15. Frost, M.; Goates, M.C.; Cheng, S. & Johnston, J. Virtual reality. *Inform. Technol. Libr*, 2020, **39**(1). doi: 10.6017/ital.v39i1.11369
16. Baumgartner-Kiradi, B.; Haberler, M. & Zeiller, M. Potential of augmented reality *In* the lib. CEUR Workshop Proc, 2018, 2299, pp. 30–37. http://ceur-ws.org/Vol-2299/. (Accessed on December 16, 2021)
17. Brinkman, B. & Brinkman, S. Ar in the library: A pilot study of multi-target acquisition usability. *In* IEEE Inter. Symp. on Mixed and Augmented Reality (ISMAR), 2013, pp. 241–242. doi: 10.1109/ISMAR.2013.6671785
18. SCARLET: Augmented reality in special collections. https://archiveshub.jisc.ac.uk/features/SCARLET/index.html. (Accessed on December 22, 2021)
19. Chalmers, A. Getting up and running with virtual reality: space and technology considerations. *Coll. Res. Libr. News*, 2021, **82**(11). doi: 10.5860/crln.82.11.517
20. Huber, A.; Embree, J.K.; Gay, A. & Gilman, N.V. Becoming immersed: Using virtual reality technologies in academic libraries to expand outreach and enhance course curricula. *Coll. Undergrad. Libr*, 2020, **27**(2–4), 245–264. doi: 10.1080/10691316.2021.1902892
21. Lavoie, R.; Main, K.; King, C. & King, D. Virtual experience, real consequences: the potential negative emotional consequences of virtual reality gameplay. *Virtual Reality,* 2021, **25**(69–81).

doi: 10.1007/s10055-020-00440-y

22. Mäkinen, H.; Haavisto, E.; Havola, S. & Koivisto, J.M. User experiences of virtual reality technologies for healthcare in learning: An integrative review. *Behav. Inform. Technol*, 2020, 1–17.
doi: 10.1080/0144929X.2020.1788162
23. Oyelude, A.A. Virtual reality (VR) and augmented reality (AR) in libraries and museums. *Libr. Hi Tech. News*, 2018, **35**(5), 1–4.
doi: 10.1108/LHTN-04-2018-0023
24. Carmo, M.B. & Cláudio, A.P. 3D virtual exhibitions. *DESIDOC J. Libr. Inf. Technol*, **33**(3), 2013, 222–235.
doi: 10.14429/djlit.33.3.4608
25. Chang, W.H. Implementation of a virtual archives system using virtual reality technology: A case study of the national archives administration Taiwan (ROC). *DESIDOC J. Libr. Inf. Technol*, 2008, **28**(4), 83–91.
doi: 10.14429/djlit.28.4.201
26. Pdf reader in Microsoft edge and immersive reader goes mobile. https://www.lexdis.org.uk/2021/08/pdf-reader-in-microsoft-edge-and-immersive-reader-goes-mobile/. (Accessed on August 4, 2021)
27. Candela, L.; Castelli, D.; Pagano, P.; Thanos, C.; Ioannidis, Y.; Koutrika, G. & Schuldt, H. Setting the foundations of digital libraries the DELOS manifesto. *D-Lib Magazine*, 2007, **13**(3/4). https://dlib.org/dlib/march07/castelli/03castelli.html. (Accessed on February 25, 2022)
28. Swanson, K. Second life. *Sci. Technol. Libr*, 2007, **27**(3), 79–86.
doi: 10.1300/J122v27n03_06
29. Lund, B.D. & Agbaji, D.A. Augmented reality for browsing physical collections in academic libraries. *Public Serv. Q*, 2018, **14**(3), 275–282.
doi: 10.1080/15228959.2018.1487812
30. Sample, A. Using augmented and virtual reality in information literacy instruction to reduce library anxiety in nontraditional and international students. *Inf. Technol. Libr*, 2020, **39**(1).
doi: 10.6017/ital.v39i1.11723

CONTRIBUTORS

Mr Samrat Guha Roy is working as Assistant Librarian in Central Library, Indian Institute of Technology Kharagpur, WB, India. His areas of interest are: Immersive Technologies, Digital Library Services, Virtual Reality, and Machine Learning.
His contribution to the current study is developing the model framework, data collection, data analysis, and completing the paper's initial draft.

Prof. Uma Kanjilal is a Professor in the School of Social Sciences (SOSS), Head of the Department of Library and Information Science in the Indira Gandhi National Open University (IGNOU). She holds the post of Director of the Centre for Online Education (COE) at IGNOU. Her research interests include: E-learning, Multimedia Courseware Development, AR/VR applications in Libraries, and Learning in Virtual Environments.
Her contribution to the present study is conceptualisation, reviewing, and preparing the paper's final draft.

Dr B. Sutradhar is a Librarian in Central Library, Indian Institute of Technology Kharagpur, WB, India. He is CoPI in the National Digital Library of India project, Govt of India. His areas of interests are: Digital Repository, Metadata Engineering, Metadata Harvesting, and Library Management.
His contribution to the present study is validating data used in the fundamental model discussed in the paper.

Dr S.K. Jalal is a Deputy Librarian in Central Library, Indian Institute of Technology Kharagpur, WB, India. His areas of interest are: Digital Repository, Metadata Engineering, Webometrics, and Library Management.
His contribution to the present study is in literature review and modeling the methods for data collection.