Travel in Europe: An Online Environment to Promote Cultural Heritage

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Abstract— The paper discusses the Travel in Europe (TiE) online environment, an innovative means to promote and divulgate heritage to European people. Users of TiE live challenging and compelling game experiences by interacting with virtual representations of European heritage. TiE exploits the concept of travel, which is both engaging by itself and also supports geographic contextualization. A player of TiE moves in several 3D reconstructions of European cities as in a commercial videogame, but we have studied further mechanisms that could be inserted in the 3D environment so to make it more appropriate to deliver educational contents: an algorithm to produce high quality models of cities and regions, the exploitation of 2D games in the 3D virtual world and the interaction in natural language with conversational virtual humans.

Index Terms— Serious games, virtual worlds ,

Manuscript received July 04, 2008. This work has been partially funded by the European Union, under the Culture 2000 Programme..

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1. INTRODUCTION

Games have always been an important aspect of human life, also having a meaningful impact on education. However, their design has to be careful, in order to support real knowledge acquisition. Several games have little, if any, educational value or may be misused. These concerns are strengthened in the case of the video-games, that provide meaningful additional features (e.g. possibility of using large databases and of exploiting interactivity, immersiveness and personalization [1]), but may also create dependency and promote/induce dangerous behaviors [2], [3]. State of the art computer games typically involve a 3D environment into which the user lives exciting experiences related to an adventure, a historical fact, a sport. Educational games exploit state of the art computing and networking technologies to provide an educational value inside an entertainment framework. However, it is not easy to combine real education and entertainment. This is testified by the fact that it is very rare to find successful commercial games that promote knowledge/skill acquisition in a particular field [4]. On the other hand, educational games tend to be perceived as boring, at least by the general public [5].

Trivial to say, entertainment is a key factor to success. Even the recent successful cognition-activity supporting games (e.g. Nintendo [6]) are perceived more as a challenge rather than an exercise. In this view, we intend to exploit paradigms and models of the state of art games and upgrade them in order to make them suited to deliver educational value. In other words, our idea is to enhance existing game concepts rather than designing educational exercises with a game aspect (e.g. score, penalties, lives). This requires finding appropriate mechanisms that are to be seamlessly embedded in the paradigms that appeal a wide audience. This is fundamental in particular if we do not aim at a specific category of users (e.g. learners that may be motivated to play

a game independent of its appeal) but we strive to promote a knowledge item (e.g. art history, biology, botanic, etc.) to the general public (e.g. in a life-long learning perspective, which is an important objective of current information society's policies). In this perspective, we are interested in exploiting 3d Virtual Reality (VR) environments, that are very popular, in particular among the youngsters. Necessary steps in the design of a VR educational game include the definition of the contents, plot and rules (e.g. concerning assignment of the score).

In this paper, we investigate in detail the Travel in Europe (TiE) online environment, where general users can live compelling experiences concerning the artistic heritage of European cities and regions. The environment supports performing adventures similar to state of the art videogames, but provides mechanisms and patterns of use that will support knowledge acquisition and effective fruition/understanding of the heritage. Having a full environment is a significant added-value, since it will not mean developing a single game, but an extensible platform on the top of which a number of different games may be built, each one of them being able to exploit the educational/cultural features, mechanisms and functions provided by the TiE environment. The main TiE features are: an algorithm to efficiently produce models of cities and regions, the exploitation of 2D games embedded in the 3D virtual world and the implementation of conversational virtual humans to interact with the player in a natural way. As a meaningful example of the potentialities of the TiE environment, we have built a sample game, a sort of a cultural treasure-hunting game to be performed among a number of virtual reconstructions of European cities.

2. RELATED WORKS

Research work argues that computer games are an engaging medium for learning since they can stimulate cognitive processes as reading explicit and implicit information, deductive and inductive reasoning, problem solving, and making inferences from information displayed across a number of screens [7]. These results have been achieved through a numbers of games that either have a direct educational value or provide knowledge/stimulate skills as a side-effect [4].

The idea of using networked Virtual Worlds (VWs) as educational medium started in nineties (e.g. ExploreNet Experiment [8]). Today, with the increasing availability of PCs and wide-band connections, VWs can reach potentially enormous communities of would-be learners. Some virtual learning worlds (e.g active worlds learning environment [9]) tend to mirror a classroom environment [10]. The social interaction enabled by VWs can contribute to improve engagement, participation and maintain learner's interest. Indeed, students perceive more satisfaction in a course if they are actively involved in it and they are allowed to develop relationship with other learners. In this perspective, an important opportunity is given by the current successful trend of Massively Multiplayer Online Game (MMOGs), that have developed, for entertainment purposes, powerful tools that may be exploited to provide knowledge to thousands of players [11].

A specific computer science research field - the Serious Gaming [4], [12] - has recently developed in order to exploit the potential of games in practical education. According to the constructivist approach [13], learning depends on the active engagement of the subject that learns, and on her/his ability to construct knowledge and understanding on the basis of her/his interaction with the environment.

Several advanced computing technologies have been used for games. They are substantially related to 3D visualization, and range, for instance, from object modeling to real-time computation, from Virtual Humans to artificial intelligence. Examining the brain's electrical activity, Kahana and others [2] have shown from a neuroscientific point of view that computer games engage spatial learning [14]. This is particularly true for 3D games, where the reconstructed environment allows a more complete and immersive experience of the space and context, at least in principle. The player can get more familiarity with the surrounding space, through exploration that may be spurred by a game by proposing to the player the accomplishment of challenging missions. Missions and tasks may spur the sense of site and critical reasoning, also through social interaction with other players.

However, there are still educational aspects that have to be further studied in order to better exploit the potential of computer technologies for the education. A significant issue concerns the risk that the player gets easily lost in the knowledge space of the simulated environment. This requires a meaningful, compelling plot and proper guidance (e.g. through spatial landmarks [15]), that can drive the player through a suited (e.g. not dispersive) knowledge path or, in a more constructive approach, can effectively support her/him

in her/his free exploration. But also other game mechanisms need to be defined and implemented in order to achieve effective and aware learning. The mechanisms should significantly enrich the environment (e.g. by supporting orientation, providing more detailed information, etc.), and should be well integrated in the game logic and aesthetic (they should not appear as "boring educational add-ons"). In the end, the environment has to be stimulating. Some such mechanisms have already been presented in the literature and in commercial games. These include the criteria for the evaluation of player enjoyment (the Flow Channel theory) [16] and the multimodal environment interaction [17].

3. TiE GAME MODULES

The TiE architecture is based on a standard game engine, with Massive Multiplayer Online Game (MMOG) facilities in order to support a wide and pleasant access [18], plus ad-hoc designed and developed cultural related game modules. These modules include: a methodology for efficient collection of architectonic urban contents and modeling of realistic 3D reconstruction, the support for conversational virtual humans, the education-relevant 2D game templates that can be embedded in the 3D reconstructions.

3.1. 3D MODELING OF CITIES

TiE involves reconstructing a number of culturally-relevant cities and villages throughout the whole Europe. A 3D reconstruction of a city or a region for education/cultural aims within an interactive environment is a process that requires a careful trade-off between the models' photorealism (in order to provide a highly impressive and culturally correct and meaningful experience) and the models' weight (in order to allow interactive real-time online exploration) and complexity.

The first term of the trade-off stresses the importance of having high detailed 3D reconstructions in order to realize a sound reconstruction of the heritage.

The second term highlights the performance problems that the TiE online environment has to overcome to provide users with a playable and enjoyable system. Moreover, complex systems are costly to implement both for the 3D modeling aspect and for the need to create proper textures (which requires taking pictures, rectifying and equalizing them, and composing in the final textures that can be managed by the final graphic engine).

In a highly interactive system, such as a 3D exploration/game, the details of the reconstructed environment are not fundamental to display, as the player moves rapidly there. However, in the case of a cultural heritage game, the player, playing the role of a sort of art detective, has also to carefully examine also the particulars, where relevant.

In order to meet the above stated requirements, we have designed the reconstruction of each covered place (e.g. a city or several areas inside a city).

The 3D model is completely geo-referenced. The ground is elevated from a vector map. So, the placement of the buildings and their borders are precise. This allows compatibility/portability to various Geographic Information Systems (GISs) and expansibility of the system (i.e. possibility of upgrading buildings with their actual textures.

In each covered area, a few Point-Of-Interests (POIs) are implemented. These are rigorous, high-detail reconstructions of a building. We use this approach for culturally meaningful buildings. For instance, the cathedral, the theater, a Renaissance palace, etc.

The textures for all the rest of the palaces are built dynamically by the TiE system using a statistical template-based algorithm [19]. Since several zones within a city are typically characterized by relatively homogeneous buildings (one or few more "styles"), the idea is to exploit a statistical description of the architectonic parameters and to build the buildings' virtual models accordingly, using a limited set of parametric building models and of textures that are instances of architectonic features representative of that area.

In this way, on the one hand the effort to cover extended urban areas is reasonably manageable (in any case, the content creator has the choice of defining the number of buildings' models, textures and parameters for the reconstruction), on the other hand, the reconstructed environment allows users to live experiences somehow similar to a real visit of a city, where a visitor typically perceives the feeling of being in a precise place but usually does not perceive/remember the particulars of each distinct building. We refer to this approach as based on an architectonic-style likelihood principle.

Moreover, the buildings that are particularly meaningful from a cultural point of view are reconstructed with high detail and with their own specific real textures (i.e. not statistically defined). These buildings may be the subject of a more attentive analysis by the player, as suggested by the game plot and rules.

3.2. CONVERSATIONAL VIRTUAL HUMANS

Conversational Virtual Humans (CVHs) are computer-controlled characters equipped with natural language dialogue capabilities which can be used to better engage the player in her/his activity. Their aim is to provide contents to introduce "backstories", assigning tasks and rewarding user performance, and, more in general, offering information to the learner. There are many different approaches to CVHs design. Several systems (e.g. Eliza [20], Parry [21] and Alice that has also its own development language called AIML [22]) are based on a pattern-matching algorithm and sentence reconstruction based on templates, with no processing of the natural language. The cost of scaling up the pattern matching approach is high, as it requires an extensive writing of rules by a human author. Other systems use statistical techniques based on semantic specification [23] or automated latent semantic analysis [24]. Latent semantic analysis [25] builds relationships between a set of documents and the terms they contain. Recent research works are focused on the definition of the character personality [26], the realization of emotional responses [27], and the understanding of the human behaviour during the interaction [28].

The 3D reconstruction of a city can be populated with CVHs to exploit the cultural heritage knowledge. The player has the possibility of asking CVHs - through natural speech queries - about knowledge stored in the system. CAs will be able to accompany users through the resources available in the environments (e.g. palaces, churches, historical places, etc.). CVHs implement Question-answering capabilities to adaptively present the knowledge available. CVHs are also able to provide non-linear interactive storytelling features, structuring the conversation in coherent, meaningful and appealing narrations. Moreover, some of them play specific roles in specific events (e.g. a TiE city can have a CVH that interprets a museum curator and his knowledge is based on the corpus of information about the masterpieces conserved in the museum). Question-answering capabilities are supported by semi-automatic knowledge extraction techniques (based on Latent Semantic Analysis) that allow CVHs to gather knowledge from the content stored in standard way (e.g cultural databases). CVHs are designed taking into account that the player should perceive them as credible in their role, in order to enhance and reinforce the player's "sense of place" [29]. For example, their conversational style has to conform to their role (e.g. a museum curator cannot speak as a greengrocer). The CVHs can also behave in a proactive way by suggesting or making advices that user can accept or refuse. For example, if the TiE environment notices that the player was lost in the virtual space a CVH approaches the player to provide him/her some information on the virtual world map.

3.3. MICROGAMES

MicroGames (MGs) are simple, short games that focus the player's attention on a particular item that she/he finds during her/his exploration of the 3D world. MGs are typically taken from well known game models, such as Puzzle, MemoryGame, FindTheWrongDetails. The idea, in fact, is that they should be immediate to play, so that the player can focus on the contents rather than on learning how to play.

We have defined a library of MG Templates. Every MG is an instance of one of such templates. We broadly divide game templates in three categories, according to the cognitive skills they mostly involve (see Table 1).

MGs categories	Descriptions
Observation games	These games privilege the sight as a sense to investigate and explore the local environment. In general, these games tend to exploit the "knowledge in the world" in order to develop the cognition activity. They aim to stimulate spatial processing skills.
Reflection games	These games tend to favor reflection, discussion among team members, analysis of questions and possible answers considering clues available in the neighborhood and concepts learned previously during the game.
Arcade games	These games stimulate similar skills as observation games. Their specificity lies in the animated graphics and engaging interaction, which helps to create a convincing and pleasant experience.

Table 1. MicroGames categories

4. A SAMPLE TIE GAME : A TREASURE HUNT IN EUROPE

The first realization from the TiE environment is a cultural treasure hunt across the Europe. Figure 1 shows a snapshot from the Genoa historical city centre reconstruction. It is "Strada Nuova" zone, an area that contains outstanding palaces from the Renaissance and Baroque age.

Figure 1. A snapshot from the TiE 3D reconstruction of Strada Nuova in Genoa city center

The player has to visit a fixed number of cities. In each town the player has a mission to accomplish. The mission is time-limited. Every mission is characterized by a number of questions. These are questions the player should think of while exploring the city. We call them visit-driving questions. They are general. The player will have to visit places, ask CVHs and others players, with those items in mind. The final city trial will concern specific challenges related to these general questions. In some cases, instead of questions we may have hints, like: pay attention to the frescoes, look at the facades' colours, etc. Moreover, the player has to reach some point of interest in the city in order to collect objects, whose list is specified in the mission chart.

During the visit the player freely chooses where to go. Orientation in the city and finding the right path are major challenges (the city as a labyrinth). Strategy has to be employed by the player in order to plan the path to all the destinations to reach.

When the player reaches a point of interest, according to the mission plan, the player will have to face a MG. Figure 2 shows a puzzle MG about the façade of Palazzo Ducale played in front of the virtual reconstruction of the building.

Accomplishment of a mission is decided at the end of the city exploration. There is a final trial with a sort of millionaire game on that city with quizzes there are related with the initial visit-driving questions. The games involve responding to questions but also some activity games (e.g. memory game, cultural tetris, also collaborative, etc.). Accomplishment of a mission appoints the player with a city-prize (e.g. a picture, a symbol), that can be conserved in the player's repository.

Figure 2. A snapshot of a MG (Puzzle) about Palazzo Ducale in Genoa. The MG is played in front of the virtual representation of the building.

In this work-in-progress environment we have made preliminary tests with high-school students and experts of art/history and education. The idea is to get some hints about usability and usefulness of the implemented environment in order to inform the further design, that is involving the implementation of the virtual environments representing 15 cities/rural areas other European countries.

Based on this analysis, we propose some indications that we tie to our experience. Of course, the analysis is early and has no statistical value, but we consider it as a useful element for a more aware discussion. We outline the indication in the following:

- the variety of cities/regions to model require a flexible algorithm of semi-automatic reconstruction because it is often needed to add some specific architectural elements or style;
- typologies of MGs should be few (15/20), so that the player can learn easily and play quickly. But variety of instances is important to keep the player motivated and attentive;
- in the 3D implementation of the CVHs interface it is important to consider the character personality, the realization of emotional responses, and the understanding of the human behavior.

5. CONCLUSIONS AND FUTURE WORKS

3D environments are very popular among gamers and ever more used for simulation and serious games. The educational value of setting an adventure/simulation in a virtual reality world is significant, in particular when training workforce in performing dangerous/special tasks (e.g. military simulations). However, when it comes to exploration of a world to learn from it, as it happens in several real-life experiences, there is the risk that a lot of "knowledge in the world" is wasted because of a lack of appropriate guidance and the difficulty of providing more in-depth information about some items without interrupting the flow of the game.

In TiE, we are developing an efficient algorithm to model virtual environments aimed at promoting artistic heritage that can been enhanced with embedded MGs and CVHs. MGs and CVHs allow the player to virtually interact with pieces of the heritage in their context and to discover/investigate some details related to that area. In this way, playing a MGs or conversing with a CVH can be thought of as sort of 1-level links in the "hypertext" represented by the 3D environment where the player lives her/his cultural adventure.

Extended user tests are necessary – and already planned – in order to achieve an appropriate assessment of the proposed approach. However, preliminary informal tests have suggested that the approach is valid.

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