Assessment of Digital Environments for Cultural Heritage Communication

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ABSTRACT

Preservation of cultural heritage requires the effective communication of values associated with its tangible and intangible elements from one generation to the next. The process of transfer of values may be termed as Cultural Heritage Communication (CHComm). This paper analyses different approaches to Cultural Heritage Communication by identifying the dimensions of interface options through which a communication metaphor is deployed. The goal of this survey is to understand the ways in which digital environments and interfaces proposed in the literature can achieve effective Cultural Heritage Communication. The analysis is based on how the literature responds to the unique requirements of implementing effective CHComm within digital environments. Inferences arising out of the survey are classified through categories that provide insights on the communication metaphor, contextual implementation, user engagement, interface optimization and targeted evaluation. Finally, we propose three suggestions with the goal of facilitating the effectiveness of CHComm with respect to interfaces of digital environments.

KEYWORDS

Cultural Heritage Communication, Interfaces, Digital Environment

1 INTRODUCTION

Cultural Heritage (CH) includes the intangible and tangible manifestations of human legacy, inherited from our previous generations, through which human evolution can be charted [17][4]. The process of transfer of values associated with CH can be termed Cultural Heritage Communication (CHComm). Cambridge English dictionary defines the term 'effective' as "successful or achieving the results that you want". In fact, effective communication refers to successful communication that achieves its intended result. The effectiveness of communication of cultural heritage has an immediate impact on the issues of conservation and preservation of the intended meaning, related to the CH, during the process of transfer of values from one generation to the next [38]. Most instances of

CHComm are expected to have communication metaphors that transfer some values associated with cultural heritage. In short, effective Cultural Heritage Communication is being defined as communication that successfully transfers the values associated with some cultural heritage to the intended audience.

Traditionally, communication to individuals or a larger group of people was done verbally, through written texts or via drawings and paintings. Folktales, Dances, Theatre dramas or Operas were also used to convey cultural information across generations. [40][19]. All of these methods are non-interactive, except for verbal communication in a person to person setting, which can result in a dialogue. For such dialogues, the presence of a 'source' person as a communicator of cultural heritage was necessary.

As the world progressed into the ages, newspapers (later mass media) and graphical representations, possibly accompanied by audio, became the norm. Multimedia content could vividly represent the knowledge of a group of experts and communicate effectively to a large group of people. There remained the issue of interactivity and also the finite amount of content that could be stored on audio-video tapes. Once personal computers and the internet became commonplace, round the clock access to large amounts of information became widely available. Now it is possible for the average person or group of people to interact with digital environments that can transfer information vetted by a group of experts without requiring the physical presence of any communicator(s). Environments can also be created to be interacted with at any time or place as per the convenience of the user. Users can also share the information they receive, reflect upon it individually or collectively, and build their unique understanding of cultural heritage, as we will see in the following sections.

1.1 Digital Environments and Interfaces

Contemporary CHComm makes use of digital environments that are built on multimedia technologies. They convey information in several modalities, such as Augmented Reality (AR), Mixed Reality (MxR), and Virtual Reality (VR). In the context of this paper, digital environments are defined as environments that depend on one or more systems that digitally communicate with one another to augment the real-world environment or create a virtual environment for users to engage with. These environments are installed in heritage sites, GLAM institutions (Galleries, Libraries, Archives, Museums), or exhibition setups. Sometimes these installations are popularised via websites and social media and in some cases, those websites and social media form a part of the digital environment for CHComm [2][39]. Environments are also available through digital distribution, such as games [41] and virtual tours [10]. Users are

increasingly familiar with digital environments due to the availability of cheap handheld devices and rise in a video-gaming culture which has been causing a shift in personalized consumption of media rather than mass communication. Digital environments are increasingly becoming cheaper and widely accessible for both cultural heritage professionals and other users. The implementation cost and the technological barriers related to creating content for digital environments has been constantly reducing over time [33]. Digital environments tend to attract groups of users who are inherently drawn towards digital technologies without necessarily alienating any other major user groups [13][11]. Additionally, social media and the internet in general provide a massive platform for the popularisation and communication of CH [24]. It is imperative for the contemporary CH professionals to understand and take advantage of the benefits offered by the digital environments for CHComm.

1.2 Role of interfaces

Digital environments provide opportunities for an individual user or a group of users to interact and learn about cultural heritage without causing any harm to the heritage. It has been often stated that, when cultural heritage sites receive increased tourist inflow, this may cause physical damage to the ruins and artifacts on-site (see e.g., [15]). Additionally, digital environments provide the designer with the option to structure and control the user experience (UX) in many ways. In fact, leveraging this ability of digital environments is one of the biggest reasons for designing interfaces that provide effective CHComm. The intention of CH professionals may be communicated through a flexible digital environment that allows for a considerably easy user interface (UI).

An interface realizes the interaction between the user and the digital environment [29]. This interaction is achieved through a series of inputs that produce a series of outputs after which the user may provide, in turn, more inputs. The series of input(I) and output(O) interactions may engage any or all the five human senses in the input and output part of the cycle, respectively [27]. This cycle loops until the user decides to stop the interaction with the environment either from having exhausted her/his curiosity [39] or having explored all the environment has to offer.

The ideal digital environment addressing CHComm would be able to generate enough interest in the user, so to explore the environment exhaustively. The job of an interface, in this case, would be to make the input process as user-friendly and natural as possible and to provide an output as immersive as possible [30]. Ideally, the interactions that occur within the interface should take the least possible effort on behalf of the user to give the most effective outcome. The outcome may be anything from a basic manipulation of user environment such as pan, zoom or rotate to the selection of specific items, activation of events or any other interaction provided by the environment. This whole cycle of interfacing through detected inputs and generated outcomes creates the experience of a user. It follows that, understanding the user experience (UX) takes center stage in the process of creating and improving digital environments for CHComm. A large part of the UX is shaped by the design of UI [8].

This paper surveys the interface approaches that have been reported in the literature. The next section reports on previous surveys, mainly focused on usability of interfaces. Then, we describe the methodology of the survey and the selection of a restricted number of projects to beanalyzed in detail. A brief view of the projects is presented and the paper is concluded with considerations on the lessons learnt.

2 RELATED WORK

A number of literature surveys have been carried out to assess the usability of interfaces across digital environments, mainly focused on the ease of use, reliability, engagement, and overall user experience [22][43][6]. These surveys have primarily addressed user feedback, which isanalyzed through quantitative and qualitative methods [2][34]. User feedback on the interface is collected for the overall UX of the environment for the majority of cases. It was observed that many of the existing UX surveys exclude the impact of immersivity provided by the output of interfaces [14][7], and only some cases account for the familiarity of the interface [2]. User feedback is considered as the method by which the papers being surveyed can be analyzed but an attempt at looking over the components that are involved in shaping the user-feedback seems to have not been undertaken. Such an attempt would help provide further insight into what components of the environment can be improved to generate positive user feedback. It is worth noting that only a few of the previous surveys cover researches that have collected user feedback about the input processes of the UI [27][7]. This usually avoids the impact of the output processes of the environment on the user's experience. For example, an evaluation that focuses on the input processes in a system will not account for the positive user reactions generated by a visually immersive output or the ability of an environment to make a person feel as if they are in another place by allowing them to move around the virtual environment through natural gestures or movements in the real world [2][42][7][6]. Increased user interest and engagement promotes positive interaction, reflection and, retention of the content delivered [41], and immersive output tends to extend the period of user interaction. Interfaces that allow clear and concise inputs for navigation and exploration of detail automatically improves the UX and when the UX of the digital environments is improved, the effectiveness of the CHComm increases [20][36][37].

3 METHODOLOGY

The goal of the survey is to understand the ways in which interfaces proposed in the literature can achieve effectiveness in CHComm. After a thorough search in journals and conference proceedings, we have selected a limited number of projects by using three preference criteria:

(1) Availability and Multiplicity of Interface Techniques: projects that are focused on digital environments using AR, MxR, VR were preferred if they relied on 'off the shelf' devices, such as Head-Mounted Devices with Controllers [21][11], Handheld Devices [10], and Desktop Devices [41]. This is because such projects may be easily replicated by CH institutions without any difficulties from a technological or economic standpoint.

(2) Extensive User Evaluation: projects that are focused on extensive qualitative and quantitative assessments of UX or reporting on some user feedback on the interface quality

were preferred [2][34][13]. This was because it is very difficult to judge the effectiveness of a method without testing it at work. Hence, we have mostly addressed projects that have made an attempt to report on the user evaluation.

(3) Novel Embedded Technologies: projects that discussed novel interfaces with embedded technologies (either 'off the shelf' technologies that supported creative solutions or custom designed technologies) were selected even if they did not meet the two criteria mentioned previously. A few examples cases: prototype interfaces intended to work with outdoor embedded technologies implemented in culturally important cemeteries with different contexts [18], movable projectors to create an AR environment showing the historic appearance of a chapel which could interact with RFID chip embedded in a 3D printed model [34]. In general, this criterion was to value those approaches that provided a creative but affordable combination of off-the-shelf technologies, even if they were not systematically evaluated. However, we left out artistic renditions to CHComm, because of their singularity (lack of easy replicability) and general lack of systematic UX evaluation.

Given these selection criteria, the survey identified the dimensions for classification to proceed with. The key factor was to safeguard the idea of valuing CH while also being engaging to the user. The dimensions identified took into account the elements of projects that could have a direct influence on the effectiveness of CHComm. These were identified as the communication metaphor, the cultural heritage context, the interface typology, the type of device, the content type, and the technology involved. Then, each research paper was scrutinized for their (attempts at) evaluation. This has led to a categorization based on the focus of the evaluation. As described previously, some evaluations focused on the overall UX while only a few also focused on the UI. These were further categorized as a focus on the input component and the output component of the UI, respectively. In understanding the communication metaphor, the challenges and opportunities that the researchers came across were noted. For example, in the creation of an augmented environment with embedded technologies in two cemeteries, a team of researchers found that dealing with historical cemeteries that have not received any recent burials and dealing with cemeteries that may have received recent burials would require completely different technological approaches [18]. The difference of behavior was required by the necessity to be sensitive to the needs of the visitors to the recent burials, who had recently lost a loved one. This created innovative responses from the research team. Another case involved the potential application of a MxR headset in combination with mapping tools, so as to display location-aware CH snippets in real-time using an AR display [5]. The opportunities and challenges, in this case, remain unexplored.

For achieving the objective of understanding the CHComm effectiveness of the interfaces and to aid in the better contrasting of the communication metaphor with the digital environment interface, we compiled a table of the surveyed literature. An illustrative excerpt is in Table 1 (please, refer to the complete table at URL https://chcomminfo.000webhostapp.com/. The table lists the elements of the interface implementation for the selected projects,

along with the communication metaphor identified for each CH context and has been used as a tool for providing comparisons and insights.

The communication metaphor makes an attempt to describe the primary objective of the digital environment. The CH context states whether the environment has been set up within a museum, an exhibition setup, on a heritage site, or if it could be accessed from anywhere. The interface of the environment is addressed through its input(I) and output(O) components. The input types have been classified into 4 categories. 'Touch' type covers all the inputs that involve touchscreens where the user directly manipulates a touch display to change the output display or trigger an output event. 'Controller' type covers all use cases where the interface requires a separate controller including, but not limited to, keyboard, mouse, VR controllers, motion tracking wand, and any such off-the-shelf controllers. 'Natural input' type covers gesture, voice, motion—tracking, eye-tracking, or gaze-based input systems, which are close to how humans act upon their natural environment. Other custom designed input systems, where an object or device are used to initiate output events, are covered under the 'Tangible' input case. The latter categorization takes inspiration from a similar earlier attempt at interface categorization by Bekele [6]. Output devices are categorized as visual, acoustic and haptic, for the respective senses that receive the output from the environment. Smell- and taste-based output cases have not been featured in the environments surveyed here. The content of the digital environments is listed as either 2D Imagery, Audio, 3D, or VR models and a mention is made if the environment is structured as based on game-design principles. Most of these environments include textual content, with some exceptions. The technologies used in the creation of these digital environments include VR, AR, MxR, micro-augmentations [3] and stereoscopic projections [1]. Micro-augmentations have been defined as any minimum meaningful stimulus provided to the visitor in an attempt to increase the learning motivation and the intra-group communication [3]. Micro-augmentation stimuli last for a very short duration, ideally a few seconds. These are aimed at creating an information gap that subsequently increases curiosity and together with carefully chosen stimuli can trigger an emotional element leading to the initiation of cognitive processes like motivation for action, learning, and increased satisfaction. The content and the technology, respectively, serve as an identifier for the modalities of implementation for each environment in question. The devices utilized in the creation of the digital environment are listed with a separation shown for their input and output components. External Devices (ED) include screens and touch screens that are whole units meant for display or control of input and other custom made combinations of devices with embedded technologies such as artefact replicas with near-field communication systems and 3D printed models of a building with integrated RFID sensors, all managed by complementary control systems. Desktop Devices (DD) refer to conventional computer systems that are placed on desktops for users to interact for cases of keyboard, mouse and screen-based systems. Handheld Devices (HD) refer to smartphones, tablets, and pads that are held in hand by the user and operates on off-the-shelf specifications. Head-Mounted Devices (HMD) are the immersive head gears with screen displays in front of the eyes. A streamlined categorization

Table 1: Interfaces for Cultural Heritage Communication

Reference	Communication Metaphor	CH Context	Interface	Content	Technology	Device	User Interface (UI) Evaluation	User Experience (UX) Evaluation
[1]	Interactive virtual exploration	Museum	I:Touch O:Visual	3D Model	Stereoscopic Projection	I:ED-Touch Screen O:ED-3D Wall+3D glasses	I:Evaluated O:Observed	Evaluated
[5]	Walkable Mixed Reality Map	Any	I:Natural (Gesture, Voice, Gaze) O:Visual, Acoustic	2D Imagery, 3D Model, Audio	Mixed Reality	I:HMD-Microsoft HoloLens 1 O:HMD-Microsoft HoloLens 1	I: Not Evaluated O:Observed	Not Evaluated
[9]	Interactive virtual and augmented game-based exploration	Exhibition Setup	I:Controller + Touch O:Visual, Acoustic	2D Imagery, 3D Model, Audio, Game	Virtual Reality, Augmented Reality	I:HMD-HTC Vive,HD-Mobile/Tab/Pad O:HMD-HTC Vive,HD-Mobile/Tab/Pad	I: Observed O:Observed	Evaluated
[23]	AR enabled walking tour	Heritage Site: Fortress	I:Touch O:Visual, Haptic	2D Imagery, 3D Model, Game	Augmented Reality	I:HD-Tab/Pad/Mobile O:HD-Tab/Pad/Mobile	I:Evaluated O:Observed	Evaluated
[32]	Tangible smart replicas at a museum	Museum	I:Tangible O:Visual, Acoustic, Haptic	Smart Replicas, 2D Imagery, Audio	Augmented Reality	I:ED-Artefact Replicas O:ED-Display Case	I:Evaluated O:Observed	Evaluated

of the kinds of evaluation of the digital environments attempted by the researchers in the papers surveyed has also been made. This categorization ties into a larger work where the effectiveness of CHComm in digital environments is beinganalyzed from various perspectives. The categorization as presented in the table mentions 'Not evaluated' where no attempt at evaluating the specific focus has been made. In case the research team has directly observed points relating to a specific focus or if their interactions with users or experts have caused them to arrive at points related to a specific focus then it is being considered as a qualitative evaluation and the categorization of 'Observed' is used to indicate the same. In case an attempt at systematic observation for a qualitative or quantitative evaluation approach has been pursued (or maybe both), then that focus for the specific research is categorized as 'Evaluated'. A more nuanced look into the categorization of these aspects is being undertaken.

4 DISCUSSION

A glance at the table reveals that a majority of the digital environments are deployed within a museum [1][2][36] or an exhibition setup [14][9][11][25]. Some working projects were implemented on the heritage sites [42] [34][23]. Broadly, the adopted communication metaphor was an exploratory digital experience such as virtual tours[10][23] or virtual exploration of details [1][14][34]. Some projects integrate game design elements [41][42] or take inspiration from narrative structure[2][9], in order to increase the user interest. Another point that stands out is that 3D models and multimedia content are preferred over simpler forms of digital content. This is to be expected as contemporary digital environments tend to use multimedia[18] and 3D models[25][34]. Basic VR systems[13][21] tend to receive comparatively lesser user interest, while increasingly interactive VR systems [36][11] and those that implement game-based design elements [9] receive higher scores in user evaluation. It also becomes apparent that certain methods of interface optimization and implementation could have improved the effectiveness of the communication metaphor[11]. In order to better explore the implications of UX on the effectiveness of CHComm, we sketched Figure 1, based on existing work in the field of UI/UX design [27] [28]. The figure depicts a human-computer interface model. Cycles of input and output (mentioned previously) occur as repetitions of this model. A number of issues that arose after the analysis of the challenges and opportunities in the projects are presented in the table under five categories, namely, communication metaphor, contextual implementation, user engagement, interface optimization and targeted evaluation.
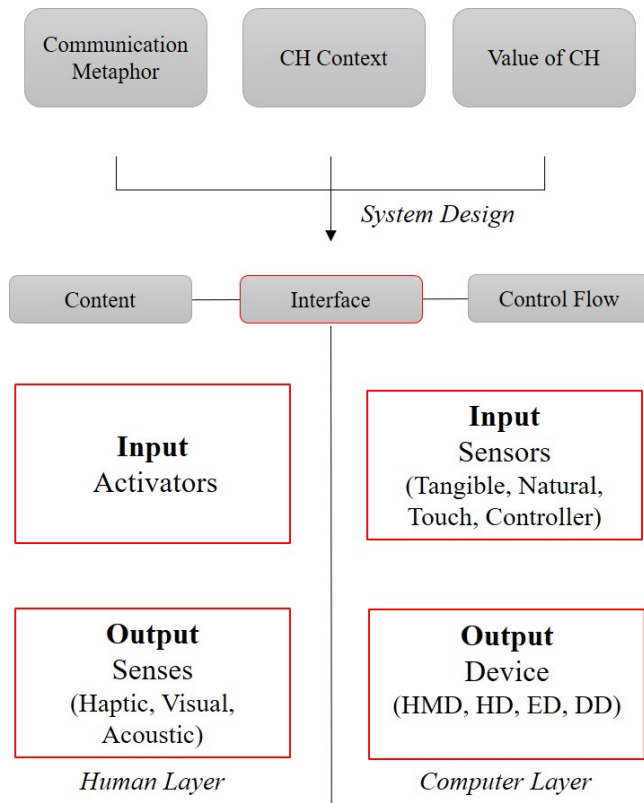
Figure 1: The human-computer interface model (Source: Authors)

4.1 Communication Metaphor

An immediate application where the discussed interfaces show promise is in providing virtual and augmented tours. This has taken various forms such as providing personalized narratives at a museum [2], AR mobile guidance of a historic district [10], customized embedded technology at cemeteries [18], and also walkable MxR with natural interaction enabled guidance [5]. Easy to use interfaces with high definition content tend to provide easy natural immersion, thereby increasing the effectiveness of the communication metaphor across all setups, such as a VR HMD built into a stereoscope [36] or a choice-based computer game [41]. Multiple interfaces provide a definite advantage for CHComm and more projects of that nature need to be explored [9] [23]. The effort to include those users that are unfamiliar or unaware of digital environments seems to be limited. Increasing the availability of information about digital environments and providing secondary interfacing opportunities through websites, focused apps, games and through social media or advertisements to a larger audience will increase the effectiveness of CHComm [41]. In the case of [41], 40,000 people responded and gave comments on the game which helped in creating a better game as seen in the next iteration, thereby improving the digital environment and increasing the effectiveness of CHComm. This can also be seen in the case of CrossCult project implementation [2]. Increasing the awareness about the existence

of digital environments for CHComm can attract larger audiences to the installations of the environments at GLAM institutions and exhibitions. This can also increase the participation of people in the preservation of cultural heritage. Making a larger population aware of the crisis in the field of cultural heritage conservation is a stated goal for organizations such the UNESCO, Global Heritage Fund [16], and Getty institute. Another benefit of increasing the audience to CHComm environments is the potential to encourage community interaction with local and global cultural heritage sites and institutions. This will eventually strengthen the individual and community interest in CH and CHComm environments as a whole.

4.2 Contextual Implementation

Digital environments installed in museums or exhibitions require a higher level of guidance for the users to feel comfortable with the environment [25][31][1]. Interfaces designed around digital environments that follow conventional game design strategies have shown positive results when used for educational application [42] [41]. Interfaces that are related to augmented reality tend to work better with a very context-specific [41] and site-specific design [18]. Augmented reality and game design elements work well when integrated into virtual tours and narratives of heritage sites or institutions[9][39][5].

4.3 User Engagement

Users appear to be easily interested in a novel approach implemented within an interface they are familiar with, such as, e.g., various VR solutions offered through the same HMD device [9][13][36][23]. Users tend to be able to easily adapt to multiple applications of a familiar interface [23][2], while a majority of the users seem to expect less from an unfamiliar interface unless they have prior experience. Users with prior experience turned out to be a minority in most cases [11][9][21][13]. Introducing elements of game design along with augmentations (AR, MxR) to the interface tends to generate user curiosity [39][42][23]. Interfaces that provide for increased interaction mimicking real life situations tend to improve the feeling of immersion and live presence. This can be seen in interactions such as breaking of clay pots, jugs and bowls [11]. Any environment that provides a good UI improves the UX and this directly increases user engagement, thereby positively impacting on the effectiveness of CHComm [7][22], refer 1. It is imperative to note the role of input and output components in a UI and the role of a good UI in creating a good overall UX [8]. A better understanding of the component of outputs in the UI and UX of a user interacting with a digital environment can lead to improving the user experience (UX) of individual users. An improved experience would be memorable and thereby improve the effectiveness of CHComm for any digital interface. An example of this is the impact of high graphic fidelity on the mind of a user. As noted in the case of the VR exploration environment based on the 800-year-old Yuan dynasty site at Sanjiangkou, users with prior experience of VR and video-gaming expected a higher graphic fidelity of the VR display. They notably felt that this detracted from their experience. On the other hand, users with no prior experience in either field felt that the environmental experience was quite good [11]. This shows that increasing the graphic fidelity of the output has

the effect of improving the experience for those familiar with the contemporary technological advancements in graphics across the fields of video games and consumer VR while immersing the newer users in the CH experience. It should be noted that the number of users who expect higher graphical fidelity is a small percentage of the users sampled in the various projects surveyed [9][12][13][35]. The important distinction to make here is that while the current systems and implementations of CHcomm environments may have adequate graphical fidelity, the CH environments dependent on visual experiences are fast being outpaced by consumer technology. It is imperative for the CH community as a whole to be aware of the advancements of consumer technology and the field of UI/UX design at the larger level so as to not being left behind by the developments in the field. This phenomenon is evident from the fact that user expectations regarding graphical fidelity increase with the familiarity to the technology [11]. A potential workaround to this is presented by inventive implementations of environments that either depend on off-the-shelf consumer technology or environments that are not overly dependent on graphical fidelity [6][14] [36] but may focus on narrative structures or personalized presentation of the communication metaphor [2][32][41].

4.4   Interface optimization

Interface optimization refers to the flow of the user interface that includes ease of use and reliability of the UI. In other words, any observation that pertains to improving the user experience by improving the UI comes under the purview of interface optimization. A robust, well optimized and responsive UI is crucial to the wider acceptance of digital environments. If the input components are perceived as clunky or if the output components in the UI design do not provide the user with sufficient information for the user to adequately experience the environment, they may not appropriately engage with the communication metaphor [14]. Some such observations are discussed here. The option to be able to move around and use AR or Micro-augmentations is under-explored in the implementation of digital environments [5][14][2]. Digital environments that are connected to a larger network of interface options through social media or the Internet tend to have a larger impact on the tools for CHcomm [41][2]. Multiple evaluations have seen some percentage of users reporting discomfort and mild sensations of nausea while using VR interfaces [36][9]. Research has suggested reducing the pixel persistence (of the virtual image) to lower than 3ms, so as to prevent users from feeling discomfort while moving their heads [27]. It has also been suggested that a higher frame rate of at least 95 FPS can increase the sensation of immersion [27]. Multiple novel ideas for interfacing with digital environments show high potential, but have not yet been applied to the full extent of their possible scope:

- Walkable MxR maps integrating CH information have been prototyped but not extensively utilized yet [5].
- Immersive 360-degree screening systems integrating motion tracking and kinaesthetic inputs have been evaluated and have shown generally positive user responses. Even so the implementation potential remains under-exploited [14].
- Utilisation of real and virtual replicas of historic artifacts have seen increased user interest emanating from both the

novelty of the interface and the ease of use in its implementation. Even so, increased user guidance as mentioned previously and challenges to widespread application remains [25][31].

When the output matches the scenario that can be expected in a real-world setting the users tend to report a sense of increased wonder. For instance, a 3D projection model on the existing walls of a chapel[34] and a 360-degree screen projecting 1:1 scale imagery of an archaeological site with natural interaction enabled [14] have both seen users reporting amazement and trying to create a mental picture of 'How it would have been'.

4.5   Targeted Evaluation

One of the striking observations from the table was the lack of targeted evaluation on the output component of the UI. The input component did not fare much better but some attempt at evaluation was made. Certain complexities in the handling of the environment by the user can only be understood and explained through targeted evaluation. The lack of targeted evaluation hides shortcomings in the UI which may negatively impact the UX. Avoiding such pitfalls can help improve the overall experience for the user, thereby improving the effectiveness of CHComm. Shortcomings that reduce the ease of use or create other issues in a UI may be supplemented by providing support or guidance in using the digital environment. This may be done by having a guide or researcher, who is present in the area where users are expected to interact with the digital environments [1][32][34]. In some cases, users may be given a short explanation or demonstration of how the environment is to be interacted with [11][10][26]. Either of these situations add a layer of physical mediation between the user and their experience of a digital environment which should ideally be avoided to generate a smooth UX. In order to try and avoid situations where the users may need assistance, the CH institution that is expected to host the digital environment may attempt to simulate a pre-visit, during the visit and post-visit scenarios, respectively, for an average user prior to designing the environment or during the process of the creation of the environment [22]. It would not be out of place to hire a consultant/expert from the field of professional UI/UX design for a project with multiple interface options or larger scope. This would be especially helpful in the case of an app, game-based or web-based environments. An exploration intended to integrate digital systems with one another has been attempted in a few research papers surveyed, but they have achieved mixed results at best [32][34][36]. Commendable strides are being taken in some cases, with regards to identifying specifics of UI and UX that users either appreciate or dislike. Using targeted questionnaires has been one approach that brings out the positives and negatives in UI/UX of a particular environment, as seen in the case of the Arkaevision project, where users were asked to describe their reaction to certain moments in their experience [9][35]. Questions trying to gauge the user response to certain elements of the UI have also been asked for the record of researchers as in the case of the design for an AR tour guide at the Hwaseong Fortress [23]. As noted previously, this attempt at UI evaluation is still heavily focused on the input end of the system and not on the output end. Questions relating

to the accessibility of certain features were not present in the research papers surveyed. For example, "Were you able to find and play the audio-recording provided as part of the exploration tour?" or "Did any popup notifications appear that distracted from the experience of the environment?" were absent. Such questioning would bring out the points in the UI design that may otherwise be overlooked. Features designed in an environment may be missed out by the users or may even be perceived as annoying if they are not seamlessly integrated into the interface. A case in point here is the observation that only a small percentage of the users used the rotate feature of the 3D screen display provided at an exhibition where the portal to the Ripoll Monastery was displayed as a 3D reconstruction. A larger majority used the pan and zoom functions[1]. A questionnaire or informal interview sessions with an adequate focus on the output component of the UI might have been able to uncover a credible explanation as to why this was the case. The responses may have ranged from a lack of interest in further exploring the model to not being aware of the existence of such a feature. The approach towards the UI design could have been tailored based on the responses received. We wish to note here that many of the research projects surveyed did not explicitly intend to analyze the UX or UI, but they were looking at the overall acceptance of their systems and therefore such occurrences are understandable.

5 CONCLUSIONS

This paper has presented a comprehensive ongoing work of surveying digital environments for cultural heritage communication. We compiled a table that aims at classifying the several approaches emerging from the literature, with the goal of retrieving the best practices and to learn about the most relevant factors that contribute to a successful interface. Digital environments and their interfaces within CHComm are reaching a stage where the primary interfacing opportunities are maturing and exploring new horizons. This is an encouraging fact for CH professionals in general and researchers of CHComm in particular.

Even so, digital environments for CHComm have a lot more potential for improvement even at the primary level, i.e. direct communication with the user. The secondary level of interfacing, i.e. generating awareness among the users, is an area that has been barely touched upon by digital environments. Wider broadcasting of the avenues offered by the digital environments needs to be focused upon by interested parties and CH professionals. Furthermore, extensive user experience evaluation needs to be integrated into research dealing with efforts to provide better interfacing. Targeted evaluation of user interfaces and UI design standards of digital environments for CHComm is something that can be done to improve the effectiveness of CHComm. We wish to state that every digital CHComm environment interface can benefit from assessing its impact on the user. The following three suggestions are made as a guideline or a way-forward for parties interested in the field of Digital CHComm effectiveness.

(1) Involvement of UI/UX design experts or the considered application of UI/UX design principles right from the early stages of the creation of any digital CHComm interface. This is in order to raise the presentation of CHComm content to a level that feels easy and attractive for the user so much that the presentation itself pushes the user to interact with every aspect of the digital environment.

(2) User experience evaluation in a context-specific manner would benefit CHComm research as a whole. Using semi-structured interviews or targeted questionnaires to understand the users' views on multiple aspects of the interface and presentation technique can provide specific insights in to the pros and cons of various modalities and technologies through which CHComm is carried out. The findings from such investigations may have ramifications outside the field of cultural heritage.

(3) Almost every CH professional would have come across digital interfaces and environments in their everyday life and it would be well worth our collective time to take note of exceptional instances of digital environment implementation. It is also suggested here that any extra funding that may be used to improve the efficiency of CHComm interfaces and environments are also well worth the expense. The treasure trove of cultural heritage that is being communicated may as well as be communicated in an effective manner.

A review of effective communication methods and by extension effective CHComm is under development and will eventually be combined with the future stages of the current work. We hope to evolve a comprehensive understanding of how the field of digital CHComm can take complete advantage of the primary and secondary interfacing opportunities that are inherent in contemporary digital environments.

6 SUPPLEMENTARY MATERIAL

The list of surveyed literature is available at https://chcomminfo.000webhostapp.com/ which is part of ongoing research carried out by the authors.

7 ACKNOWLEDGEMENTS

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