ARTISTS: A VIRTUAL REALITY CULTURAL EXPERIENCE PERSONALIZED ARTWORKS SYSTEM: THE "CHILDREN CONCERT" PAINTING CASE STUDY

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Abstract

In recent years, there is a constant tendency in integrating modern technologies into mobile guides and applications in Cultural Heritage (CH) domain, aiming in enriching cultural user experience. Amongst them, Virtual Reality (VR) has widely been used in digital reconstruction or restoration of damaged cultural artifacts and monuments, allowing a deeper perception in their characteristics and unique history. This work presents a VR environment that takes into account the diverse needs and characteristics of visitors and digitally immerses them into paintings, giving them the ability to directly interact with their characteristics with the Leap Motion controller. To test our proposed system, a mobile prototype application has been designed, focused on the famous painting "Children Concert" created by Georgios Iakovidis, which also integrates the User Personas and the different scenarios depending on users' profile.

Keywords: *Cultural Heritage; Cultural User Experience; Natural Interaction; User personas; Virtual Reality;*

Introduction

In recent years, various works argue about the positive influence that Augmented Reality (AR) and Virtual Reality (VR) could have on the fields of language studies, social sciences, mathematics and physics, medical science, art, entertainment, advertising and marketing (Chang Kuo-En, 2014). According to Chang, Chang, Hou, Sung, Chao, Lee, VR and AR technologies promote art appreciation to museum visitors during a visit. In other words, visitors that used those technologies to guide through a museum learned more about the exhibits comparing to all other visitors that used conventional guides

(audio guides) or walked freely without any kind of guidance. A VR guide can boost mental and visual focus on exhibits, achieving a level of flow (Mihaly Csikszentmihalyi, 1975), which motivates user to seek more knowledge and extend his visit.

Meanwhile, personalization methods in User Experience (UX) and Cultural User Experience (CUX) appear to give a new perspective to mobile guides and applications in Cultural Heritage (CH). Personalization (Antoniou & Lepouras, 2010) is based on the assumption that an computer system can understand the user's needs, while its success relies greatly on the accurate elicitation of the user profile. The main reason for personalization need is simple: Everyone is unique. Matching visitor's experience, knowledge and demands is a highly challenging and demanding task. Capturing special personal characteristics, before or during the visit in a cultural site, has been implemented using several methods, for example using ontologies, methodological approach, statistical approach (Pujol Laia et al., 2012), or indirect approach by taking advantage of social networks like Facebook (Antoniou Angeliki et al., 2016), or finally, according to visitor's age and behavior.

Current work presents a Virtual Reality interface that represents digitally the world of paintings, allowing users to interact with the aspects of the painting in a 3D environment. The presented framework also integrates personalization, user personas (based on the User Personas methodology [Konstantakis Markos et al., 2017]) and context awareness techniques to improve users' experience. In Section 2 we briefly present our ARTISTS framework, the technologies that we used along and how we integrate them to the application, the frameworks' architecture and a use case scenario with our prototype based on and the famous painting "Children Concert" created by Georgios Iakovidis. Finally in Section 3 we discuss our future work.

ARTISTS Framework

Description

ARTISTS is a mobile application that brings to life famous paintings, by digitally construct its aspects in a Virtual Reality environment, where users can interact with its

3D models. Users immerse into the VR world by using their own devices mounted on a VR headset (Google Cardboard), and then interact with the 3D environment using gestures that are captured by the Leap Motion controller, that's attached on the headset. The proposed interface not only puts user inside a painting, allowing them to observe and interact with the 3D models in many angles, but also uses various methodologies (context-awareness, personalization, and gesture-recognition) in order to enhance user's cultural experience.

ARTISTS prototype has been designed based on the famous painting "Children's Concert" by Greek painter George Iakovidis, which can be found in Athens National Gallery – Greece, and in a digital format in "George Iakovidis" digital gallery, in Hidira village – Lesvos. For this painting, seven 3D human models were created, along with their animations and sounds, in accordance with the 7 characters found in the original painting. Painting's surrounding space (a bright room having some furniture) has been digitally reconstructed in a VR environment, taking into consideration the limited resources of mobile devices.

ARTISTS prior version was a mobile application in which users were also able to interact with the 3D version of a painting by just tapping on mobile device's screen, thus without totally immersion to the VR environment. Application settings like sound, running scenarios, animations etc were depending on user's profile and interests, a functionality that still stands in ARTISTS, but with the use of more accurate methodologies.

Technologies used in ARTISTS Context Awareness

In ARTISTS design, we take into consideration parts of the context like the ambient noise level, processing power of the mobile device and screen resolution, trying to improve users' experience regardless of environmental conditions. In particular, in a quite noisy environment (to the noise level of 50dB), sound volume can be increased up to 50%, whilst in extremely noisy conditions (noise level more than 70dB), application audio volume mutes to avoid Lombard effect (Varadarajan Vaishnevi, Hansen John H.L., 2006). In a full scale application of ARTISTS, noise levels would be measured by a sensors network, in accordance with user's position in space. Furthermore, processing power of the portable device in use can be a crucial asset which can deeply affect user experience. Insufficient resources could affect the reproduction of high- resolution 3D animation and graphics needed to construct the VR environment, while also screen resolution could be a negative factor in displaying high resolution graphics. A short benchmark on the background, during application installation can easily adjust applications' settings to the appropriate level based in devices' capabilities before the initialization of the application, thus avoiding malfunctions during users' experience.

Personalized User Experience

In our case, we use the User Personas method, which categorize users based on their profile during a museum visit. User Personas (Morris, Hargreaves and McIntyre, 2004) are not real people but avatars created studying real people's characteristics. We use 4 User Personas with the names "Follower", "Browser", "Searcher" and "Researcher". Followers try to follow any guidance provided by the museum or cultural site, trying also to learn something by it. Browsers won't follow a guide but go anywhere, in every place that looks interesting, and then, they search for information about it. Searchers will search and collect detailed information on specific exhibits or collections whilst Researchers step further on a scientific research about specific exhibits (Konstantakis et al., 2018).

Gesture Recognition and 3D Interaction

Gesture recognition refers to computers' ability to understand gestures involving physical movements of multiple body parts (fingers, arms, hands, head, feet, etc) and execute commands based on the corresponding gesture, thus allowing interaction with the computer environment. Many gesture recognition approaches suggest that gestures used as interaction methods between humans, can also been successfully applied as a natural and intuitive way to interact with machines [Ren et al., 2016][Yeo et al, 2015].

In ARTISTS framework, we use the Leap Motion controller to track users' hands and match their movements with commands in the virtual environment. As users' mobile device is found into a Google Cardboard type VR device, it is impossible to tap on the screen. Leap Motion API gives us the tools to interact with the app interface by using hands. Simple tasks like selecting a character, dragging the volume slider, selecting from menus and pressing on UI buttons can be done with natural hand movements in space, in a quite accurate, intuitive and entertaining way.

User Personas

The design of personas as 'fictional' characters is considered as a very consistent and representative way to define actual users and their goals. However, it is important to clarify the exact number of personas in each occasion in order to focus on the visitor profiles to be examined. On ARTISTS, we take into consideration these UPs and their characteristics and we create more Personas by splitting Followers and Browsers into 3 Levels. Searchers and Researchers are combined and split into 2 Levels. These Levels have a quantitative meaning. For example, Level 2 Researcher has done more research and shows more of the initial Researcher characteristics than Level 1 Researcher.

In order to match each museum (or any other cultural site) visitor to an ARTIST persona, the system collects and process various data about visitors. Data mining is ARTISTS involves no user interference or preparation and it's a 3-stages process:

1. *Face recognition:* Using Microsoft Cognitive Services, user age and emotions are calculated by their face picture taken from the device's front camera that is sent over network. In addition, a database of visitors is created, turning every possible upcoming visit into a more successfully personalized experience.
2. *Social networks data mining:* Using data mining algorithms, visitor's data (profile and prior experience) are extracted from user social profiles (Facebook, Twitter or Instagram). Fully compatible with GDPR rules, algorithms can only use data that users expose as public.
3. *Behavior study:* Sensors embedded into the visiting area monitor visitors' path and behavior into space, providing ARTISTS more personalization data.

System Architecture

ARTISTS is a Client – Server system, as shown in *Image 1*. Core of the system is a server, located either in a museum (or any cultural site) or in a remote position. Server supports communication between database, application and sensors network (installed in museum). Furthermore, more server tasks are responsible for matching visitors to predefined personas, or displaying multimedia for the VR environment.

The mobile application creates the appropriate interface between user and ARTISTS system. Depending on visitors' profile, the system shows a different scenario and service. Server also is responsible for handling sensors' and Smart Objects (SO) input that can alter applications' content.

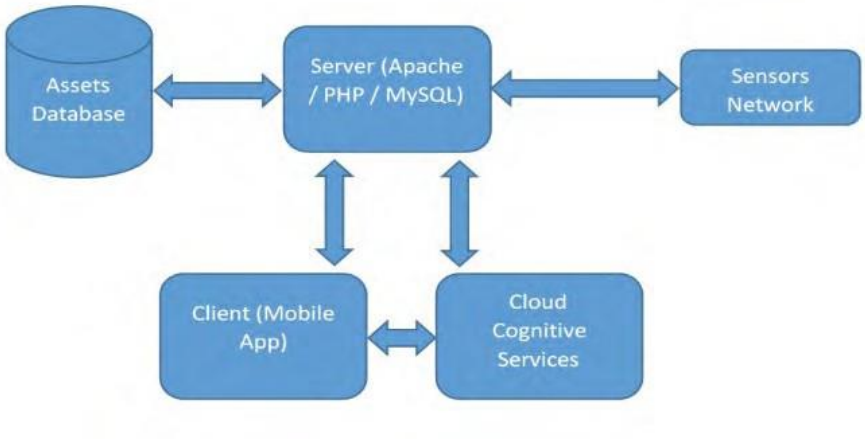

Image 1: System architecture in ARTISTS

General			Interaction				Efficiency / Performance			
User type	**Age**	**Smartphone**	**Menu**	**Characters**	**Sounds**	**Game**	**Motion**	**Sound**	**Quality**	**Fidelity**
Follower Level 1	Child	No	Basic 2	None	None	Yes	Fun	Medium	Low	Low
	Elder	No	Basic 1	None	None	No	Slow	Low	Low	Low
Follower Level 2	Child	Yes	Basic 2	Basic	Basic	Yes	Fun	Medium	Low	Low
	Adult	Yes	Basic 1	Basic	Basic	No	Slow	Low	Low	Low
	Elder	Yes	Basic 1	Basic	Basic	No	Slow	Low	Low	Low
Follower Level 3	Teenager	Yes	Basic 1	Basic	Basic	No	Medium	Medium	Low	Low
	Adult	Yes	Basic 1	Basic	Basic	No	Medium	Low	Low	Low
Browser Level 1	Child	Yes	Basic 2	Extended	Extended	Yes	Fun	High	Low	Low
	Teenager	Yes	Full 1	Full	Full	No	Full	High	Low	Low
	Adult	Yes	Basic 1	Extended	Extended	No	Medium	Medium	Low	Low
	Elder	Yes	Basic 1	Basic	Basic	No	Slow	Low	Low	Low
Browser Level 2	Teenager	Yes	Full 1	Extended	Extended	No	Full	High	Low	Low
	Adult	Yes	Full 1	Extended	Extended	No	Full	Medium	Low	Low
	Elder	Yes	Basic 1	Basic	Basic	No	Medium	Medium	Low	Low
Browser Level 3	Teenager	Yes	Full 2	Full	Full	Yes	Full	High	Low	Low
	Adult	Yes	Full 1	Full	Full	No	Full	High	Low	Low
Researcher Level 1	Teenager	Yes	Full 2	Extended	Extended	Yes	Medium	Medium	High	Low
	Adult	Yes	Basic 1	Basic	Basic	No	Medium	Medium	High	High
Researcher Level 2	Adult	Yes	Basic 1	Basic	Basic	No	Slow	Low	High	High

Table 1: Interaction – usage scenarios in ARTISTS.

Use Case Scenario

After getting necessary visitor data and assigning one persona from Table 1, one of the 19 usage scenarios may initiate. These scenarios are 19 in total and matching a visitor to a scenario is a dynamic process. For example, user can start visiting a museum as a Level 3 Follower, but after a while, his behavior can turn him into Level 1 Browser and then Level 2 Browser. This happens because behavior monitoring is an ongoing process that gives feedback data which can eventually change the flow of user experience. Each one of the scenarios in Table 2 is different in functionality, interactivity, display quality and load, audio (Table 2).

Image 2: The VR representation famous painting "Children Concert" created by Georgios Iakovidis

Conclusion - Future work

In this work, we describe the ARTISTS framework, a mobile application that displays a VR reconstructed environment of a painting, and immerses users allowing them to interact with its 3D aspects. We used the Leap Motion controller as a sensor for detecting gestures, alongside with Unity, Microsoft's Azure Cognitive Services and Android Studio for the implementation of the application and the MySQL database that stores the 3D environment and painting's data. Our next step includes the ARTISTS evaluation stage, in which we will test our framework to evaluate user's experience and the efficiency of our integrated technologies.

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