Historical Knowledge Management Through Virtual Reality: Theoretical Aspects and Experiment Proposal

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Abstract. In this paper, we explain our hypothesis on the use of virtual reality for historical knowledge management and we describe an experimental protocol using Unity3D engine. In order to visualize and analyze complex historical information, virtual reality is used to provide an interactive and immersive environment. The user can interact on linked heterogeneous data like semantics, geometry, and temporal information. Our system provides the ability to visualize different information and to interpret historical hypothesis. The approach is based on historical research datasets related to Nantes harbor in 1900. Along to this final user application, we propose a research methodology to ensure a scalable system.

1 Introduction

Knowledge management is a complex process for any kind of information. Dealing with historical information is specific in many ways: uncertainty, lack of geographical and temporal precision, heterogeneity, information connectivity, nesting level of details, etc. In order to improve this information management, we use a product-process based approach using industrial engineering methods and tools. Input data are real objects from museum collection, archives documents, historians analysis. Then, we design a dedicated information system combining multi-dimension information. Finally, we need to design human-machine interfaces to interact with gathered knowledge. This last point is crucial when dealing with historical research process: we need to provide the ability to control documents versioning, multiple and sometime contradictory sourcing, and different interpretations.

Our case study is related to a significant museum collection object: the scale model of Nantes harbor, designed in 1899 by Paul-Auguste Duchesne for the 1900 Paris Worlds Fair. This object was designed to promote industrial and commercial activity of Nantes harbor at that time. Its scale is about 1/450 and it measures 9.20 meters long by 1.85 meters wide. This artefact is a representation of about 9 km^2 of the city so is a significant source for the work of historians.

In addition to the maintenance and the promotion processes of the museum, there is a great challenge for the understanding and the connection of historical information to historians. Many museum objects are connected along the museographic discourse, and this scale model is a chance to enhance the ability to understand history through museology.

2 Related Works

Displaying historical metadata in a virtual 3D environment implies several issues related to both user interface and data visualization and manipulation. A lot of work has been done in the field of user interfaces for virtual reality [1] even if new devices are constantly challenging this research area. In this paper, we do not focus on the design issues but rather on the benefit from using virtual reality for historical data management.

As far as cultural heritage is concerned, many research works have emerged in the literature, especially dedicated to archaeology and sometimes using virtual reality [2] [6] [3]. It leads to a better understanding of tangible or intangible heritage. Based on these works, we can assume that both the discourse and the end users are crucial to take into account to ensure a scientific work.

Our approach is based on industrial engineering for the management of historical knowledge. This has been proven useful, especially when dealing with industrial heritage [5] [4]. The proposed methodology is human centered all along the capitalization process, from the acquisition of data (scanning, archives analysis) to the promotion of heritage knowledge and feedback process through multi-modal interfaces. Now, we are studying the benefits of virtual reality for cultural heritage understanding and analysis. Virtual reality help us to visualize and to manipulate data in order to analyze historical hypothesis, providing different points of view and possibly different levels of detail.

3 Methodology

Our proposal is to design a virtual reality environment to both experts and museum visitors to understand and analyze historical data (Figure 1). We make the hypothesis that virtual reality can help historian during the process of writing history (make connections between historical data and manipulate data). It can also help other people like museum visitors to understand this process: how history is written and how historians work, and therefore providing a new way of interaction and understanding of cultural heritage. Finally, virtual reality allows to build a link between the information system and the users setting up knowledge capitalization and contextmapping methods. We use Unity3D software to develop the experiment application.

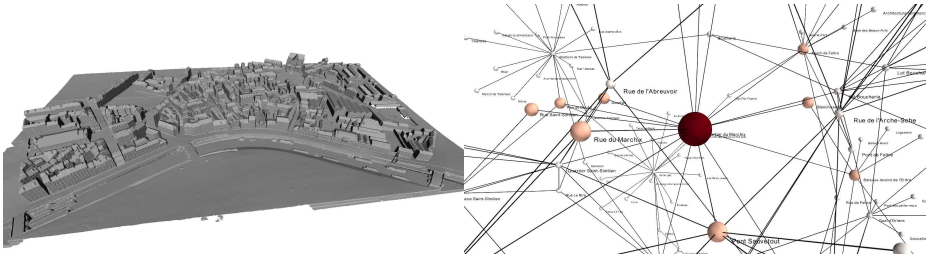

Fig. 1: Historical data: digitized 3D model and semantic network.

4 Virtual Reality Interface Proposal

4.1 Data types

The visualization of historical information in 3D environment is a complex task as it deals with items which are geolocalized or not, connected among themselves, and obviously time dependent. For a coherent interface, every type of item is associated to an individual data sheet which is shown when the item is selected, it contains metadata such as name, description, pictures and 3D models when useful. Three kinds of data are considered for their representation in the application (Figure 2):

- Geo-located items with 3D geometry, this is the case of buildings, monuments and street furniture for example. The underlying historical data is easily accessed, the user can select the item of interest directly in the 3D scene on the scale model.
- Geo-located items without 3D geometry, this is the case of areas such as streets or districts. To quickly see their location, visual indicators are placed on the 3D scene which can be selected. For point coordinates, a vertical luminous ray is created, for large surfaces, the user can see transparent prisms which cover the areas.
- Non geo-located items such as people, events or custom groups. These can't be easily visualized on the 3D scene so they are accessed using menus within the interface.

One of the main goals of the historian is to establish connections between different historical items, so each data sheet shows the items which are part of the same semantic group (Figure 3). In the same way, an interesting possibility for the historian is to create his own custom groups of items as he explores the city. He can add all 3 types of data (buildings, areas and people/events) to a bookmark menu in order to build new custom groups.

4.2 Navigation and display

We propose several solutions to explore this heterogeneous data. First, the user can navigate in the scene using bird view paradigm: it allows to visualize in-

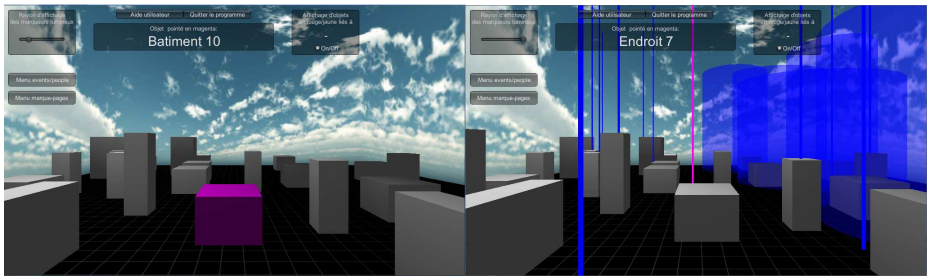

Fig. 2: Geo-located items with and without 3D geometry in the virtual scene.

formation through different points of view. He can also fast travel to another location by selecting a visible point on the model, the camera will travel in a direct line or hover above the destination, which can be useful to quickly explore points of interest.

The user can quickly see the details or move the camera on one of these items, he can also choose to highlight the entire group on the 3D scene to quickly see the locations of items of interest.

Each historical sheet (Figure 3) can show the evolution of the item selected through time, the user can choose an era within the available data and check the details relevant to this age, it can be a different picture or a different description for example.

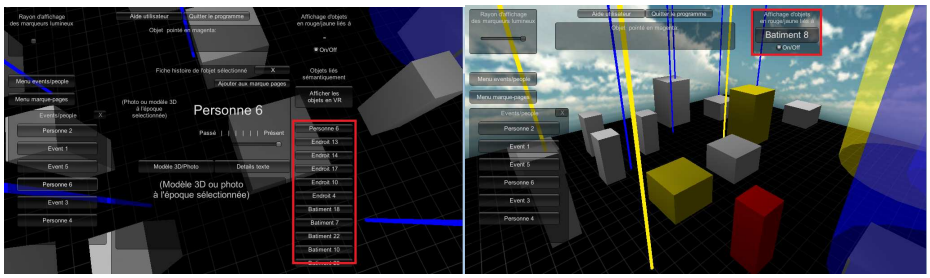

Fig. 3: Visualizing connections between items in the scene based on database information.

If we combine all these data types previously seen, the interface and the visualization can become messy and non-efficient. The solution would be to use filters and layers to show only what the historian is interested in at the moment. The first step is to create a numeric cursor to choose the radius where we display the luminous rays around the user, allowing to manage the number of semantic details.

5 Discussion and future works

This experiment is a first step towards a more complete VR experience, the goal was to present a coherent interface for historians which allows all kinds of exploration between very different types of data. Our system also provides the ability to visualize in real-time the consequences of user action on the system: connect pieces of information, adding semantic meaning, extract or visualize sub-part of the global network.

Concerning future improvements, we could implement new sub-types of data based on the 3 main categories, menus to allow an efficient use of filters and custom groups or the implementation of text-based tags on the 3D scene for example. Some research works are related to the use of levels of detail for complex visualization, especially for urban data. However we have to keep in mind that new functions could be hindrances to the user workflow, the final application should realize the best compromise between the coherence of the interface, the efficiency of the exploration and the implementation difficulties with a big heterogeneous dataset.

Next work will be managing the whole pipeline from 3D acquisition to the integration in the virtual scene. Some 3D post-processing needs to be done in order to adapt the raw 3D mesh into a convenient format for Unity3D engine. Moreover, other functionalities can be integrated: data annotation, mapping data to standard models such as cultural heritage ontologies. This would allow historians to complete this step with context rather than doing it *a priori*. Tracking devices could also be used to record cognitive paths into the virtual scene, we will explore this possibility in the future.

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