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Augmented reality and virtual reality technologies for promoting African cultural heritage, museums and libraries: the new wheel of immersion

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Abstract

The decline in library attendance and limited access to museum collections raise new challenges in Africa. This article explores the potential of augmented and virtual reality technologies as tools for cultural and scientific mediation. Based on qualitative observations and interviews conducted at the University Library of Dakar and the Léopold Sédar Senghor Museum, it critically discusses existing models (Fuchs, Jolivalt) and introduces the 'mobile wheel' framework developed at LARSIC. Findings highlight that immersion and interaction levels must be adapted to institutional typologies and disciplines, thereby opening new avenues for the promotion of African cultural heritage.

Biography

Alioune Cissé is a library curator and head of the collections management department at Cheikh Anta Diop University in Dakar. A doctoral student in information and communication sciences at the LARSIC/LETHOSS laboratory, his work focuses on the application of immersive technologies (virtual and augmented reality) in the promotion of African cultural heritage, particularly in libraries and museums.

Introduction

The digital revolution has led to major transformations in all spheres of human activity: governments, industries, communities and citizens are all influenced by information and communication technologies.

These transformations have not spared the African historical cultural heritage sector, museums and libraries. The digital environment has brought about a profound change in information uses and behaviours. The development of digital technology has profoundly changed the ways in which knowledge is appropriated.

As a result, Africa's historical cultural heritage, preserved in museums and libraries, is still finding its way and is undergoing a period of transition that could profoundly change its face. The challenge today is to take advantage of technological advances to strengthen the place of African cultural heritage in the information society.

This requires museums and libraries to adapt to new digital practices (particularly AI), without betraying their primary mission of providing access to information and culture, and to reconcile institutional legitimacy with the attractiveness of a renewed service offering.

Libraries have therefore contributed to the preservation and promotion of heritage. African cultural heritage is thus one of UNESCO's main activities. It lacks visibility across the continent and needs to be better promoted.

African cultural heritage suffers from a lack of promotion and awareness, even though it is essential for a community to preserve its history in order to protect it from oblivion and pass it on to future generations.

In an era strongly marked by digital technology, why does this deficiency, caused by a lack of visibility, promotion and enhancement, remain?

The main problem with African cultural heritage is its lack of promotion. In Africa, museums, which are part of this cultural heritage, must be promoted. Museum attendance has fallen sharply with the development of the health crisis.

The main problem with museums is their accessibility. Visitors are sometimes forced to travel long and costly distances from one site to another in order to visit a museum and discover the rich cultural and artistic heritage it contains.

Until now, museums have not exploited the potential of digital technology to popularise their collections and make them accessible to a wide audience. As for libraries in Africa, we note that attendance rates have become very low. It could even be said that the taste for reading has declined among young people and even adults.

Thus, books, which are documents in paper format, are beginning to become somewhat obsolete, and the younger generations need to read on a medium adapted to the digital context.

1. Theoretical and conceptual framework

This research can be placed within the theoretical framework of social computing. Social computing is essentially the use of computers for social purposes. Before the Internet, computers were widely used as tools to increase productivity. The Internet introduced a social element, allowing users to network, share their interests, publish personal information and use their computers for more than just getting work done faster.

We will have these different applications, such as augmented guided tours.

This is how Harry E Pence, in an article entitled Smartphones, Objects and Augmented Reality, presents augmented reality as an application based on geolocation.

To promote works located in public spaces, an augmented reality project was carried out by librarian Liv Valmestad at the University of Manitoba in Canada.

In Germany, the Bavarian State Library in Munich developed a mobile application in 2011 that provides access to a wealth of information and multimedia resources about King Louis III of Bavaria.

Also using QR codes that allow MP3 files to be downloaded to a mobile device, the libraries at Ryerson University (Canada) and the University of Bath (England) offer audio-guided tours of their spaces.

Thanks to the use of QR codes, themed selections of books and exhibitions displayed on special stands in libraries have become interactive.

Librarians can select documents based on a theme that changes every month. The list of documents in the monthly selection can then be downloaded from the themed web page using QR codes affixed to the documents.

This is available in the section called "Carré V.I.P" (Very Interesting Publications) at the Blonay – St-Légier library.

2. Research methodology

Proponents of the qualitative paradigm reject the objectivity of reality in social science research (Lincoln and Guba, 1985). They believe that researchers construct reality and are themselves part of it. According to proponents of the qualitative approach, objectification and generalisation in social sciences are impossible and undesirable. They emphasise rich descriptions and place greater importance on induction.

In terms of the method of analysis, we will first use written analysis, then analytical questioning, and finally thematic analysis.

Thematic analysis is a qualitative research method used to identify, analyse and interpret recurring themes or patterns in a set of data, whether it be texts, interviews, speeches or other types of material. This method is often used in the social sciences, humanities and other fields of research to understand the main concepts, ideas and perceptions emerging from a body of data.

Drawing on the writings of Suzanne Beer (2020) in her book entitled "*Virtual* Museums *& Museum Realities"*, we find the concept of a virtual museum, which refers to a web page with digital content.

Based on the reality that a museum must be physical or institutional, the virtual museum can be defined as a concept that broadly refers to the field of museology.

3. Results and discussion

According to Suzanne Beer, the concept of a museum refers to a specific relationship with reality.

Thus, the concepts of virtual and augmented reality will enable better exploration of museums through preservation, identification and communication.

Thanks to virtual reality technologies, the virtual museum will be an extension of the real museum by facilitating mediation.

Investment in digital and internet resources is growing exponentially, and given the evolution of information technology, the forms taken by virtual museums, according to Suzanne Beer, are unpredictable.

The concept of the virtual museum will give a glimpse of the use of virtual reality and augmented reality technologies applied to museums, with a semioticisation that allows robotisation to capture the subjectivity of the visitor.

Beyond the limits set by Suzanne Beer for the 'virtual museum', virtual reality is supposed to break down temporal and spatial barriers, bringing forth an inaccessible reality.

Users can access stores and floors and consult documents that are indirectly accessible.

This semiotisation can also be part of an essentially intellectual activity through a design that is closer to sensitivity and the body, for which knowledge is acquired effortlessly, through absorption.

We conducted our bibliographic data research using keyword searches based on our study topic in scientific databases (International Scholarly Vox, Jstor, Cairn, Persée, revues.org).

The keywords selected for the search were:

- Virtual reality and libraries
- Virtual reality and museums
- Virtual reality and African cultural heritage
- Augmented reality and libraries
- Augmented reality and museums
- Augmented Reality and African Cultural Heritage
- African Cultural Heritage

The results of our database searches have enabled us to identify interesting bibliographical references relevant to our research topic.

We will focus on three main themes, which are

- New reality in the world of immersion

- Virtual reality and augmented reality technologies for promoting cultural and heritage archives

- The contribution of information science to virtual and augmented reality

4. New reality in the world of immersion

According to Philipe Fuchs (2023) in his theory of virtual reality: Real-world applications

For almost fifty years, we have been using virtual reality without knowing it, especially in the automotive industry.

Philipe Fuchs highlights the shortcomings of virtual reality technologies, with the low definition of screens in the early days, which is associated with the low pixel density of screens.

According to Fuchs, multinational web companies and GAFAM have invested heavily in virtual applications such as Unity and Virtool, but despite this, they have not yet achieved great success.

Despite huge and heavy investments, such as the Google Glass project, success is still a long way off.

This is why he will draw on the concept of interdisciplinarity, because for him, experimenting with virtual reality must essentially involve bringing together many sciences and disciplines.

Philippe Fuchs' idea becomes very interesting when he asserts that engineering sciences alone cannot develop with virtual, augmented or mixed reality technologies.

Limiting oneself to computer science would be very reductive and could be detrimental to the development of augmented reality.

This interdisciplinary approach suggests the future use of virtual reality headsets in libraries and museums, as well as in the context of accessing communication from books in collections. Immersive documentary research will be an innovation in library science activities.

4.1. Limitations of Philipe Fuchs' theory

The fundamental question will therefore be to see whether the standards and rules of virtual reality in particular, and the conditions for immersion and interaction, can be applied without variation in different fields and disciplines.

The standards of virtual reality established in computer science: are they all valid in medicine? Aeronautics? Automotive technology? Information science and communication?

Once in the field of information science, documentation and communication, and therefore in the social sciences, will the requirements set by Philipe Fuchs still be applicable?

5. Virtual reality and augmented reality technologies for promoting archives, culture and heritage

Studies conducted by Marie Hermine Vigneron (2018): virtual reality and augmented reality technologies for promoting archives will propose the development of an imaginary augmented reality product.

To promote cultural heritage, the concepts of promotion and mediation will be developed in her writings. She thus advocates for a virtual exhibition in line with publications. For her, promotion should not focus on objects that are destined to disappear or be removed from the collections. This notion of promotion therefore contributes to permanent conservation.

Marie Hermine Vigneron has thus defined the concept of promotion in two parts: scientific promotion and cultural or heritage promotion.

Omayma Ben Mbarek (2021), in her study on augmented reality and value creation in museums published in Le virtuel au chercheur, presents a tool for promoting visitor experiences in the cultural context of museums.

This augmented reality has the ability to superimpose information onto the real world. Her study has helped to highlight the role of innovative augmented reality technology while emphasising the important aspect of enhancement in the context of a qualitative study.

Omayma Ben Mbarick's results highlighted several values: educational, experimental, experiential, social, epistemic, and conditional.

According to Cedric Boudjema (2021) in Virtual Technology at the Service of Researchers: Museum Education in Virtual Museums, museum education encompasses educational and cultural activities and museum mediation.

For him, museums are not immune to the digital transformation that is changing their professions.

5.1. Comparing the methodologies of Philipe Fuchs and Anna Marie Vigneron

Anna Marie Vigneron's methodology contrasts with that of Philipe Fuchs

A comparison of the methodologies of Philipe Fuchs and Anna Marie Vigneron suggests that the concepts of virtual reality and augmented reality, and the standards of virtual reality and augmented reality, vary depending on the discipline.

It will not be the same, and therefore will not comply with operating standards if it changes domains. Therefore, virtual or augmented reality applied in medicine or computer science will not be the same if applied in a library or museum.

The term "mediation through technology" recurs in Anne Marie Vigneron's work with new virtual cities, augmented pasts and time travel.

6. The contribution of information science to virtual and augmented reality

6.1. The virtual environment

According to the study by Jolivalt Bernard (1995) La réalité virtuelle (Virtual Reality), he emphasises that virtual reality is a methodology born out of computer science, optics and robotics.

He asserts that virtual reality is a space that overlaps with reality without interfering with it, and that incursion into reality is an unlikely journey.

This is debatable, as the reconstruction of the Lascaux cave shows that travelling into reality can be a sure way to revisit historical or cultural heritage.

According to Bernard Jolivalt, cognitive scientist William Bricken prefers to use the term 'virtual environment', which places greater emphasis on the involvement of humans immersed in the virtual world. By simulation, he means an exact reproduction of reality.

This notion of an exact reproduction of reality is sometimes rejected by researchers such as Philipe Fuchs, or sometimes

accepted, as is the case with Bernard Joilivalt, who asserts that Jaron Lanier believes virtual reality is a window onto the world of the imagination. Bernard Joilivalt, who asserts that Jaron Lanier believes virtual reality is a window onto the world of the imagination.

6.2. The immersive experience according to the Burdea model

According to Jolivalt Bernard, Burdea's triangle defines the three aspects of virtual reality, which are: immersion, interaction, and imagination, while Morton Heiling, with his Sensorama machine project, attempts to engage the five senses: sight, hearing, smell, touch, and taste, according to their percentage.

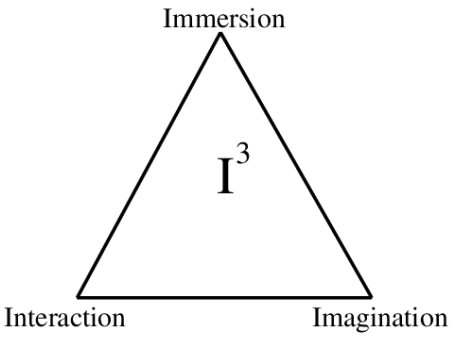


Figure 1 – The Immersion-Interaction-Imagination triangle according to Burdea & Coiffet (1993)

6.3. Limitations of the Burdea model

Reproducing the concepts of taste and smell will pose problems, which will slow down the Sensorama project, which will not be completed due to a lack of funding.

Not all sensory faculties can be involved in virtual reality, and depending on the field of application, the choice of sensory intervention will be studied.

Is Philipe Fuchs's reasoning valid in all fields?

In the field of information science and more specifically librarianship, is it absurd to reproduce a real reading space with the possibility of accessing collections in virtual mode?

If finding information is the priority for both users and curators, then documentary research takes precedence over the reproduction of real space.

In this case, reproducing reality in reality mode, with the possibility of accessing digital collections, does not obey Fuchs' theory.

This reproduction of reality through virtual reality, which is considered absurd, can become useful for users, and this usefulness will be developed in our thesis.

Philipe Fuchs's thinking deserves to be improved and developed further.

Information and communication sciences, more specifically documentary information sciences: library science and museology can use AR tools to create new realities in the world of immersion.

However, Anne Marie Vigneron makes promising developments on these technologies by asserting that AR and VR productions make it possible to reach a disadvantaged audience that does not have the opportunity to travel or discover the value offered by archive services.

For Marie, AR and VR technologies are an alternative to physically discovering heritage. She also highlights an important limitation of AR and VR, citing, for example, audiences with visual impairments, who will obviously have difficulty understanding the most advanced AR and VR productions.

As Professor Michitaka Hirose of Tokyo University states, the virtual concept does not mean fictional, because the notion of virtual reality in a university library for researchers may be limited to a space that overlaps with reality.

6.4. The immersive experience according to David Zelter's AIP cube

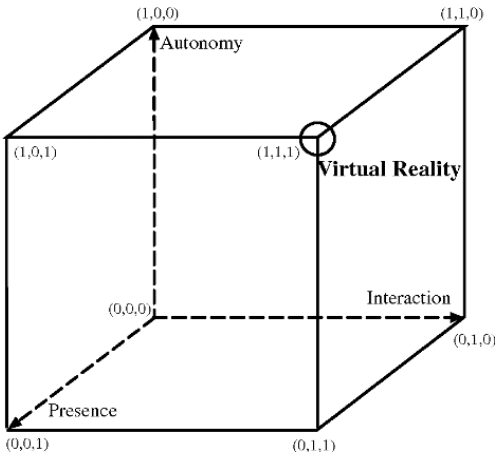


Figure 2 – The AIP cube (Zelter, 1992).

Parallel to Burdea's triangle, the AIP cube by David Zelter, a researcher at the Computer Graphics and Animation Group in Massachusetts, differentiates between the virtual and the real and introduces the terms Autonomy, **Interaction** and **Presence** by positing the duality between the real and the virtual.

Beyond trigonometric calculations, real-time imaging and visual display, Jolilvalt asserted that without computer graphics, virtual reality would not exist. Computer graphics make virtual reality.

According to Yvan Sutherland, the screen is the window through which an individual views the virtual world.

Bernard Jolivalt emphasises that the concepts of thermal feedback and force feedback with exoskeletons will be used by virtual reality technology, as will mechanical trackers and optical trackers.

It will be important to emphasise whether or not the use of force feedback or thermal feedback is necessary. The fundamental question is whether force feedback or thermal feedback is necessary in information science, for example in university libraries.

A researcher in a library will be concerned, for example, with reading a scientific article, but will not need thermal or force feedback.

6.5. Limitations of the Zelter cube

The Burdea Triangle and the Zelter cube are not fully applicable in all fields. The same can be said for brain interfaces, clones and avatars, and finally for exoskeletons

Their applicability depends on the fields of action, in line with the idea developed by Bernard Jolivalt.

The development of Augmented Reality will not be the same in automotive technology, medicine, computer science, and information and communication sciences.

Immersive reality makes it possible to avoid long journeys and also reconstruction.

Towards a mobile virtual and augmented reality device

The establishment of a scientific committee suggests a mobile, rotating system that depends on the reality on the ground. Indeed, Burdea's triangle and Zelter's square cannot be static.

We will propose a model, a mobile augmented and virtual reality device; the value of this state of the art for improving and correcting all previous theories put forward on augmented and virtual reality.

Conclusion

The concepts of virtual reality and augmented reality vary depending on the field and area of study. The definitions of AR and VR would not be the same in the fields of computer science, medicine, mechanics, libraries, and archives. For example, as described by Philipe Fusch, we have 360° video in computer science with total immersion and interaction.

On the other hand, as described by Anne Vigneron, visits are made using a VR headset connected to a smartphone, which allows for greater immersion.

However, the user cannot move around inside the virtual reconstruction of the building, or the visitor discovers immersion or interaction through a direct application via their smartphone screen.

The visitor's head moves around the space, but they cannot move themselves. They are therefore forced to use directional arrows to move around in this virtual space.

It seems that the concepts of AR and VR change depending on the field, and we can even say that the rules and design tools for AR and VR vary depending on the discipline and field. In the field of library and information science: the collection, processing and dissemination of information is a priority. The most important thing in a library is access to documentary information.

In university research libraries, the user, the researcher, opts for information and technical research. The concept of virtual reality applied to research in a university library will differ from virtual reality applied in a school or children's library. The concepts of AR and VR will be designed according to the type of library or museum. The design of VR in a university research library will differ from the design of VR in a school or children's library.

In school or children's libraries, entertainment through learning and play, known as edutainment, is the dominant feature. Therefore, play and the fun aspect are paramount in children's libraries.

In university and research libraries, the design of tools for virtual and augmented reality will take into account the mastery of research tools and access to scientific and technical documentation. The virtualisation of university library

collections will differ from the virtualisation of children's library collections.

Easy access to a collection and its use will be taken into account by developers. When setting up an AR and VR system.

Normally, the design of a virtual reality system in a university library should focus on reading documents in a 3D virtual environment.

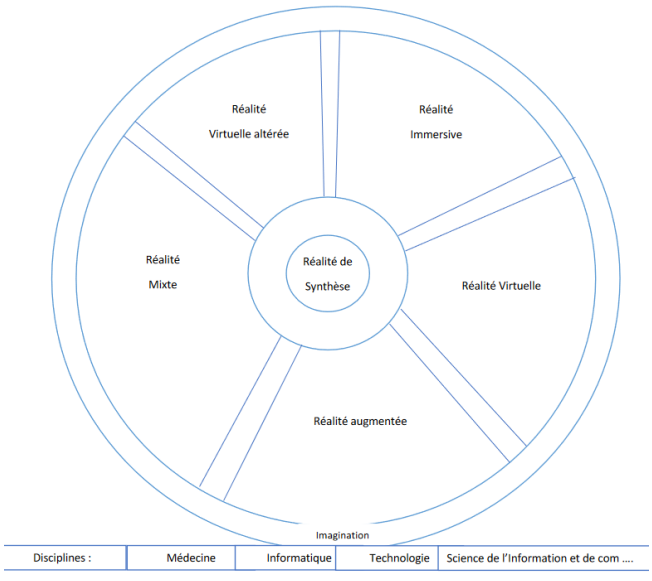
What will interest researchers in a university library is the use of articles or books, preferably in 3D if possible. Burdea's triangle will therefore be much more useful in a children's library than in a university library

We will therefore move towards a new design for a VR device in university libraries that will emphasise the research and easy use of documents and conservation.

This design will be much simpler than the design of an AR and VR device in a school, children's or rural library.

For example, in a rural library, training and practical learning will be paramount: and the design of an AR device will go beyond the imagination and require the concepts of total or partial immersion and interaction.

The degree of immersion and interaction therefore varies depending on the practice or use different body movements: therefore, motor skills.



Roue mobile du LARSIC

Figure 3 – Roue mobile du LARSIC

The design of a virtual reality, augmented reality or synthetic reality project based on imagination must be in line with the level of professional practice. The more practice is involved, the more the concepts of immersion and interaction must be applied.

In the field of information and communication sciences, more specifically in university libraries and museums, we will see the degree of immersion and interaction that will need to be applied. Even within information science, virtual or augmented reality design standards vary depending on the type of library.

The degree of immersion and interaction in a university library is different from that in a school or public library. This difference applies in the fields of medicine, science, technology, computer science and the humanities.

The LARSIC mobile wheel could be the beginning of a solution in synthetic reality construction projects, as it uses imagination and, beyond Burdea's triangle and Zelter's cube, proposes the reality system to be applied.

Depending on the degree of immersion and interaction, this mobile wheel will use synthetic reality by choosing either altered virtual reality, immersive reality, augmented reality, or mixed reality.

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