Game-Based 3D Simulation of Life in the Middle Ages for the Edutainment in Cultural Heritage

The reconstruction of medieval Otranto

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Abstract—**Virtual Reality applications on Cultural Heritage are increasing, according to a general trend towards virtual reproduction and interaction mediated by the computer system. The effects of this trend, both on education and research, are still far from being completely tested and defined. The aim of the MediaEvo Project is to develop a multi-channel and multi-sensory platform for the edutainment in Cultural Heritage, towards integration of human sciences and new data processing technologies, for the realization of a digital didactic game oriented to the knowledge of medieval history and society. The developing of the project has enhanced interactions among historical, pedagogical and ICT researches, morphological inquiries, data management systems, by means of the definition of a virtual immersive platform for playing and educating. The platform is also intended to collect feedback and validate hypothesis and findings coming from researchers. This essay introduces the questions related to the educative use of ICT and describes the steps of the reconstruction of the town of Otranto in the Middle Ages: data collection and integration, organization of work and software applications.**

Keywords- Simulation; Edutainment; Virtual Cultural Heritage; Urban History

I. INTRODUCTION

There is a worldwide interest in for Virtual Reality (VR) technology in Cultural Heritage in order to recreate historical sites and events for such purposes as education, special project commissions and showcase features at visitor centers.

The power of VR lies in its ability to open up places and to see things not normally accessible to people. VR also allows users to explore objects and to experience events that could not normally be explored without alterations of scale or time. The user can actively participate in creating new knowledge by doing and interacting with other users and objects in the virtual environment.

The use of VR has defined new fields inside traditional research contexts. Today we consider virtual archaeology, virtual architecture or urbanism and so on as defined disciplines specialized in enhanced virtual representation or reconstruction as a distinctive methodology of approach.

One of the best uses of virtual models is creating an environment to help students to learn about ancient cultures and to interact in a new way, using many possibilities for collaboration, in a shared social space.

Recreating or simulating ancient cultures, virtual heritage applications create a bridge between historic characters and contemporary users.

There are many experiences of historical environment reconstruction, the most successful are available on the web or have been presented in international conferences. Some of them relate to the elaboration of models or algorithms for better representing and reconstructing important sites, others explore Augmented Reality applications for Cultural Heritage, others test ontological systems for data managing and sharing**.**

It is a widely held point of view that cultural heritage is diminishing continuously. While new treasures emerge from places previously unexplored or ignored, a larger number of buildings and sites are compromised by natural or human action. This process leads to the demise of important historical documents and artistic goods.

The improvement of technological capabilities enriches the possibilities for research and protection and enhances the value of cultural heritage, thus halting their demise.

Firstly, the increased speed of communication, data exchange and data processing offers to the research community the dimension of real-time interconnectivity.

Secondly, the overall amount of information originating from both qualitative and quantitative exploration with the support of technologically advanced equipments, compared with that of a few decades ago, leads to the possibility of an extremely detailed description of reality.

The systems for cataloguing and managing these data have been structured with complex and ontological categories (the term *ontology* refers to a "specification of a representational vocabulary for a shared domain of discourse - definitions of classes, relations, functions, and

other object" [1]) that define common protocols for enhancing classification and comparison, even among distant users.

Finally, the elements that constitute the overall sign of the times are the possibilities presented by the means for a realistic representation of everything that comes from research, from the hyper sensorial reproduction of reality to the reconstruction of different hypotheses and scenarios.

The expansion of these means necessitates a contextual disciplinary revision of interest to all those in the field of humanistic studies. Historians cannot afford to buck the trend to a post-literary dimension of knowledge transmission or knowledge itself [2].

The new phase of contemporary civilization has been defined post-modern or, more correctly, post-historic [3], for the predominance of representation and hard virtualization of reality.

Evolution in research methodology corresponds to a general debate on communication and education closely linked to the characteristics of a changing perception of teaching, oscillating between experimental impulses and conservative attitudes [4], [5], [6].

The approach to the historical city, in terms of research and understanding both academic and popular, has been enriched by new tools and thanks to the development and proliferation of advanced technologies. The speed with which the use of computers and electronic devices has grown by a very wide range of users demands constant progress in the ways in which information is gathered, managed and transmitted.

On one hand the virtualization of space has reached such levels of mimesis as to influence the perceptual field and the capacity for evaluation of the experience. On the other hand, this factor, which is destabilizing for the whole field of investigation and understanding of reality – already predicted nearly half a century ago by various authors –, has completely changed the praxis and market for entertainment. Thus positively influencing the rate of contextual assimilation of the information but also negatively affecting concentration spans for its reception.

The new post-historical and communicative research frontier that interprets these processes focuses on the possibility of increasing a multidisciplinary approach and interchange, reacting in an active way to the promotion of cultural heritage and safeguarding against the degenerative processes that undermine it.

Communication and transfer of data nowadays occurs in real time, making an infinite amount of information available originating from quantitative and qualitative investigation. New systems for cataloguing and managing this data are organised according to structures of reference which are of a formal-ontological nature and ever more complex for which common protocols evolve facilitating the identification and comparison even of realities which are quite distinct from each other.

Finally, the already immense possibilities for realistic representation of all that emerges from research are growing, from the information that is detected with extreme precision to the different reconstructive hypotheses.

On this basis, the MediaEvo Project is aimed at creating a multichannel and multisensory edutainment platform for Cultural Heritage, through the integration of the human sciences and Information and Communication Technologies (ICT).

The activities include the creation of an educational video game aimed at spreading knowledge of medieval society in the area of Salento through the reconstruction of the city of Otranto in the XIII century.

II. RECONSTRUCTING HISTORICAL CONTEXTS

The virtual reconstruction of a historical landscape can be divided in five levels [7].

1) The first level, *Archaeological Landscape*, regards all the information coming from physical measurement (we choose to call it, properly, *Realscape*).

2) The second level is the *Interpreted Landscape* or *Mapscape* that is defined by the systematic organization of data.

3) The third one is the hypothesis of a possible landscape in the past, *Ancient Potential Landscape* or *Pastscape*.

4) The fourth level involves the experience of historical context through a process of immersion which defines contemporary perceptions. With the aid of the social sciences this leads to the definition of Perceived Landscape or Mindscape.

5) The final level is the Webscape, the grid of outer relations and communication that is useful to test the process and collect the necessary feedback.

In the academic world, the "historic vision" is usually limited to professors, scholars and researchers, who share the interpretation codes for extracting the ancient landscape from the actual one. In this new stream of experimentation, geared towards interaction and edutainment, the researcher finally becomes part of a system through which to study and interpret space.

In a virtual interactive town, the possibilities of information exchange increase dramatically from the static reconstruction to the simulation. The simulation allows the construction of a platform that adds the definition of game rules and plots to interaction and immersion. This allows players to easily experience and recognize topographical and temporal coordinates of virtual space. In this way the past is actualized with real behaviors, producing at the same time, the vision of pastscape and mindscape in the virtual reality built on realscape and related to the mapscape.

Studying a town and its historic landscape involves different methods of analysis, interpretation and communication using digital technologies. Geographical Information System (GIS), remote sensing, laser scanning, photogrammetry, computer vision, 3D modeling, Virtual Reality (VR) and Augmented Reality (AR) are instruments

of a multidisciplinary system that links historical knowledge, structural recognition, geotopography, geology, sociology, urban and architectonic analysis, engineering and graphic skills.

The ancient town, as an information unit, can be defined as a *meme* [8], a cultural unit code that locates and describes the process of territorialization of human society. It is the space-time relation between man and environment at a certain time [9].

III. RELATED WORK

The methodological and disciplinary peculiarities concerning VR have opened up new possibilities within disciplines that have led on, in the space of only a few years, to develop distinct characters of their own. Now days, we speak of virtual archaeology, virtual architecture, virtual town planning and so on, indicating that part of the discipline which is closely linked to material contexts and specialized in the reconstruction or verification of classical assumptions or of new hypotheses. The pure humanistic disciplines (history, philosophy, etc.) are still some way from this point. Their contribution, however, is fundamental in order to validate all the work in this environment.

Several VR applications in Cultural Heritage have been developed, but only very few of these with an edutainment aim.

Song et al. [10] present the historical and cultural content of the reconstructed 3D VE to the general public in a pedagogical and entertaining way; they incorporate interactive storytelling techniques into a Digital Heritage application. Because they believe interactive storytelling techniques can enrich the process of exploring the VE since each visitor can walk away with a different virtual experience.

Kiefer et al. [11] describe a subclass of location-based games, Geogames, which are characterized by a specific spatial-temporal structuring of the game events and assert that spatial-temporal structuring makes it easy to integrate educational content into the course of the game.

Cutrì et al. [12] study the use of mobile technologies equipped with global positioning systems as an information aid for archaeological visits. They conclude that the use of this kind of technology is an effective tool to promote the archeo-geographical value of the site.

Luyten et al. [13] present Archie, a mobile guide system that uses a social-constructionist approach to enhance the learning experience for museum visitors. They created a collaborative game for youngsters that is built on top of a generic mobile guide framework. The framework offers a set of services such as a rich interactive presentation, communication facilities among visitors and the possibility to personalize the interface according to the user group.

In the work of reconstructing historical or archaeological landscapes, extensive experimentation takes place on the net or has been presented during the course of international conferences. These primarily concern the elaboration of algorithmic models in order to better comprehend and reconstruct the sites, technological applications for AR applied to cultural heritage and ontological systems and data management.

An example of activity in the fields closest to the object of the present research is the work of the Institute for Architectural and Monumental Heritage [14] which has produced various reconstructions of the city of Metaponto (in the province of Matera) and of Muro Leccese (in the province of Lecce) and the monasteries of Santa Maria of Cerrate (province of Lecce) and Jure Vetere in the medieval age [15].

The reconstruction of the site of Faragola (province of Foggia) by the University of Foggia, undertaken as part of the Project Itinera [16]and known as *Time Machine*, fits within the trend of an experiential relationship within an archaeological context.

Other applications facilitate access to and reading of the cultural patrimony both within the museum and online: *Appia Antica Project* [17], *Virtual Rome Project* [18], *Muvi,* a virtual museum dealing with daily life in the XX century [19], and *Nu.M.E. Project*, a virtual museum concerned with the city of Bologna [20], are all to be considered prominent examples of experience relating to the latter.

On a strongly interactive level and related specifically to multichannel edutainment, examples of applications utilizing Virtual Collaborative Environments (CVEs) are found in the platform *City Cluster* [21] that permits the user to share in a virtual visit of various cities, *Quest Atlantis Project* [22] for teaching about archaeological contexts and *Integrated Technologies of Robotics and Virtual Environment in Archaeology Project* [23] that indicates a more professional use of VR interaction aimed not only at information dissemination but also scientific examination.

IV. THE MEDIAEVO PROJECT

The MediaEvo Project aims to develop a multi-channel and multi-sensorial platform in Cultural Heritage and to test new data processing technologies for the realization of a digital didactic game oriented to the knowledge of medieval history and society.

The game is intended as a means to experience a loyal representation of the possible scenarios (environments, characters and social roles) in the historic-geographical context of Otranto during Swabian Age (XIII century).

We chose Otranto as an example town; Otranto is located in the south of Italy. Due to its geographical position (in the extreme East of Italy), Otranto was like a bridge between East and West.

The implementation of the edutainment platform is strongly influenced by the definition of the scenery that is the world in which the framework is placed with the related learning objects and learning path, the characters, the scene's objects, the logic and so the rules of the game, the audio content, the texts and anything related to its use.

The framework will have features of strategy games, in which the decision-making capacities of a user have a big

impact on the result, which in our case is the achievement of a learning target. Nevertheless the strategy and tactics are in general opposed by unforeseeable factors (provided by the game) connected with the edutainment modules, in order to provide a higher level of participation, which is expressed in terms of the ease with which it is learnt. The idea is to provide a competition between the players, during the learning.

The system, on the basis of a well defined learning target and eventually based on knowledge of the user, will continuously propose a learning path (learning path composed of a sequence of learning objects), in order to allow the achievement of particular learning results.

V. MEDIEVAL OTRANTO AS A SCENERY

The city of Otranto was identified as a unique and eloquent historical setting for the project. Although the specific field of research was focused on the late middle ages, the project is set in a site which has been densely inhabited since before the VII century BCE and which conserves the signs of the previous cultural stratifications.

In figure 1 is shown a bird's eye perspective of the old town of Otranto [24].

The project leaves open the possibility for further work on other historical phases with the prospect of developing a complete ‘time machine’.

Through its art, spatial relationships and landscape, Otranto provides evidence of the close contact between Mediterranean cultures, particularly those of western Roman Catholicism, Byzantium and Islam. The year considered representative for the medieval reconstruction is 1227 - the year in which Emperor Frederick II of Swabia and his court entered the city for the first time to embark for the Sixth Crusade.

From the analysis of the monuments and documents, numerous useful points that facilitate the multicultural experience emerge to enrich the educative platform of immediate reference.

Otranto was officially a bilingual city. Together with Latin, Byzantine Greek was officially spoken by the archbishop during religious celebrations and both languages were taught at San Nicola of Casole - one of the great centers of cultural conservation and diffusion known as the *scriptoria*.

Being a maritime and mercantile city, the languages of the populace were many and varied. Throughout its history, Otranto has been settled by cultures that have influenced on the city on both an historical and artistic level [25], [26].

This cultural melting pot produced a particular mix of knowledge and traditions, still recognizable in some of the customs, handcrafts, and figurative art and in the articulation of space in Otranto. Interaction in a local context of this kind cannot but represent situations that resonate with the great themes of medieval civilization, in a sort of tiny virtual encyclopedia.

Figure 1. Bird's eye perspective of the old tonw of Otranto.

VI. THE STEPS OF RECONSTRUCTION

The ancient town of Otranto preserves relevant elements that witness Middle Ages culture but also the former and latter ones. This could increase the pedagogical purposes and place the project in a more complex, complete, "time machine" perspective.

In 1227, when the Emperor Frederick II of Swabia, entered the town with his wife and court, Otranto was a cultural melting pot. Even if there were two official languages, latin and byzantine greek, walking in the town it wasn't uncommon to hear people talking in hebrew, armenian, vareg, french, provencal, german, arabic, etc.

All those elements can be reflected in a big deal of situations that are useful for educational purposes. In other terms we could say that Otranto, as it is represented in the game, becomes a compact, interactive, little encyclopedia of Middle Ages civilization.

A. Data acquisition

The general information we first collect are actual Digital Terrain Models (DTM), thematic, technical, hydro-geological, nautical charts. On local side, surveys and metering operations produced maps of street organization, urban limits and fortifications, monuments and materials, referenced to absolute coordinates (*mapscape*).

Information coming from archaeology (published or available in archives) has been inserted in topographic charts, distinguishing the different historical period [27], [28].

The overall amount of data acquired and represented defines the actual state and conformation of the town (*realscape*) on which we are making a process of subtraction (reverse stratigraphy), in order to obtain the urban fabric on year 1227.

Unfortunately, during the last centuries, there has been a substantial loss of historical documents. The survived ones are not enough to describe efficiently the town in Middle Ages.

The first views of Otranto date to the end of XV century. They are more symbolic than realistic. Furthermore, historical maps and views have been collected and classified, together with relevant documents and plans.

B. Data interpretation

The numerous gaps regarding, above all, the urban structure and placement of notable building, monumental and functional contexts were filled in part by a historical-urban and architectonic analysis in order to establish the spatial hierarchy, the urban poles, the lot sizes and the typological distribution [29].

The material elements were compared with analogous situations relating to surrounding areas or cities and modulation grids on a typological-functional basis were used for the built environment, the objects, the clothes and activities.

The possible scenarios for the era in question were added to the base consisting of the above-mentioned data (*pastscape*). This is updated in real time, little by little as the extent and detail of the research and representation is extended and enriched.

C. The creation of the urban landscape

The first phase of the reconstruction involved the use of GIS in order to model the georeferenced DTM, on the basis of the reconstruction of the hypothesized altitude and sea level of the time. On this, the extra-urban roadways were identified, defining the hierarchy of pathways and their structural characteristics (stone, pressed earth, rock, etc) and relating them to the presumed location of the port.

Reasoning on the basis of vicinity and typology, the settlement maps for the various homogenous parts of the city were made, starting with the area around the Saint Peter's church.

The architectonic elements reconstructed were made using two modalities. The existing monumental buildings were modelled on the basis of a critical reconstructive survey which rendered them in their XIII century state, with what is supposed to have been lost at the hand of degrade, maintenance or restoration integrated into the reconstruction.

The curtain walls and the residential units of different types were based on an analysis of the city and the metrics of the time [30], they were reproduced, catalogued and entered into a database. For every one of these a set of variations was foreseen (form, composition of levels, openings, mouldings, surfaces, materials, etc) to distinguish them and promote a realistic perception of the game.

The historic scenario is however a static representation of a context. The final goal of interactive reconstruction is the definition of an immersive platform able to let players experience and feel the socio-cultural values of that period (mindscape). This is reached towards the creation of high representative interactive contexts:

- defensive (fortifications, castle);
- religious (the diocesan space: cathedral-tower bell-square and the churches);
- infrastructural (function and hierarchy of road axes, identification of the central distribution system and its links);
- commercial (buildings and structure devoted to exchange, commerce, distribution and collection of goods);
- intermodal (port, regional roads);
- sub-urban (expansion areas, non urban functions: monasteries, docks, fields, etc.);
- residential (neighborhood, social-economical-racial concentration and building types);
- artisan (arts and crafts);
- familiar.

D. Analysis and findings

1) The walls

The defensive context, which includes the city walls, the castle, the internal and external garrisons for surveillance and responding to attacks, is to be considered the first context of reference for reasons of both a cultural and spatial nature.

By definition in contemporary historiography: a city is an urban area surrounded by a ring of walls, inside which men of different families and occupations live without interruption [31].

Until the present day, the city has preserved its defensive structure that is the result of sudden, radical defensive reorganization after the Christian recapture of the city after their tragic expulsion by the Ottomans in 1480.

The age and the impact of this intervention don't allow us to effectively determine the original medieval image. A more circumstantial investigation is required. In relation to the historical documentation, the findings of archaeological campaigns and above all on the basis of the analysis of the urban fabric, some useful considerations relevant to the reconstruction can be expressed.

The historical centre of Otranto is located on a strip of land between two watercourses. The natural elevation rises to an altitude of approximately 35metres above average sea level (in the area of the current cemetery) and falls to an average of 14 metres in the ancient city, fronting onto the sea at 12 metres.

The coastline near the city centre is characterised by an inlet, which corresponds with the two outlets for the water channels and results in a double internal cove that the promontory of land constituting the residential centre overlooks.

Between these, the larger of the two water basins, the Idro, is a fundamental element for the entire settlement (he probably gave the name to the town, according to someone) for the fact that it guarantees a minimal, continual supply of water in a region which is characterized by an intrinsic lack of surface water.

In figure 2 is shown the definition of hydrographical, urban and defensive structures of the Otranto town.

The geomorphology and hydrology of the site identify a natural system that contains within it and influences the characteristics of the residential centre both on a functional level, in terms of the infrastructure and – above all for the ancient and medieval eras – on a strategic-defensive level.

The archaeological evidence reveals a substantial continuous settlement located on the shore of the sea, which dates to the Messapian era, made evident by the surviving fragments of city walls – often reinforced – brought to light in the course of archaeological excavations.

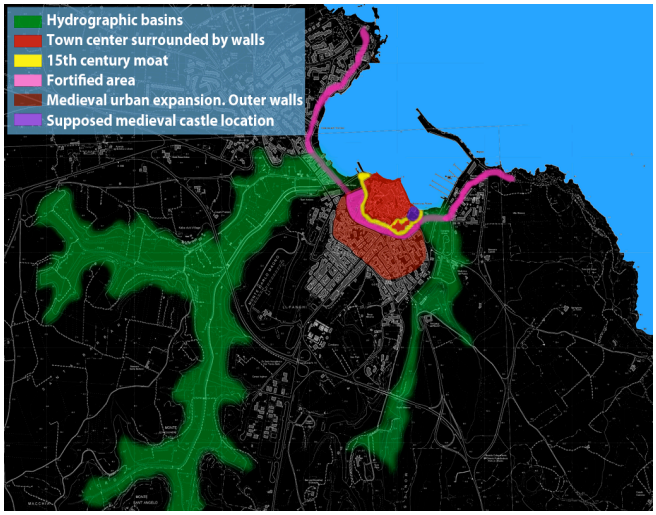

Figure 2. Definition of hydrographical, urban and defensive structures.

Without going into too much detail regarding preceding eras, for the late Middle Ages one can certainly talk of a city well defended by parallel rings of walls on the inland side and guarded by a system of towers and curtain walls on the sea, organized according to the framework usual in the poliorcetics of that time (*turres, cortinas et barbacanas* [32]).

Between the XI and XIII centuries the city did not undergo any traumatic events that influenced its form. This meant a structural continuity that substantially supported the demographic fluctuations and functional needs through constant adaptation [33]. We can suppose, then, from that period on, a certain saturation of the fabric within the inner circle.

Because of the strategic role of the port, extra-urban development occurred in such a way as to assure different levels of defence of the settlement, in order to avoid exposing large parts of the city and its resources to sacking by assailants and to impede direct attack upon the city centre.

The archaeological evidence which demonstrates the existence of an external wall built on the abutments of the ancient pre-Roman wall in medieval times supports the logic of "parallel rings" (according to a logic consistent with continuity and economic rationalism) which were built according to a byzantine model with round towers and curtain walls whose extension is still faintly visible today in the form of the development of the modern city.

Another wall or system of towers, of which there is evidence in a number of pictures, was located along the internal coast of the bay, in order to monitor for and repel eventual disembarkation by assailants; from the Swabian age, the defence of the territory was based on a rational and well developed system which involved direct or indirect communication between positions, towers and castles [34].

2) The castle

All this system had to have its fulcrum in the castle, the location of which during the Middle Ages is still uncertain. On the basis of descriptions of the access to the port from the sea made in the second half of the XIII century in *Lo Compasso de navegare e la Puglia* we know that the fort overlooked the sea [35].

The only descriptive reports that we have of the castrum in the first half of the 13th century refers to the necessity to leads us to imagine a fortification exposed to high tides, while at the same time, according to the *Compasso* intervene in order to repair two towers damaged by the sea (*due turres ex maris percussione continua minantur ruinam* [36]).

The present day form of the area between the port and the city, upon that we can hypothesize the medieval castle, was probably heavily modified by the excavation of the moat in the modern era. From reading the contour lines, from the signs of the quarry and the Bastion of Pelasgi, it's apparent that the original rock face was lowered by several metres, converting the original and naturally craggy slope, which was approximately 7-8 metres above sea level into the present day low lying plane which connects the 15th century moat with the sea [37], [38].

Further confirmation seems to come from the network of the urban roads (path matrix), which appears to be "oriented" towards what once must have been the 'sea gate' defence for the castle.

The constructed masses were then enclosed within a system of curtain walls interspersed with towers which opened onto the bay where the port was situated; a vital place for the economic life of the city. The castle, with its functional and symbolic value, was the fulcrum of this landscape composition.

3) The gates

Questions connected with the closure and defence of the urban space are tied to aspects that concern the connection of the city with the outside and with the structures of exchange.

We know from contemporary descriptions that the main gate of the city opened onto river Idro while the abovementioned seaward gate, opened towards the south [39]. Apart from the main gate, a small gate *(porticella)* connected part of the city with the surrounding countryside.

4) The churches

On the religious side, two ecclesiastical buildings are those best known from the archaeological investigations and studies: the cathedral [40] and the St. Peter's church [41], for which functional continuity has been established since the Early Middle Ages.

They can be considered the epicentres of well-defined sectors of the city for their importance to the cultural and iconological *meme* of Otranto.

5) Connections and activities

The image of the city from the land was mediated by a number of churches and monastic settlements outside the city walls, residential suburbs or facilities for warehousing goods or for the production of handcrafts and other goods. The public road that connected the city with Lecce and Brindisi to the north and with Castro and Leuca to the south skirted the external wall of the city, deviating around the city near the port. Along the basin of the river Idro, on the rocky banks, a series of caves that probably date back to the cave dwelling culture of late antiquity or the Paleochristian period

opened up [42]. Based on the principle of continual function as seen with other structures, these were probably still in use by the lower levels of the population for housing, shelter for animals, craft making workshops or as deposits for agricultural tools.

The city of the Late Middle Ages, in periods of political stability and before the Saracen raids, passed through a phase of consolidation of its economy of scale based on exchange and the port. Services and specialisation were developed supporting a well-developed social pyramid. This led to a marked diversification in the various types of housing, in large part erased by the modern walls and by more recent reconstruction.

6) Housing

The urban fabric within the walls presents obvious heterogeneity that is related to the peculiar stratified and paratactic condition of its formation. For the area overlooking the sea, located on a natural raised plane (acropolis), an ordinary, regular, geometric layout, based on the model of the classical Greek-Roman atrium-peristyle house which was widespread in byzantine town planning seems evident (for Otranto, upon an initial analysis of the ground floors, a base model of around 15.6x21.8 metres is revealed, corresponding to a unit measuring 50x70 byzantine feet of 31.2538 centimetres).

The reading is complicated in the lower areas where overlapping fragments of structures that resemble the Roman insulae model are positioned in order to accommodate the matrix of paths and natural terraces defined by the natural contours.

There are examples of building relating to different settlement logic. Such is the case near the cathedral and bishop's palace which is laid out on a east-west axis in correspondence with the liturgical orientation, but equally obvious is a border area which saturates the area adjacent to the linear northern front of the medieval wall, on which the Romanesque bell tower sits, then enlarged when the walls of the 15th century were erected.

From the XII century onwards some of these modules were replaced with terrace houses that were common in the commercial area. The basic type of structure in the medieval period, two rooms with vaulting on the ground floor and attic in wood on the upper floors [43], was based on the model of shop and residence and is found in the historical centre, in scattered agglomerations along the pathways. Other lots, originally atrium-peristyle houses were substituted in later ages (from the XVI century) to make way for the creation, in grouping or lines, of aristocratic residences.

7) Services

Structural reading based on the recognition of logical distribution or relative elementary modules is only one of the interpretive keys available. The city of Otranto in the Middle Ages was also characterized socially. The scene was brought to life by large or small family groups living according to a rigid subdivision and hierarchy of tasks: travellers who lived in the *xenodochia*; pilgrim beggars on their way to or from the east [44]; merchants and craftsmen; men of religion; milites and pedites.

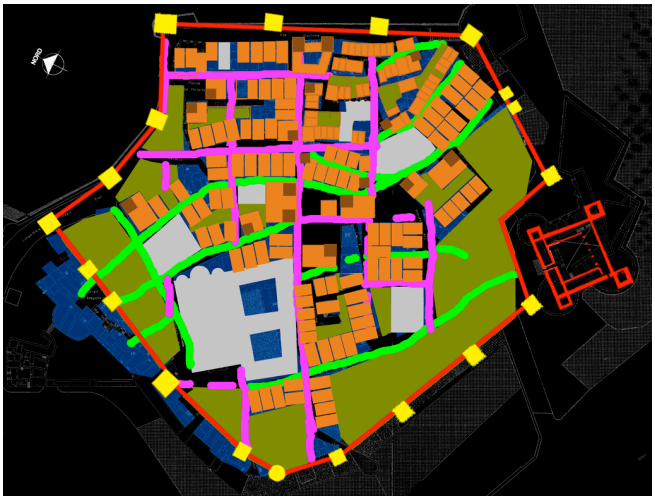

Figure 3. Schematic plan of supposed medieval Otranto.

The city itself was a machine designed for defence in case of attack, to facilitate or hinder certain categories of weapons: the windy road, narrow staircases, conferred an operational advantage on the citizens without horses who could, working from the land and their windows, fire long ranging arms) [45], etc.

All these layers overlap to define and characterise the real object of the research that opens the field to the infinity of things that can be expressed by the virtual.

In figure 3 is shown the schematic plan of supposed medieval Otranto showing the hierarchy and distribution of routes. In this figure are reported the ancient classic structure ante Middle Ages in magenta, the medieval ones according to contour lines in light green, the buildings (dwellings in orange, ecclesiastical in light grey, towers in brown), the spaces (courts in black, gardens and fields in olive green) and the fortifications (towers and gates in yellow, walls and castle in red).

The scheme is drawn on the actual ground plan of the town (in background white on black) compared to the 19th Century plan (in blue).

VII. 3D MODELING AND GAME ENGINE

A Digital Terrain Model (DTM) that has been produced using ESRI ArcGIS, containing all historical information like sea level, rivers, etc. It has been saved in .dif format and imported in the game engine.

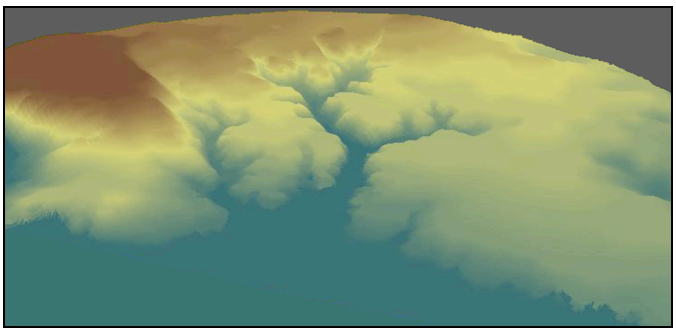

Figure 4. Digital Terrain Model of Otranto site.

Figure 5. Location of Otranto town in DTM.

In figure 4 is shown the Digital Terrain Model (with a magnification of 5) of the Otranto site and in figure 5 the location of the town in this model.

For building and street modelling, we first used AutoCAD, 3ds Max, Cinema 4D. Characters and animation are made using 3ds Max.

Once defined a list of modular elementary residential unit, according to the local medieval unit system, we composed the urban landscape in which monuments, infrastructures and situations are located.

In Figure 5 is shown the plane-volumetric reconstruction in CAD application and in Figure 6 is reported a 3D model of actual Otranto.

VIII. BUILDING OF THE VIRTUAL ENVIRONMENT

For the building of the virtual environment we used the Torque Constructor editor of GarageGames for creating 3D architectural contents for the Torque 3D engine.

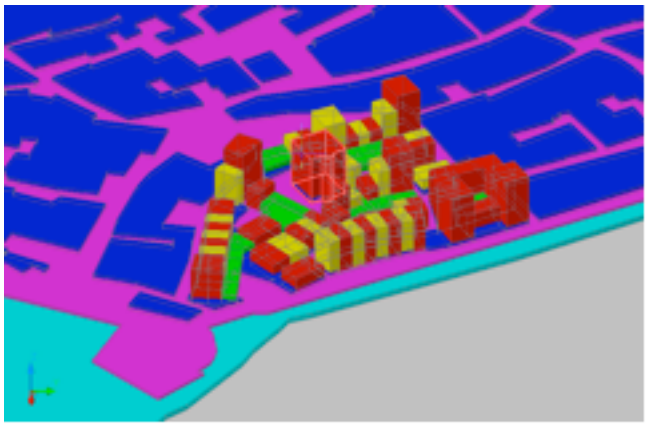

Figure 6. 3D model of buildings distribution.

For the building of specific monuments, such as Saint Peter's Church, the Cathedral and the Castle, we used first a CAM in order to obtain a more accurate definition of the architectural structures and then we imported these models into the Torque 3D engine [46].

Figure 7. Render view of actual old town of Otranto.

The choice of the Torque Constructor was prompted by technical considerations regarding the ability of software to perform a direct mapping of the files ".map", the compatibility level with the Torque Game Engine chosen to develop the game, the immediacy and the usability of internal tools. The application also includes all the converters needed to export file from '.map' to '.dif' compressed structure.

The Torque Constructor has proved to be an efficient tool for the direct implementation of 3D graphics models. In particular, it has many geometrical tools for the graphic processing of the reality context and different controls to select the top of the structure or individual brush model.

All units made in the Torque Constructor have been imported into the Torque Game Engine. The initial testing step revealed several problems of navigability of the objects. These problems were related to the incompatibility between the domains of collision associated with the objects imported into the three-dimensional environment and the avatar.

Tests carried out have helped to identify and resolve these problems by setting the values associated to the collision domains and to the proportions between objects and avatars. At present all units are properly imported and successfully navigated.

In Figure 4 a set of residential units are shown.

In the context of the computer graphics for cultural heritage, a stable algorithm has been implemented to import CAD objects into the Torque Game Engine platform and to ensure navigation into each graphic structure. This technique together with an efficient system for exporting textures and paintings will be used to realize graphic complex environments for the 2D/3D reconstruction in cultural heritage.

The first monument to be modelled has been St. Peter's Church, due both to its characteristic of modularity that is useful for testing the software and its historical relevance as unique byzantine building located in a medieval context.

After drawing and importing the church with textures and lights we experienced problems with the non-convex objects produced by common modelling software that drove us to use only Torque dedicated applications like Torque Constructor.

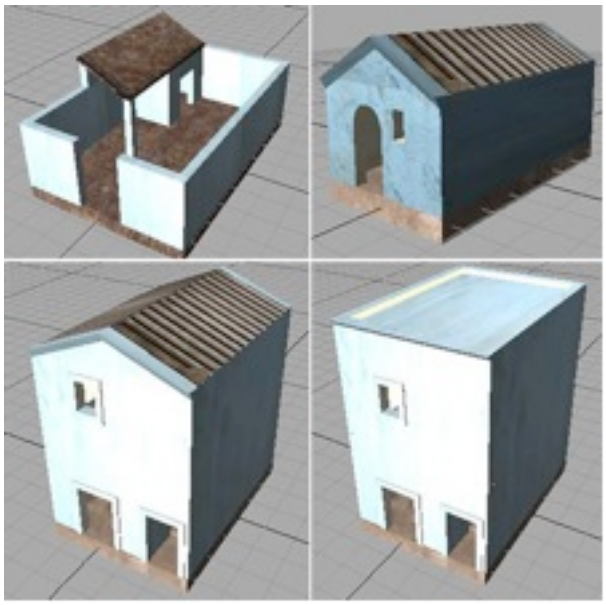

Figure 8. A set of residential units

In Figure 11 is shown the reconstruction of St. Peter's Church and its surroundings; in particular, in 11(a) is reported the scheme of the reconstructed church with (in black) a chapel that existed in the Middle Ages and was afterwards destroyed.

In Figure 12 is shown the reconstruction of Otranto Cathedral; in particular, in 12(a) is reported the mosaic of the internal floor of the church.

IX. PLAYERS AND ARTIFICIAL INTELLIGENCE

Inside MediaEvo Project has been implemented a module to manage the interactions with Artificial Intelligence [47]. The artificial intelligence (AI) is necessary to establish relations among characters in the virtual game and to exchange multimedia information and by prompting commands real time. The ability to interact with AI characters is the principal key for retrieving knowledge and experiences from a virtual reality environment.

In the MediaEvo Project, the component of Artificial Intelligence is based on a graphical interface, with the following specifications: the interface should allow the starting of the interaction by pushing a default button on the keyboard; the interface should provide a choice of applications to be given as instructions to the virtual character; the interface should display all workable interactions with a virtual character. For this purpose, a reconfigurable database of instructions has been generated.

The configurable database has direct access to the AI Interactive module. The AI Interactive Module has been realized according to the guidelines of the scripts implemented in Torque Game Engine [47].

In figure 9 is reported the algorithm to manage the Artificial Intelligence.

The AI Interactive algorithm can be divided into two main modules: AIT Server Management Code and AIT GUI Management Code. When the player selects an item of the AIT Queries database, the GUI interface establishes a communication between the player and a virtual AI character. The selected item contains the instruction that could be imparted to the AI character. The instruction is managed from the AIT GUI Management Code module that encapsulates the information into a single system call.

Finally, the system call is routed to the AIT Server Management Code module and then it is interpreted to identify the corresponding action, into the AIT Actions database.

The game has been designed for enabling multi-playing in order to provide a real-time interaction with other game sessions localized in the reconstructed virtual environment.

Some multimedia elements are available in the MediaEvo platform for the context of edutainment in cultural heritage. The main ones are: 1. the availability of audio clips and sounds in the game; 2. the use of triggers to start up audio or video events when a player reaches some checkpoints or thresholds.

In Figure 10 is shown the visualization of a video that pops up when a player gets close enough to the entrance of St. Peter's church. In the same figure 10 is also shown a virtual radar, a mean to let players know their position in the town and the one of other players.

X. THE ALGORITHM FOR THE AUDIO AND VOICEIP

Inside the MediaEvo Project has been implemented a module to integrate voice and text interactions between the players and other characters located into the Torque virtual environment.

The trigger between the vocal process and the Torque virtual environment is realized through a system call implemented and built into the kernel of the Torque Game Engine.

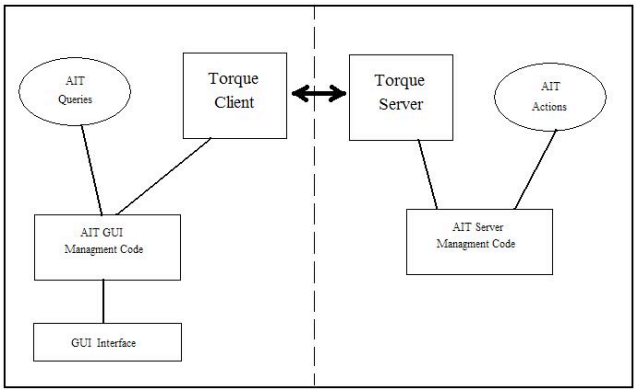

Figure 9. Artificial Intelligence.

Figure 10. The opening of a multimedia clip video.

The insertion of the vocal connections can increase the interactions with characters and/or players in the virtual game and allow performing some input and output that normally are performed throughout keyboard, mouse, screen, and other input/output devices.

The possibility to establish a vocal connection with other players is one of the best ways for retrieving knowledge and experiences during the virtual game. The vocal interaction contains some algorithms to realize text-to-speech systems. It is also possible to ask some actions directly to the players through the audio channel.

In addition, in the audio module has been implemented a system to realize a VoiceIP connection between all players. The audio module is based on a simple graphical interface provided with a bar that indicates the microphone audio level during the vocal conversation and a flag that specifies if the audio module is working or not.

The audio module has been integrated with some scripts inside the Torque Game Engine. All the audio conversations are transmitted through a protocol compatible with the Internet platform.

The Speaky toolkit [48] has been provided by MediaVoice Company, partner of the MediaEvo Project, and is based on two modules: the Voice Platform and the Control Center Modules.

The main task of the Voice Platform is to handle the voice interaction between the user and the applications. The Control Center helps the users to configure Speaky parameters.

The Speaky platform supports Loquendo engine for Automatic Speech Recognition (ASR) and Text To Speech (TTS) in Italian language. The MediaVoice Company is working for a multi-language version of the product.

The vocal interactions are realized by using a specific remote command that can communicate with the Speaky Toolkit for imparting voice interactions.

XI. CONCLUSION AND FUTURE WORK

The MediaEvo Project has led the researchers to consider some of the issues presented by the multidisciplinary nature of the project and the close correlation between technical and humanistic fields. In particular, conditions were created that implied history researchers to test model built using information coming from their work.

In larger terms, the reconstruction of the medieval city of Otranto in the MediaEvo Project, determined the conditions for testing the overall functionality and systemic coherence through the real time production of environments, objects, situations, and virtual landscapes, thought up in order to represent the totality of knowledge of that times.

The representation, intended for communicating and educating, was designed to open itself up to the interactive and multisensory dimension in such a way as to become simultaneously subject, object and context of the experience. Communication and representation are not limited to the pathway of a one-way guided narrative, but open up possibilities for more enjoyable elements of interaction and a multisensory mediation, in which can merge objects, subjects and the experiential context.

Measured against the notable potential of a virtual scenario, a series of properties have been defined sufficiently to give the game platform an effective educational value [49].

By incorporating historical, technical and educational considerations the final product presents itself as a “complete-open-interactive” environment, with a good historical-philological validation, while allowing for continuous updating and testing. Since the Middle Ages are only partially explored, by these means an ideal extent of the knowledge of a context can be represented and experienced in its material totality.

Already tested for other urban realities, by opening itself to exponential complexity, the Time Machine is definitively becoming a formidable tool for the acquisition of knowledge, the enhancement and safeguarding of cultural heritage.

The MediaEvo Project evaluates the premises upon which the future development of an historical cyberspace is capable of contextualising past experience, in order to explore a range of parallel realities based on description and philological reconstructions.

In the MediaEvo Project has also been tested the possibility to enjoy the virtual environments using the Apple IPhone mobile. The IPhone version of MediaEvo Project through the iTGE platform for IPhone Torque is still in progress.

ACKNOWLEDGMENT

The authors wish to thank Pierpaolo Limone of Foggia University for the advice in the pedagogical development of the game and Massimo Limoncelli for the building of the 3D model of the Otranto Cathedral.

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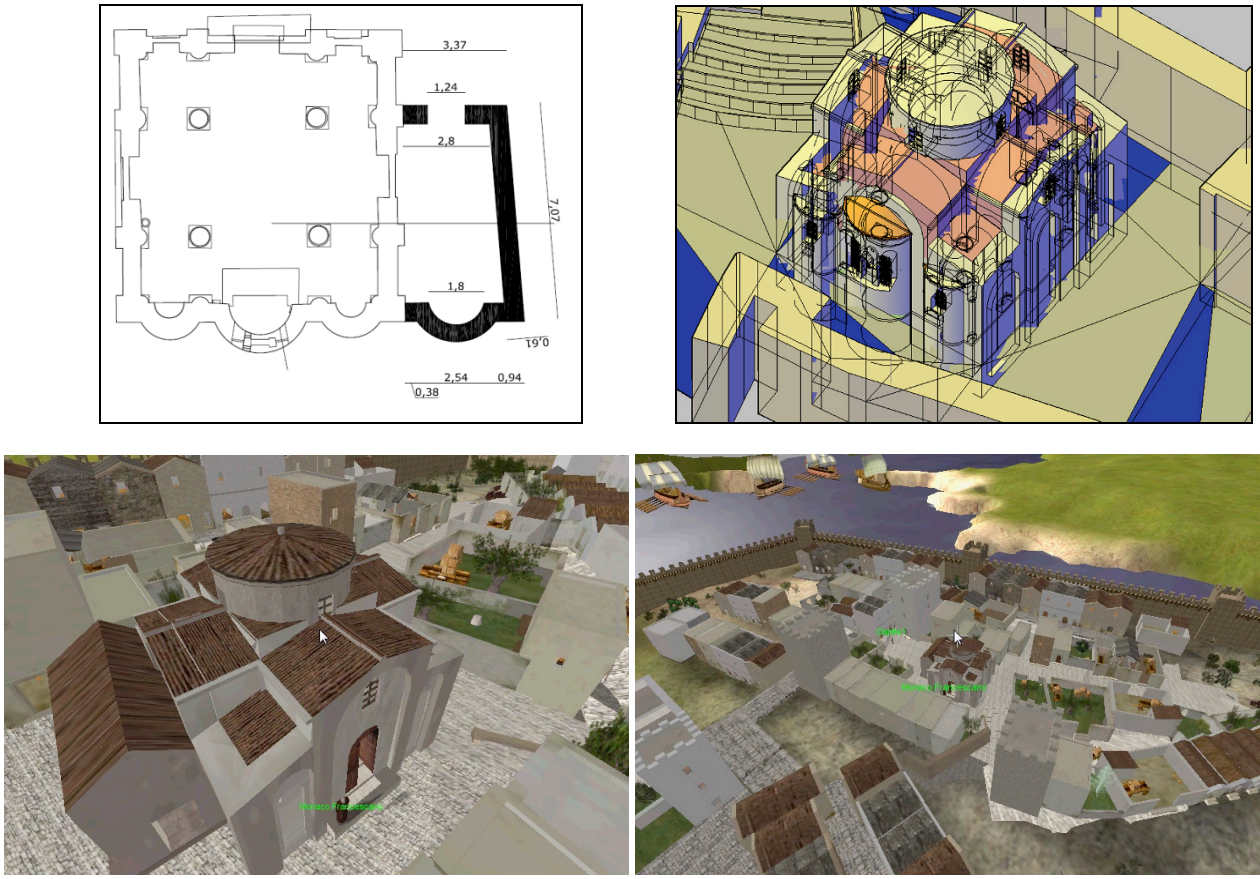

Figure 11. The reconstruction of St. Peter's Church: (a) scheme of the reconstructed church with the later removed chapel in black; (b) virtual model made using a CAD software; (c) the virtual reconstructed church; (d) the church in its surroundings.

Figure 12. The reconstruction of Otranto Cathedral. 12(a) facade, exterior view; 12(b) the famous medieval mosaic on the internal floor.