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Abstract. Based upon the core concept of the LiveCity Project we focus on the specific *City Cultural Experiences v2v Pilot,* designed to allow for visitors at two defined locations to interact with one another in a joint experience and to get educational/entertainment benefits, originating directly from the museum content delivery. We discuss a set of semi-pervasive games (the so-called *"Twin Cities"* games) which are designed to bring people together at remotely twinned locations through the use of video-to-video communication and multi-touch interaction. We also present an early classification of video-to-video (v2v) interaction games that is designed to inform designers about the potential of such technologies. We classify them as: using video for awareness and communication, interacting with video and video as a game.

Keywords: Content management system (CMS), Internet, gamification, "mixed" reality game, pervasive game, video-to-video (v2v) communication.

1   Introduction

Information and communication technologies (ICTs) can enable learning and educational activities and help people gain new skills in the modern digital-based economies and societies [1]. Among the core priorities for maximizing the social and economic potential of ICT [2] should be the proper development & the dispersion -*as widely as possible*- of a variety of modern infrastructures and/or corresponding facili-

ties, composing the so called *"Future Internet" (FI)* [3]. Thus, the future economy will be a network-based knowledge economy, with the Internet being at its center. This option will be critical to support growth and investments as well as to ensure citizens can access the content and services they want, occasionally via new modes and novel educational or communication means.

The aim of the *LiveCity ("Live Video-to-Video Supporting Interactive City Infrastructure") Project* is to empower the citizens of a city to interact with each other in a more productive, efficient and socially useful way by using high quality video-to-video (v2v) over the Internet. Video-to-video can be used for a variety of selected activities such as to save patients' lives, improve city administration, reduce fuel costs, reduce carbon footprint, enhance education and improve city experiences for tourists and cultural consumers. To realize its specific targets, LiveCity proposes certain well defined scenarios/use-cases and then it realizes, *during its life-time*, corresponding pilot actions with the involvement of multiple users. According to the original LiveCity context and conformant to the specific description of its WP4 *("City Cultural & Educational Experiences v2v Pilot")*, two specific scenarios will be developed and the inclusion of live (interactive) v2v communication for use in schools and museums will be examined, *respectively*. In particular, one of the two essential scenarios is the *"Museum Exhibit"* which proposes the establishment a cultural-oriented scenario and it is designed to allow the visitors at two defined locations to interact with one another in a "joint experience"; the related "locations" are the city of Athens (with the participation-involvement of *OTE's Telecommunications Museum*) and the city of Luxembourg (with the participation/involvement of the *Post & Telecoms (P&T) Museum*). LiveCity also aims to "promote" awareness of each city to visitors at both locations. The final design will use live interactive v2v as the "basis" for the interaction along with a multi-touch table and perhaps an external display, operated at both museums. Via this modern kind of application, "games" that are to be deployed will allow people playing together in real time, solving a number of puzzles and clues about related topics as well as promoting a variety of educational aspects for various potential categories of users - museum visitors (i.e.: pupils, students, teachers, educators and the public). Focusing upon an interactive v2v communication directly to the public via the LiveCity Project, can be a decisive option for the promotion of *OTE's Telecommunications Museum* collections to the Hellenic and/or the European public and for the proper and wider dissemination of its programs and/or other related (educational, informative, etc.) initiatives, towards supporting the effort for a more efficient digital cultural and scientific inclusion of local and virtual citizens; this is particularly important for LiveCity as this museum also intends to apply the corresponding facilities to educationally-oriented activities in cooperation with two schools of the Municipality of Vrilissia in Athens, also participating to the Live-City scope. Moreover, similar beneficiary options stand for the *P&T Museum* in the city of Luxembourg. The proposed activities and the related methodologies will also make all involved people learning more effectively and will support the acquisition of new skills, via the usage of v2v facilities, on a "pure" multimedia-based environment. This will help the effort for ensuring the effective use and exploitation of cultural resources by developing technologies and for making them widely available, usable and re-usable regardless of their form, location, time-sphere, etc. In the scope of LiveCity-based activities, it should be expected that either visitors of the involved

museums or other potential users of the proposed innovative solutions may be able to have benefits, directly from the museum content delivery. This will also help to "disperse" cultural and scientific-technological knowledge in a broader multi-media-based environment and will "trigger" or "challenge" new options for enhancing quality of experience (QoE) for the end-users.

2   Background

Modern Internet-based facilities have radically modified the way people can communicate, amuse or even make business (in a variety of sectors [4]) and this has become obvious in a variety of v2v platforms supporting such aspects. Digital distribution of cultural and creative content can enable content providers to reach new and larger audiences while this also permits users to enjoy new experiences. According to the actual EU policy [5], Europe needs to "push ahead" with the creation, production and distribution (on all platforms) of digital content. Yet to date there is little bringing together of museums, cultural venues or twinned cities by using recent technologies. Within the scope of the LiveCity Project we have promoted the realization of a way of interactive v2v communication between citizens being at "twinned museum" sites, intending to support exchange of information and of experiences; museums can reside in different cities as well as in different European countries. This innovative manner of communication also focuses upon specific cultural and educational aspects with the aim of further enhancing interactivity between all potentially involved users. The challenge becomes greater as, apart from museums, other organizations such as schools, educational institutes or municipal authorities can also "join" the effort at later stages. In order to allow for the exhibit to be used after LiveCity has ended at other locations, a content management system (CMS) is being developed which will allow other venues or cities to "add" their own content to the standard deployed games. We have chosen to "base" the game on the underlying definition of "mixed" reality ([6], [7]) which states that a *"mixed reality is one where multiple devices allow views and interactions within a given context"*. This is in contrast to the mixed reality continuum [8] which consists of two opposing "poles", real environments and virtual environments with augmented reality and augmented virtuality exisiting in between. Drawing on the first definition, a "game" could consist of mobile devices, fixed screens and tablet computers. Based on this approach we have developed a platform which embraces displays, multi-touch tables and allows the addition of tablet devices. Given the emphasis on supporting collaboration between two remote locations the game is known as ***"Twin Cities".***

The inspiration for our work comes from two previous EC-funded projects, that is: *IPerG*[1] which developed the "epidemic menace game" and *IPCity*[2] which developed

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[1] *IPerG* (*Integrated Project on Pervasive Gaming*) was an EU-funded project (FP6 - 004457) which started on 01.09.2004 and came to an end on 29.02.2008. Its aim has been the creation of entirely new game experiences, which are tightly interwoven with our everyday lives through the objects, devices and people that surround us and the places we inhabit. The approach has been through the exploration of several showcase games which come under the

the mixed reality tent to allow improved participation in the urban redesign process. In the *IPerG* case, a control room consisting of multiple screens was used where players there could control *-or provide-* advice to players outside using mobile devices. In our system, there are two connected "control" rooms where visitors at each museum can play together a set of common games. From the *IPCity* scope we embraced the idea of using an interactive table-top and video display of a remote location and scouting. In the *IPCity* example, people move objects around on the interactive table and simultaneously these moves are represented on the large screen.

3 Pervasive Gaming Examples in the LiveCity Context

Pervasive games focus on a game play that is embedded in our physical world. Elements of the physical world are inherent parts of the game. Their characteristics and states are sensed and can influence the course of the game. Moreover, pervasive games allow for a game that can be potentially accessed at any time and from any location. Many of these games rely on mobile and pervasive computing technology, such as cellular phones and location sensors and focus on location-based aspects. The *"Twin Cities"* game is semi-pervasive in the sense that it extends two of three facets of pervasive gaming ([9], [10]), namely social and temporal expansion. For example, unlike traditional computer of board games, the *"Twin Cities"* lets anyone take part, thus making it a socially expanded game. Indeed, the only restriction on who can play relates to how many people can physically stand round the table, coupled with any legal considerations (e.g., legal age of consent to use such systems). Additionally, the public location of the game means that others can see and even partially participate in the experience. Due to the "shared nature" of the experience (which is to be outlined in the following parts) this lets people assume many roles [11], including: (i) *Player*: someone who influences the game, e.g. someone who directly takes part by using the table; (ii) *Spectator*: someone who is aware of the game and can influence it, (e.g. standing around but not directly playing the game); (iii) *Bystander*: Someone who is unaware of ongoing game, and has no ability to participate. (These could be other museum visitors who walk around the area but do not pay attention to the game).

  In addition to the spatial expansion, *"Twin Cities"* also explores the use of temporal expansion in the context that while individual games can be played, they may take as long as the players wish or indeed be merged into a set of games in which the players collaborate or compete over a period of time - *which again is undefined*. At the time of writing the present paper, we are exploring how to let players save their scores and retain them for future use. This would allow them to return to the venues many times

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description of "pervasive games" - *a radically new game form that extends gaming experiences out into the physical world*. [*http://iperg.sics.se/index.php.*].

[2] *IPCity* (FP-2004-IST-4-27571) was an IP EU-funded Sixth Framework program on *Interaction and Presence in Urban Environments*. Its research aim was to investigate analytical and technological approaches to presence in real life settings. Analytically, this includes extending the approaches to presence accounting for the participative and social constitution of presence, the multiplicity and distribution of events in time and space. More information can be found at: *http://www.ipcity.eu/*.

and play against other potential users. We intend to explore the concept of "gamification" [12] where elements such as leader-boards or badges can be used to confer status on people and to encourage them to "remain" within the game. *"**Presence"** is a critical component of the experience within the "Twin Cities" context, intending to allow people from different cultures to get together via a "game-like" environment. In our scope we can consider two main forms of presence [13]:

- *Social presence:* The feeling of being with another person.
- *Physical presence:* The feeling of being at another place.

The *"Twin Cities"* framework targets the concept of social presence where the video feed is designed to make people feel like they are together [14]. In particular, the emphasis is on improving communication through the use of tangible user interfaces such as the multi-touch table. Prior work in the *IPCity* context has identified that a shared table approach can be used to foster communication between different people and this encourages negotiation & discussion about relevant topics. Our approach extends this perspective to video communication and to remote locations.

3.1   Game Design

This section provides an overview of the selected game designs. Since both involved "parties" are *Telecommunications/Post Museums* (in Athens and Luxembourg) it would be desirable [15] to combine the following key factors: (i) Take advantage of live v2v infrastructure, *where it is possible*, to enhance the experience of the games within the participating museums; (ii) consider and promote awareness of the other museum's exhibits-collections, and; (iii) provide general information about telecommunications and/or related technical facilities. In order to perform an effective design and thus to ensure wider applicability-adoptability of the games, the latter have been designed in a way to be "*as simple as possible*" regarding their perceptive concept without necessitating any specific technical -or other- prior knowledge by the intended users-visitors of the museums. The related concept, per game, has been selected so that to be explicitly relevant to a collection of exhibits and/or to an event-activity promoted by the museum(s). Furthermore, a critical priority of the full game design process was to improve cultural and educational interactivity between users residing in different locations (i.e., cities or countries), in parallel with the inclusion of multi-player setting so that to have, occasionally, many participating users.

Designing the games ([16], [17]) should also take under consideration the factors discussed as follows: 1) For both involved museums we have considered the next classification regarding visitors: *a)* School groups (i.e.: ages 5-15) cover 90% of visitors (*school groups usually consist of teams of 20-35 students*); *b)* Individual children (i.e.: ages 5-10) cover 5%, and; *c)* Adults (i.e.: ages 35-45) cover the remaining 5% of the visitors' population. 2) Some of the games should mainly address adults in order to "attract" this age group; in this context: *a)* There should be a co-operation mode between the visitors of the two museums; *b)* A game should be playable in both groups and by individuals; *c)* A game should encourage movement and discovery of the related museum's collections. Among the priorities that have influenced the game design process was the inclusion of "multi-player" involvement, although this also depends on other factors like the frequency of visits, any specific events that can

attract more people in certain time-slots, etc. In order to overcome this restriction, it would be ideal if the game(s) could be considered as "operational" even in case of the absence of (remote) players ([18], [19]). This simply implicates that it should be possible, for a museum's visitor to "access" a game being at a certain level of progress or to access a new one. The LiveCity platform supports a v2v-based game concept to fulfill this feature, together with the one of the "distant presence". In addition, appropriate equipment (such as cameras) is to be set-up in the participating museums to extend the proximity area of the multi-touch tables that are to be used for the games. The following sections discuss the selected game designs.

3.1.1 Game Conceptualization

As noted earlier, our work is predominantly focused on providing a degree of social presence between game players, our objective being to use multi-touch interaction and a live video feed between the two locations. Our initial game designs focus on supporting social presence from three main game design perspectives where video is used in different ways to encourage play, discussion and cross-cultural awareness. These are outlined in Table 1 below, with the top level "using video for awareness and communication" being the most basic through "Video as the Game", where the objective is to make the video component the goal. A brief description based on each game is provided in the following section; a more thorough description and additional rationale for the concepts used in some of the games can be found in [19].

Table 1. Use of live video-to-video feeds in games

Level	Example Games
Using video for awareness and communication	Mosaic, memory and putting things in the right order and quiz and build it together
Interacting with video	Embedded video in mosaics or memory games
Video as the game	TV show with live video mixed with CMS content – create a live broadcast

Using Video for Awareness and Communication

These games use video to encourage discussion *about* the content on each multi-touch table. Rather than the video being the driving factor in the game, video is used passively where players at each location can see and hear the players at the other location while they take part either in local game (one museum only) or multi-player game (two museums playing together). This style of game play was conceived as a way to break down the usual "cultural divide" between twinned locations such as towns or museums where the actual inhabitants or visitors often never meet one another and instead it is on the officials or designated people who get a chance to meet. The approach is also designed to be relatively free form in the sense that while the games should encourage discussion about the content at both museums the visitors are in fact totally free to talk about whatever they wish as there are no content, time or participant restrictions. To a limited extent this allows for a semi-pervasive experience as

both players and spectators can take part. Indeed, as the games are ongoing, spectators are free to interact as they wish, perhaps just waving to people or even talking to people at the remote locations. This, in turn, may shape players' behavior.

Fig.1. Mosaic/Jigsaw game example

For this game type content from each museum is placed in a jigsaw or mosaic which is then put into the wrong order (see Fig.1). Players of the games are then asked to put re-assemble the contents to create the correct image. A more complex version of mosaic based on the "Interacting with Video" level is outlined later.

While mosaic/jigsaw mainly concentrate on visual content play, i.e. they are about reassembling an image the "putting things in the right order" concept operates on both this and the conceptual level. Alternatively, content can be placed in the right order based on conceptual details. For example, at the conceptual level in a telecoms museum, people could be asked to construct a telecoms network across Europe by connecting the correct components such as cables, switches and tele-houses in the right order. Alternative approaches to this include placing things in historical order (see Fig.2).
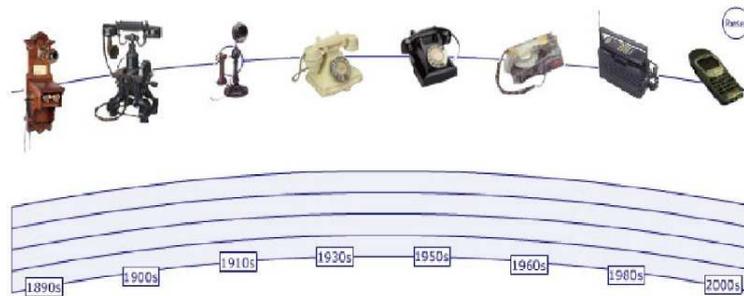

Fig.2. Put-in-order game with telephone devices

The classic memory game is familiar to many people and is often played with a deck of cards where people turn over two cards and if they match they keep them facing up. The game is played until all cards have been matched in pairs. This approach is used within our system but with tiles, each tile consisting of a piece of relevant content for example telephones or stamps (see Fig.3). The memory game can be played either on a visual basis or again on a conceptual one, where people are asked to memorize related concepts when turning over cards.

Quizzes are another popular format and are again applied with LiveCity, in the example (see Fig.4) (know as "Whose phone is it?") players are asked to match the phone with the right person. In this case, multi-touch is used to drag the images around. While players may be able to guess some of the answers for this, other quizzes' players may also need to spend time finding out about contents in the museum. Additionally, this approach encourages the exchange of information between the two museums as players could be quizzed on content in the other museum. This would necessitate that players find out and discuss content together.

**Fig.3.** Memory game example: stamps **Fig.4.** The quiz game concept
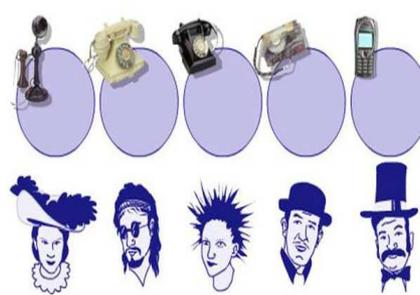
The building together game starts by showing the players an image of an object (e.g.: a museum exhibit, art piece, building, or something else), which is then split into several parts which, *in turn*, are randomly rotated, resized and mixed. The objective is to "build" the original object from its parts. On the first floor of the *OTE's Museum* in Athens there is a wall-to-wall poster of Alexander Graham Bell, which consists of dozens of the Museum's exhibits and could be easily used for the purposes of this specific game (*as shown in* Fig.5). Multi-touch interaction enables an arbitrary number of players to collaborate in the game. Collaboration with the remote players will be facilitated by the live v2v link between game sites. Multi-touch interaction enables an arbitrary number of players to collaborate in the game. Collaboration with the remote players will be facilitated by the live v2v link between game sites.
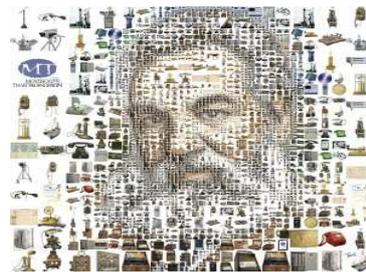
Fig.5. The *Alexander Graham Bell* "build together" game concept

The previous games use the multi-touch table and video feed from a static location in the museum which could result in people being drawn away from the museum

content. This problem is not unique to our proposed games and has also been noted in [20] where authors suggest that care should be taken to integrate "more closely" real world elements with game content. Therefore, in order to encourage greater exploration of the museum itself, they could be combined with mobile devices so that people must search for information within the museum and take a video or picture in order to complete the game.

Interacting with Video

The majority of the games described in the previous section can also use live video as content. Under this scenario the live video feed becomes embedded to form all -or part- of that particular game. This approach means that players have to physically collaborate on both sides by, *for example*, remaining still in order for players at the other location so that they can correctly reassemble the mosaic. However, as video is relatively uncontrollable they may adopt other strategies such as using particular movements in order to play a game. These types of games have the potential to increase the level of embodied interaction among players which we hope will, in turn, raise their sense of involvement, engagement and social presence.

In the mosaic game, players at each location could see a live video feed of people from the other location; the video feed is then broken up incorrectly across the mosaic tiles. Under this scenario the players would be confronted with the choice of remaining still at each location -or if they are particularly competitive- perhaps moving around in order to confuse the people at the other location. Such an approach would allow for the exploration of collaborative versus co-operative forms of embodied interaction within such games. Related to this gaming concept is the memory game with a live video feed; under this scenario one of more of the tiles could contain live video from each location which players then have to match. In this setting one tile could represent one feed, or a feed could be spread across many tiles.

Video as the Game

This concept *uses the video feed* as the *objective* of the game. The objective of the TV broadcast game is to create an engaging gamified museum browsing experience which encourages visitors to browse more attentively, discover important, interesting or unusual exhibits selected by the exhibition curators, learn about them and share that knowledge via the live video stream with visitors at the other museum. This approach utilizes the v2v platform, multi-touch table and mobile devices. The game functions in the following way: The visitors of the connected museums can browse through the images of the other museums' exhibits by using multi-touch tables. If the visitors of the Museum A (Team A) want to learn more about a particular exhibit they click a "Show it" button. The multi-touch table at the Museum B displays a message that someone from the Museum A wants to see the particular object. The objective of the Museum B visitors (Team B) is to locate and present the object via live video stream by using provided mobile devices with the game application. Once the challenge is accepted the game starts. First, Team B has to locate the object and take the picture of it by using the mobile application. The picture is instantly displayed in the Museum A and its team confirms that the correct exhibit is photographed. Then Team B has up to 5 minutes to learn as much as possible about the object and prepare to present it. Meanwhile, Team A is shown a presentational video or audio guide based

presentation about the same object, they can read additional information and see more images of the particular object. When Team B is ready (or when 5 minute time limit is reached), they start the "broadcast" and have up to 2 minutes to present the object through live video. The provided mobile camera-enabled devices -such as tablets- are used to capture the video, by using the game application. When 2 minutes run out the video is stopped, or can be done manually, if the team mentioned everything they wanted. While the presentation is running, people in Museum A see a live video stream and the list of facts about the object on the multi-touch table. If the broadcasting team mentions a certain fact or feature, the viewers have to tap on the button to confirm that the fact was mentioned correctly. Once the broadcast is over, the teams can swap and the presenter can request to present the object from the other museum too. The points are calculated for the least amount of time taken to locate the exhibit, and prepare for the presentation. Facts about the exhibit can have different point weight depending on their complexity (e.g. a player scores 1 point for mentioning that the object is a "light bulb and 5 points for mentioning "Thomas Edison"). Every participating museum can create or accept the challenges and the roles can be switched instantly once the running activity is finished.

Content Management

In order to let other twinned locations create similar experiences, a content management system has been developed which lets other venues use their content within the game templates.

4 Conclusion

In this paper we have presented a number of games which use video in different ways to promote cross-cultural awareness at twinned locations. Our work was based on the view that video-to-video is largely underutilized within the domain of game playing yet when combined with multi-touch and related forms of intuitive interaction it has a great potential to provide rich experiences. We have expanded upon this by providing three different levels of game which use video-to-video communication in different ways. This classification should provide a useful basis upon which future work can be based. Furthermore, the designs and classifications indicate that at a generic level video to video interaction offers a potential to improve interaction between people and in particular within the proposed cultural contexts.

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