Strategic utilization of the VR and AR technologies for the African cultural heritage promotion and management.

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Abstract. The importance and purpose of heritage preservation have been extensively discussed in tourism research and has also been linked with regional and national development strategies. Because of time degradation, human activities, and the overcrowding effect, heritage preservation and reconstruction efforts are becoming critical to ensure the sustainability of heritage sites and disseminate the history and the potential of a region or a country. Virtual reality (VR) and augmented reality (AR) offer useful applications in heritage preservation. This study aims to explore the potential of these interactive technologies to be applied in heritage preservation in Africa, introduce strategies and applications developed Egypt and Tunis but also from Oman, and Finland, and highlight their impact in regional and national socio-economic development. As members of the Time Machine Europe this paper analyzes previous experiences in global scale and aim is to contribute in large-scale digitalization projects in Europe but also world-wide.

Keywords: Virtual Reality · Augmented Reality · Cultural Heritage · Digital Strategy · Africa · Digital Museums · Regional Development · Tourism · Startup Society · Management

1. Introduction

For many decades Africa has been considered as an unexplored opportunity in all possible dimensions (human resources, raw material, natural resources, cultural resources, etc). However, and despite the growth of the 2.000-2008, the development rate of the continent does not follow the pace of its reputation. The economic growth of Africa has stabilized at 3.4 % in 2019 but is expected to pick up to 3.9 % in 2020 and 4.1 % in 2021, but to remain below historical highs of 2009 [1].

This growth can be considered as the minimum in every conservative plan, and this raises serious consideration on why these dynamics continue to be unexplored or explored without the presence of the western world. The European investments in the

continent are far less compared to the Asian. China and India invest massively in Africa with significant key and critical projects in agriculture, infrastructure, and transportation. According to Ernst & Young's latest Africa Attractiveness report, China is the single largest contributor of foreign directive investment with 293 projects since 2005, totalling an investment outlay of $66.4 billion and creating 130,750 jobs [2].

While for some Africa is the land of opportunity, for others it an unknown environment, far from their preferences on where investments shall be made. This distance can be considered due to the lack of information western managers and investors have about the continent. One way to tackle this challenge is the introduction of virtual reality technologies where the African civilization, culture and history can be projected in an immersive, safe and engaging way. The use of Virtual Reality but also Augment and Mixed Reality can reveal investment opportunities in Africa thought the promotion of the history and culture of the continent.

This paper shortly reports findings from the strategies and pilot projects developed in Egypt and Tunis. Together with previous development activities in Europe (Finland and Baltic Sea region) as well as in Asia (Oman) a quite wide understanding has been obtained on how mobile, AR, and VR applications could be used as a part of cultural heritage projects. Due to latest digitalization period, museums and libraries have already enough digital content for new value creation to be added on their operations. Digital property can now be seen as a raw material for innovative gamified solutions.

An example is the TUAS Turku Castle AR application which the represents renaissance era paintings in a form which can serve visitors who are interested in stories behind paintings but also those who are more interested in gamified features. Both the tourist and game application modes engage a physical visit to Turku Castle [3]. Another application developed by TUAS for the Turku Castle namely Medieval Gastrobox in turn represents immersive experiences in Cave environment [4]. LightsOn! is AR application that can be seen as a way of subjectivizing visitor's experience at eight cultural heritage locations and historical sites in Finland and Estonia [5].

2. The cultural digital transformation of Egypt

Egypt can be considered as a pioneer country in the creation and adaptation of cultural digital heritage strategies. The decision to move massively on a cultural digitization strategy aimed to present the opportunities of the unexplored Egypt though its history while demonstrating the technological readiness and advancements of the country.

The results of this strategy have been remarkable as Egypt developed and keeps on being developed with impressive grow rates (5-7% GDP) despite the devastating crisis it faced during the political instability caused by the revolution of 2011 (-4% in GDP) [6]. Prior the revolution the country was developing with rates of 6 and 8% per year which is far more what the most advanced European country had (Fig. 1). This development was achieved as Egypt attracted partners instead of investors that utilized its human resources and technological readiness.

Fig. 1. Egypt's annual growth rate from 2008 to 2018 [6].

Through a digital transformation strategy initiated with the establishment of the Ministry of Information and Communication Technology, the development trajectory of the country increased exponentially [7]. This was achieved mainly from two key projects launched by the Ministry of ICT. The first one was the establishment of the Software Engineering Competence Centre (SECC) which transferred in Egypt US software engineering standards such as the powerful Capability Maturity Model [8]. This plan established Egypt as a software engineering power were qualitative and affordable software could be developed instead of cheap and unreliable.

The second key project was the development of the CULTNAT organization whose aim was to utilize the upcoming software engineering brainpower of Egypt and digitally transform its entire cultural heritage into digital museums, libraries, publications, and applications [9]. CULTNAT became an applied research centre where innovations like the Culturama [10], Eternal Egypt, Holographic technologies, and others are developed with advanced technologies and impressive results such. The digitization of the Egyptian cultural heritage became a strategy that won many EU research and innovation grants despite the fact the Egypt is not in the EU. Today Egypt continues of this route with the leaders of this digital revolution (MICT, CULTNAT, and SECC) to expand and support this strategy (Fig. 2).
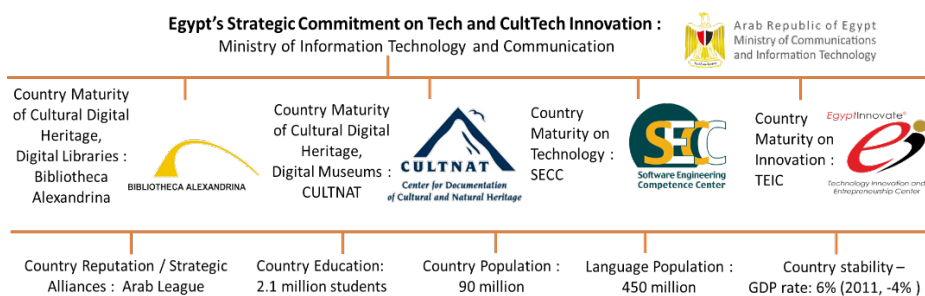

Fig. 2. Egypt's CultTech strategy pillars.

3.   Extending the cultural digital transformation of Egypt with VR and AR

The example of Egypt can be adopted in other African countries. At one hand, and even that many countries have indicated progress in several sectors they have not yet achieved a digitization strategy and results similar to Egypt. On the other hand, the opportunities many countries can offer to investors may be considered more than what Egypt provides today. Since the development of a similar strategy with Egypt can be a plan that needs at least a decade to bring results, other countries can utilize the benefits VR and AR offers to develop their initial digital cultural heritage promotion and link on that business and development opportunities around the disseminated regions.

VR can drive the user in a specific locations providing the information and education needed to understand the area, the culture and the people in a safe at low-cost way. Investors can learn the country and explore its opportunities by virtually learning the cultural and societal evolution. This can reflect the economical evolution in natural and human resources but also in intellectual capital. AR can extend the VR promotion strategy by offering, as an incentive to those who visit the country, further opportunities in the physical locations that have not been provided in the VR spaces.

Digitization of cultural heritage with AR and VR technologies can be the beginning of developing a technology oriented national extroversion strategy for visitors and investors.   The technology exists and the cases are several.

4.   The Bardo Museum in Tunis

Bardo application is related to the great fortune of Tunisia's tourism which is Bardo National Museum. The Mediterranean Development Initiative (MDI) program "Heart to Art", aims to provide guests with an unexpected way of connecting with the historical artifacts of museum by encouraging crosscutting and transversal viewings of them. Such connections permit the visitors to go deeper than customary method of museum presentations (e.g., type of a statue, construction date, its place of origin).

"Heart for Art" is employed as (a) a tool for user profiling, (b) medium to introduce to the potential visitors of the museum specified thematic topics, (c) an advertising technique of not only the venue but also the mobile app and (d) a tool for creating souvenirs for the visitors that could be used in social media to remind them of their visit

Besides, the Bardo Museum retains the stigma of the terrorist attack of 2015 [11]. This program enables to remember that it was there where lives were lost. Instead people will be able to talk about the Museum where masterpieces are brought to life. It will be a victory of culture against terrorism.

The objectives of the Bardo app are about reaching a paintings collection (unlocking pictures need to be scanned) and display their information; provide multi-language system works (English-Suomi and soon French and Arabic) and get the movement in touch: zoom in to move forward and drawing an arc to rotate in the model scene.

These are achieved with an Animated and Voice Recognition User Interface, a dictionary system that allows users to search any word or title by typing it or calling it. Another application, the 'Escape Room' is currently under development.

The application intents to be a source of information and a guide at the same time for the tourists where they can experience of the collection list of the Romain Mosaics, 3D models of stairs, textured walls, carpets and texturing the floor, and level design of the first room (Fig. 3).
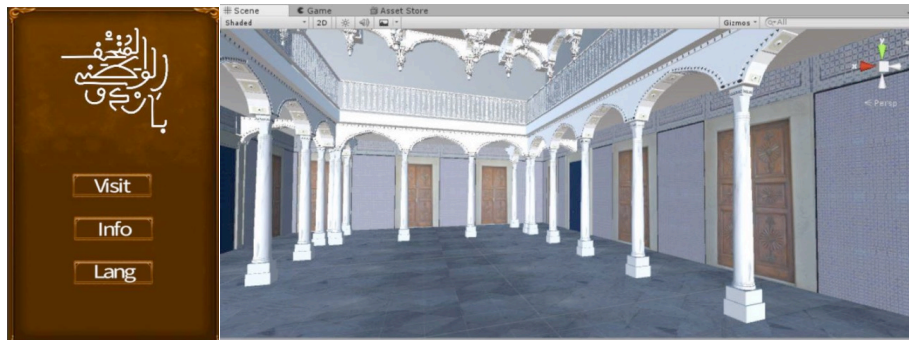

Fig. 3. 3D model from the MDI "Heart to Art" program.

The results of the first prototype allow the visitor to enter in the room, see all the mosaics dark or search for them, either by clicking search button and the mosaics shine, or by using the IBM Watson technology for voice recognition. If the user knows the title of the mosaic or the object, he/she can say it and the camera will focus on it. If the user clicks on it, a panel will display the full description about the object in the current language of the mobile phone if that language exists in the available languages, else it will be displayed in English.

MDI uses gamification as a tool to attract visitors, unfamiliar with heritage, art and history, especially in remote cities and villages. The use of gamification makes it possible to turn museums and heritage in general more into attractive, especially for audiences less accustomed to visiting them. The gamification of a museum visit creates a bridge between generations and facilitates learning in an unconscious way.

MDI focus is to teach to young job seekers coding while creating with them a gamified application that promotes the Tunisian heritage in an innovative and fun way. The objective of the program is for Tunisians and for tourists to discover the masterpieces of the mosaics of the Bardo Museum and to get acquainted with them by "bringing them to life" (through 3D modeling) and listening to the story they have to tell.

5. The Museum/Castle in Oman

In 2017, the TUAS Turku Castle in Your Hands application [3] was scaled to meet requirements in Arabic countries' cultural and technical context and requirements to use multilingual content. Nizwa Fort as one of the most popular tourist locations in Oman was chosen as a demonstration site. This application was developed in Turku University of Applied Sciences in a close cooperation with researchers from Nizwa and Sohar College of Applied Sciences.

The goal was to develop an application that could engage users to physical visit in the fort. Cultural heritage projects developed under virtual reality and augmented reality can increase the sensory and cognitive experiences for tourism [12].

In this sense and during the development phase a lot of valuable information was received from the Finnish Ministry of Tourism on this fort such as related to usability, user experience, and cultural differences. This prototype contained various similar features that were previously developed for the Turku Castle in Your Hands application. For example, users are introduced to the historical site with a two-dimensional map for showcasing points of interest such as VR mode in certain locations. While visiting in the fort additional information is available by using the scanning feature. That is to say some additional information can be unlocked with image recognition. Some custom graphics are produced for the use as markers. These markers are placed around the fort. One of the rooms of the fort can be inspected in VR mode. This mode consists of game and puzzle feature to engage visitors to learn more about the museum artefacts.

Fig. 4. Nizwa Fort. External map and interior spaces.

To address this challenge a gamified application to be applied in cultural heritage in African continent is introduced, along with the technologies that can be used to increase regional and financial sustainability. Effective gamified applications can reveal commercialization opportunities and monetization practices that can assure return of investment on their development [13], [14]. Selecting the best modernization approach in games of any kind is highly related with the type of game itself and its players/users target group [15].

In this gamified cultural heritage approach the user interacts with the application in indoor conditions, guided to selected on of the various digitized monuments. The application utilizes AR technology and provides multilingual guidance that can trigger just in time affordable augmented information of artefacts in the museums. The information is textual and includes multi-media in different formats. Visual markers are used as triggers in the indoor environments. Depending on the conditions (e.g. lightning, geometry) museum artefacts such as statues or paintings itself are used as visual markers. On the monument site, the application offers relevant augmented content to enhance the visit. In the outdoor environment, GPS positioning is used as the main trigger, and visual markers will be considered in environments without GPS coverage.

Most of the mobile phones are nowadays supporting above mentioned technologies. So the technology itself is ready to be used widely in African hoping to bring various stakeholders onboard to form a vital startup society, able to collaborate across borders and cultural differences, share profits, generate stories, and express societal harmony.

6.   Technology Architecture and Infrastructure

Based on the experiences reported in the previous sections a CultHer Architecture is proposed to be used for the utilization of augmented reality in cultural heritage promotion and management in Africa. (Fig. 5)
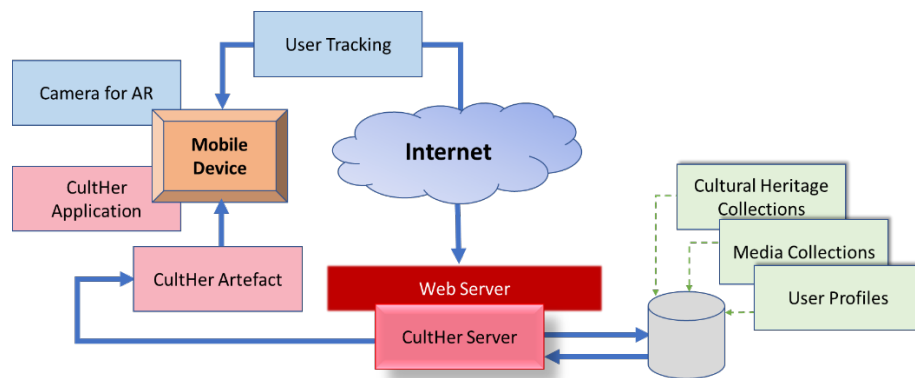

Fig. 5. Architecture for strategic utilization of augmented reality for cultural heritage promotion and management.

Mobile devices are widely used in African continent with high computing power. Their features have been evaluated in various test-generate cycles and found AR to be a robust solution to promote cultural heritage in various projects. The CultHer server is capable to utilize cultural heritage collections such as Europeana, a widely used cultural heritage collection in EU supporting semantic web and linked data. The AR City mobile application [16] combines a semantic ontology data model with AR related content. Enriching cultural heritage experiences with visual and auditorial media content and with customized and localized representations of stories based on user profiling allows the creation of immersive experiences for users interested in cultural heritage in African continent.

The CultHer application has been developed with the Unity game engine and identifies cultural heritage artefacts by utilizing mobile device camera as a sensor. Depending on mobile platforms this mobile AR application uses Google's ARCore or Apple's ARKit frameworks. It's a client server solution that enables user tracking and makes it possible to create customized experiences for the users, and in the same time collect behavioral data to be used in both in research and business development.

7. Alignment with the Science, Technology and Innovation Strategy for Africa 2024, and the UN 2030 Sustainable agenda.

In June 2014, the 23rd Ordinary Session of African Union Heads of State and Government Summit adopted a 10-year Science, Technology, and Innovation Strategy for Africa (STISA-2024) [17]. The strategy is part of the long-term people centered AU Agenda 2063 which is underpinned by science, technology and innovation as multi-function tools and enablers for achieving continental development goals. The Agenda calls for the diversification of sources of growth and sustenance of Africa's current economic performance, and in the long-run, lifting large sections of our population out of poverty.

The proposed strategy entails upgrading Africa's human capital to meet modern demands and the aspirations of Agenda 2063, the long-term plan for transforming the continent. This objective is in line with the Science, Technology, and Innovation Strategy for Africa 2024, which sets out a means to follow through on the Agenda, feeding into the recognition of technology and innovation as mechanisms to implement the recently adopted UN Sustainable Development Goals.

The 2030 Agenda of the United Nations identifies 17 Sustainable Development Goals (SDGs), offering a holistic sustainability framework focused on the premise that sustainability and sustainable growth have a social, economic, and environmental aspect. The framework relates the social with the ecological aspects as well with the economic aspects, all under the environmental impact, meaning that the wellbeing of the earth and the biosphere is a concern for social and economic well-being [18]. The goals provide a blueprint for peace and prosperity for the people and the planet, embodying crucial calls for action by all countries in a global partnership [19]. Many of the 17 SDGs such as goal 4 (Quality Education), 5 (Gender Equality), 8 (Decent Work and Economic Growth), 10 (Reduce Inequalities), 11 (Sustainable Cities and Communities), and 17 (Partnerships), address major human societal needs and develop the social infrastructure on which people and regions can grow and prosper [20].

Digital museums and technologies contribute on the adaptation of the UN SDGs as they reduce inequalities between the privileged and the less privileged, men and women or younger and older by offering the same access to knowledge and education, for all people, anywhere and anytime. The effectiveness of VR and AR in digital cultural heritage creates partnerships which can assure decent work and economic growth for the people and their regions. Furthermore, digital technologies are the ultimate tools for substance development as they reduce unnecessary transformation and logistics while promoting in the most ecological way regional and national opportunities. Digital strategies are sustainable strategies that require, as fuel to operate, only human intellectual capital, knowledge which is in excess in Africa.

8. Areas of further research.

Even that VR and AR can be considered promising technologies on the exploitation and dissemination of cultural heritage there are concerns regarding the cost of such

investments, the technological maturity of the users, the technological infrastructure of the country and the costs to acquire qualitative equipment that can offer the best possible virtual experience and the expected results.

These issues are related with the technical, economical, and political dimension of the PESTLE analysis [21] but also with the social dimension on the readiness of the society to accepts such disruptive digital transformations on sectors that traditionally have been operated physically. This research will be extended to analyze the readiness of specific African countries and regions to adopt such strategies and identify the return on their investments.

Furthermore, it will emphasize on the detailed alignment of the proposed strategies with the UN sustainable development goals indicating which goals can be achieved and how. This can lead to the development of a roadmap that define how the use of advanced virtual reality technologies and strategies in digitization of cultural heritage can deliver local and regional sustainable development.

9.   Conclusions.

The rapid development of Africa has stated over the last twenty years and continues to grow. The annual African GDP increased by 50% in the first decade of 2000, moving from 1.067 billion$ in 2000 (2.45% growth) to 1.561 billion $ in 2008 (5.6% growth). This makes Africa the 3rd world's faster grown region compared to the developed economies which are in the seventh place [22].

This impressive progress has been achieved with the effective communication of the African investment opportunities that can be beneficial for the investors, the African nations, and the people. VR and AR technologies open the communication borders and disseminate such opportunities in an immersive, safe, and engaging way. The digitization of cultural heritage is one way a country can export its culture and relate it with its development strategy [23].

The examples presented in this paper indicate a global trend towards cultural heritage digitization across the world. From Europe (Finland, Esthonia and Latvia), to Asia (Oman) and Africa (Egypt and Tunis) cultural heritage digitization strategies and project can be used to support national and regional development aligned with the UN sustainable goals for growth and property. It can be concluded that Africa is expected, and able, to positively surprise the world through its digital transformation readiness. A start seems to be the digitization of its cultural heritage and but its certain that it won't stop there.

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