

Universcity: Towards a Holistic Approach to Educational Virtual City Design

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Abstract— In this paper, we seek to develop a holistic approach to educational virtual cities, introducing a concept of ‘Universcity’ as a framework for a wide range of social, cultural, and educational activities, a city for students, researchers, and other learners to live and work in. The metaphor of a city is widely used in the design of virtual worlds. However, a systematic approach to learning support in virtual cities is not fully developed yet. To fill the gap, we consider a city as a place for lifelong learning, with a broad spectrum of disciplines and areas of knowledge. We have investigated these aspects in the implementation of two projects where virtual reality was used for the contextualization of educational activities. Based on the experiences from these projects and related work, we propose an initial design of ‘Universcity’.

Keywords—virtual cities, 3D virtual environments, learning environments, cultural heritage, serious games

I. INTRODUCTION

Adopting 3D virtual environments for serious purposes is becoming more and more widespread. This paper focuses on *virtual cities* – environments representing real or fictional cities and supporting a range of different activities for the purposes of education, entertainment, and socializing for local communities.

Based on our experience in two projects, we argue that the virtual city may be an excellent metaphor for an educational environment. The overall virtual environment may also include tools and facilities that support social life, cultural development, geo navigation-based activities and so on. All together, these features create an environment for students, teachers, researchers, and other learners to ‘live’ and work in.

Integrating cultural and social layers into educational environment is inspired by social constructivism [1]. This approach addresses collaborative and social dimensions of learning and stresses the importance of cultural background and social environment for learning. In reality, learning is

usually interconnected with city’s social and cultural life. For example, students might have a colloquium meeting in a café or in a park; they attend various concerts, political debates, and exhibitions. Similarly, tourists learn about a city’s culture and history by visiting historical buildings and monuments, museums, and other public places. City’s permanent residents learn by attending and participating in various local community events and programs.

Despite the metaphor of a city is widely used in the design of virtual worlds [2, 3], a systematic approach to learning support in virtual cities is not fully developed yet. As it is stressed in [3], all kinds of virtual worlds will likely offer various opportunities for learning. However, as we explored in [4], existing virtual cities often lack of incorporating education and training aspects into virtual city design.

In this paper, we discuss the modeling of a virtual city as a place for lifelong learning, with a broad spectrum of disciplines and areas of knowledge. We sustain this idea with our working experience on two projects: “Travel in Europe” (TIE) and “Virtual City of Yoshkar-Ola” (VCYO). Both projects have connections with the city of Trondheim that we use as an example for the new virtual city concept.

We propose a virtual city as an advanced Virtual Reality application to support learning, cultural, and social activities of students, researchers, and other learners. The city model we propose is a students’ city, where the university is a city-shaping institution and students play an important role in the local society.

II. DESIGNING VIRTUAL CITIES FOR CULTURE AND EDUCATION

In this section, we present and discuss issues and findings from our work on designing educational experiences in culturally and socially meaningful virtual environments.

A. *Serious Games for a Contextualized Exploration of History and Culture*

Research on cognitive processing – how information is stored, retrieved, and represented – stresses the importance of helping learners develop well-connected knowledge structures representing relationships among facts and concepts. When the knowledge structure for a topic is well-connected, new information is more readily acquired, since the cognitive load is low [5].

Thus, designing a proper cognition-supporting structure is necessary when developing interactive applications, such as Serious Games, that aim at knowledge acquisition and/or skill development. Analyzing effective Serious Games, a paradigm can be abstracted, that tends to provide players with a suited knowledge structure for the addressed topic [6]. In rough terms, the Sand-Box Serious Game model consists of a concrete spatial organization (the Virtual World of the game) and distributed tasks that embody units of knowledge.

Serious Games on cultural heritage can well exploit this paradigm since exploration of artistic artifacts can be performed inside a reconstructed area (typically urban), which is the contextual world to be explored in an adventure-like fashion. This is the paradigm that has been implemented in the Travel in Europe (TiE) project (<http://www.tieproject.eu>), of which, in the following we briefly describe the model we have developed for creating urban virtual environments suitable for cultural experiences.

A 3D reconstruction of a city or a region for education/cultural aims within an interactive environment (e.g. a Serious game) is a process that requires a careful trade-off between the models' photorealism, which is necessary to provide a highly impressive and culturally correct and meaningful experience, and the models' complexity and weight, in order to allow interactive real-time online exploration. In order to meet the above stated requirements, TiE [7] has designed the reconstruction of each covered place, e.g. a city or several areas inside a city, as it follows:

The 3D model is completely geo-referenced. This allows exploiting synergies with Geographic Information Systems (GISs), implementing location-based services with open GIS APIs (e.g. Google Maps and Microsoft Virtual Earth).

In the city, a few Point-Of-Interests (POIs) are implemented (Fig. 1). These buildings are rigorously reconstructed by hand at a high level of detail. The textures for all the rest of the palaces are built by the TiE system using a statistical template-based algorithm. Since several zones within a city are typically characterized by relatively homogeneous buildings, the system builds 3D virtual models featuring textures obtained by statistically composing architectonic elements.

Virtual city of Trondheim implemented within TiE contains 8 major POIs, including university main building, and 2 urban AS areas. According to the TiE targets, the city has been implemented in order to allow virtual tourists explore the urban environment in a sort of cultural treasure hunt and play trials (e.g. quizzes, contextualized arcade mini-games) embedded in the context (e.g. the cathedral). The same virtual environment can also be used for contextualized meetings and by international students to freely and

pleasantly learn about the city and the university before their arrival.



Figure 1. Trondheim's cathedral – Point of Interest in TiE

B. *Connecting Reality and Virtuality with Social Tools*

A multi-user mode opens wide possibilities in a virtual city context. Users would be able to explore environment with friends, chatting and helping each other, which is more engaging than in a single-user mode. A city will be a social arena where people can meet and communicate. Furthermore, it will enable various forms of collaborative learning. We explored these ideas working on a project Virtual City of Yoshkar-Ola (VCYO) – a multi-user virtual world (<http://virtyola.ru/index.php?lang=english>).

VCYO is a 3D virtual environment representing the central part of the city of Yoshkar-Ola in exact manner (Fig. 2).



Figure 2. The main square in the Virtual City of Yoshkar-Ola

The idea of the project was creating local social networks based on a virtual city as a natural environment for communication and as a subject of common interest for citizens. Therefore, we integrated traditional social networking tools, such as profiles, friend lists, blogs, messages, comments, and others into 3D environment.

Urban environment, different places, landmarks and buildings are important subjects of discussions for local citizens and visitors. In VCYO we included a possibility to

post notes and comments on any 3D content that provides a strong connection between the real and the virtual environments. It is possible to examine descriptions of places and buildings in the city, users' notes and photos in the virtual world. A user can also add their own comments to existing notes or photos, to leave their own notes and put their own pictures around the world.

A citizen of this virtual city can create a social network with other users, filling a profile, adding friends to a friend list, keeping a blog, and commenting others' blogs. VCYO also contains some educational tools to enable live virtual lectures such as facilities for slide show, video and web.

In VCYO, we have performed an explorative case study to identify to what extent a virtual world of a city can enhance educational process. The case study educed some limitations of the system, but it showed that a virtual city can successfully be used in a wide range of educational activities. We proposed new services and scenarios for supporting educational activities in a virtual city, in particular in connection to an integrated virtual campus [4].

The city environment contains also a replica of Trondheim's landmark – the main building of the Norwegian University of Science and Technology (NTNU) as a symbol of collaboration between universities and as a fun element. Norwegian students participating in the case study could simply recognize this building. They posted a number of text and graphic notes around the building and discussed many related issues in comments. Answering a questionnaire, many of NTNU students expressed the wish to be citizens of a Virtual Trondheim [4].

III. DISCUSSION

In this section we apply a holistic approach to an educational virtual city and propose a concept of 'Universcity'.

A. Holistic approach to an Educational Virtual City

Applying a holistic approach to a virtual city, we are seeking to integrate different aspects of city life, such as culture, society, education, and entertainment. We consider 'Universcity' as an integral/holistic organism, since in reality all these aspects are interconnected. We use the city of Trondheim as an example of such a 'Universcity', for the reason that education and research has traditionally a very strong position in the city. In addition, Trondheim has a rich history and cultural heritage, being over 1000 years old and an ancient capital of Norway.

Like many cities with similar complexity, Trondheim consists of several layers, so a virtual city realization with a focus on for example only historical aspects would provide an incomplete picture of the city. Therefore the 'Universcity' should be seen as a framework for a wide range of social, cultural, and educational activities, an environment for students, researchers and other learners to live and work in.

When speaking of educational virtual city design, we focus on different aspects, including realistic models, connection to reality, facilities for collaboration, games, and social tools. Our experiences from VCYO project shows that connection with the reality and social tools in a virtual city context creates a unique environment that can be used for

educational purposes. Working on TiE project, we got useful experience in developing realistic and interactive 3D urban environments as well as discovered the potential of serious games in a city context.

The outcomes of these two projects correlate with our previous research in using 3D virtual environments for educational purposes and become a basis for further research on educational virtual cities.

B. Multilayer structure

'Universcity' is a virtual city for students, researchers, and other stakeholders, with education as a main purpose, a university campus as a main feature and all other features serving for learning support. The word 'Universcity' is a neologism and consists of two parts. The first part symbolizes a Universe as a global, complex organism and at the same time – a virtual world. The second part is city, but together they become University that stresses educational nature of the concept/word. In the following we discuss this concept, focusing on the most successful features from the projects described in the paper.

In 'Universcity', we consider different layers representing corresponding aspects of city life.

Cultural layer focuses on the support for the exploration of the cultural and historical aspects of the city. The corresponding features of the 'Universcity' may include the following:

- Realistic, authentic environment and avatars creating a sense of immersion and the right atmosphere;
- Various places for learning and cultural development such as virtual museums, theaters, clubs, public offices, with corresponding tools and resources;
- Tourist facilities, such as 'city tours' led by agents, 'tourist offices' with information and links to the major points of interest, bookmarks, and 'transportation routes' marked between different places;
- Time layers that allow seeing how a place looked in different periods of time. Historical buildings as well as future urban plans may be created and appeared on demand instead of present buildings.

Social layer is about supporting the social fabric of the city and its inhabitants, its development and maintenance. The corresponding features of the 'Universcity' may include the following tools and facilities:

- Communication support: text and voice chats, gestures and artifacts, profiles and friend lists;
- Community support and awareness mechanisms: location based social networking, social recommendation, educational/scientific events and festivals, feeds and bulletin boards;
- Places to socialize and hang out, community places, and a network of scientific and knowledge intensive organizations with corresponding information;
- Possibilities for creating and sharing content, including 3D constructions.

Educational and research layer focuses on supporting educational/research activities and networks characteristic for 'Universcity'. Such activities and networks extend far beyond campuses and labs where the students and scientists

‘officially’ work. Various educational materials, course and project work as well as social events can be arranged using a Virtual Campus framework [4]. At the same time, the layer may provide connections between educational/scientific network and society. The educational and research layer will therefore need some facilities and tools supporting both learning and interaction between students, researchers and city’s inhabitants:

- Contextualized resources contained in the city buildings and places, such as information about local government in a city hall. Any type of media or links to external resources can be applied;
- Virtual Campus – a framework for supporting educational and research activities for colleges, universities, research institutions and knowledge intensive companies. In ‘Universcity’, Virtual Campus is hierarchically integrated into a virtual city context. Virtual Campus provides auditoriums for virtual lectures, facilities for practical exercises and social life support. Moreover, Virtual Campus can link education with culture and history, if accurately reconstructed and providing contextualized information;
- Creative Virtual Workshop (CVW) – a framework that supports collaborative learning and work on educational content in a social environment. CVW, in its turn, is hierarchically integrated into Virtual Campus. CVW consists of 3 parts: a workplace, with a library of resources, building tutorials and tools, a virtual stage for presenting projects, with a slide-show screen, a place for presenting 3D constructions and seats for the public, and a virtual gallery to store and exhibit student constructions [8];
- Virtual Research Arena (VRA) – a special framework in a Virtual Campus for creating awareness about educational and research activities, promoting cross-fertilization between different environments and engaging general public. VRA can be considered as an instance of CVW. The virtual arena may recreate the physical one, such as raised in Trondheim’s city center during the yearly Norwegian science week. It has a number of tents and stands open to the public and serves as a link between city inhabitants and the research environments. The virtual research arena may be visited across distances and different time zones. While the physical exhibitions and stands will be removed after the end of the festival, the virtual exhibits will be available for as long as needed.

Entertainment layer focuses on creating a stimulating atmosphere in the virtual city, both around work and leisure activities. In addition, introducing gaming elements would appeal to previous experiences from 3D videogames, reduce the barrier for novices and serve as a powerful motivational factor. Entertainment layer may include the following tools and facilities:

- Fun atmosphere and appealing environment with realistic recreations of landmarks and style areas;
- Integrated quizzes, quests and contextual games;

- Location and mobile multi-user games (for example ‘treasure hunt’ scenario) that connect the entertainment layer to other layers.

It is important to realize that the division into layers is rather fluid as the cultural, social, educational, and entertainment aspects of the city are closely related and may be experienced by city inhabitant and learners simultaneously in many situations. Various scenarios may be developed for the users, allowing them to adapt participation according to their preferences. These scenarios may offer social, cultural, educational or entertainment activities as well as a combination of them.

IV. CONCLUSION

In this paper we have discussed the concept of educational virtual city as a place for learning, social and cultural development, suggesting a holistic approach to the design. The concept of ‘Universcity’ is a general framework with hierarchical and multilayer structure. The concept can be used for designing virtual cities, most relevant for research- or/and education-intensive cities. The presented approach was developed based on related work and the experience in 2 projects: VCYO and TIE, where we explored different aspects of virtual cities.

REFERENCES

- [1] L. S. Vygotsky, *Mind in society: the development of higher psychological processes*. Cambridge, MA: Harvard University Press, 1978.
- [2] M. Dodge, S. Doyle, A. Smith, and S. Fleetwood, "Towards the Virtual City: VR & Internet GIS for Urban Planning," in *Virtual Reality and Geographical Information Systems Workshop*, London, UK, 1998.
- [3] S. de Freitas, "Serious Virtual Worlds report," Joint Information Systems Committee, Bristol / London, UK, 2008.
- [4] M. Fominykh, E. Prasolova-Førland, M. Morozov, and A. Gerasimov, "Virtual Campus in the Context of Virtual Students’ City: Case Study," in *21st World Conference on Educational Multimedia, Hypermedia & Telecommunications (Ed-Media)*, Honolulu, Hawaii, 2009, pp. 559–568.
- [5] F. L. Greitzer, O. A. Kuchar, and K. Huston, "Cognitive Science Implications for Enhancing Training Effectiveness in a Serious Gaming Context," *Journal on Educational Resources in Computing (JERIC)*, vol. 7(3), 2007.
- [6] F. Bellotti, R. Berta, A. D. Gloria, and L. Primavera, "Adaptive Experience Engine for Serious Games," *IEEE Transactions on Computational Intelligence and AI in Games*, vol. 1(4), 2009, pp. 264–280.
- [7] F. Bellotti, R. Berta, A. de Gloria, and L. Primavera, "Travel in Europe: an online game environment to promote and divulgate European heritage," in *Visual Travel Recommender Systems, Social Communities and User Interface Design*, N. Sharda, Ed.: IGI Global, 2010, pp. 194–208.
- [8] E. Prasolova-Førland, M. Fominykh, and T. G. Wyeld, "Virtual Campus of NTNU as a place for 3D Educational Visualizations," in *1st Global Conference on Learning and Technology (Global Learn Asia Pacific)*, Penang, Malaysia, 2010, pp. 3593–3600.