A Content-Centered Methodology for Authoring 3D Interactive Worlds for Cultural Heritage

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ABSTRACT

The application of 3D visualization technologies to cultural heritage has deeply evolved along years, shifting from the role of an ancillary technical solution to the dignity of a new media. However, the responsibility of building a complete 3D world often relies on a single designer who must be expert in different domains: graphics, interaction, and application domain.

In this paper we propose a new *content-centered* methodology for the production of 3D interactive environments for cultural heritage, including a more appropriate definition of subjects and skills involved. The methodology has been applied to the design of guided tours presenting cultural events, in order to test its benefits. The experimental results demonstrate that this methodology enables content experts to produce significant 3D experiences collaborating with a team of computer scientists, without concerning about low level implementation details.

KEYWORDS: 3D worlds, authoring, content-centered methodology, cultural heritage, VRML

INTRODUCTION

Low-level representation and rendering of complex three-dimensional worlds is no longer a troublesome task. There are both a wide number of methods for rendering the scene and standard graphic libraries that communicate efficiently with the underlying hardware. Application developers don't need to worry about underlying hardware, but have a standard way to write their application; this guarantees both rapid development and portability of solutions across different graphic platforms.

Advances in hardware today allow users to explore 3D scenes in real time, enlarging the issues related to 3D representation. This new situation has led human computer interface specialists to study the issues related to interaction in 3D scenes. If the early computer graphics years were characterized by the production of static renderings of scenes, to be used as a complementary support to presentations performed with other media, today 3D graphics have acquired the dignity of a new media, often used autonomously as a new way to communicate, to teach and to play [1].
This change of perspective due to hardware and software advances requires a redefinition of the production methodology, including a revision of the subjects involved in this new media, in order to obtain a full exploitation of its potentialities. In spite of this evolution, the modalities of production of 3D environments often reflect the older model; *authors* (i.e. *3D modelers*) are often still deputed to the whole construction of the 3D interactive worlds, while in many cases such worlds

demand the specific contribution of experts belonging to different areas. For example, a 3D virtual exhibition can be certainly characterized by a three-dimensional building but the main focus is on the layout of the works exposed, that should be placed according to the vision of the art expert that organizes the event.

Therefore a major feature of the production methodology should be the direct involvement of the *specific content expert*: in the exhibition example the focus is on the works of art, so the key figure should be the art expert. Unfortunately in many cases experts are relegated to the role of external consultants, and this doesn't permit a full exploitation of the new 3D interactive media expressiveness.

We propose in this paper a new framework for the production of 3D interactive environments, including a more appropriate definition of subjects and skills involved; the re-definition of *author* will be a key component of this perspective change.

THE CURRENT 3D WORLDS PRODUCTION MODEL

Figure 1 shows the current production model for interactive 3D scenes. It is based on three main roles: the vendor, the author/world builder, and the final user.
The *vendor* implements a 3D browser according to VRML specification, including a number of interface artifacts to perform actions, such as moving or rotating, which are not defined by the VRML standard[1].

The *author/world builder* is the key role in the whole process, since manipulates the 3D geometry, defines the interactive behaviors and organizes often also the hypertextual content. The author operates following the specification of the 3D language and the additional specifications given by the vendor.

The *final user* interacts with the application using the artifacts implemented by the vendor and by the author.

Using this method, the *author/world builder* is directly responsible for designing all the aspects of the application, from the style of presentation to the interaction model. The expert of the content domain gives his/her contribution filtered through the technical sensibility of the author, with no direct control on content organization; for this reason the content expert is not evidenced in the figure.

The author uses a number of specialized tools that require a deep technical knowledge in order to manipulate the 3D primitives, the interaction artifacts and the other media that are part of the interactive world, such as video, text and audio. The technical skill required and the absence of modularity result in 3D scenes which are hardly reusable by other authors because of the complicated low level relations between the various components of the interactive environment.

A COMPREHENSIVE PROPOSAL FOR AUTHORING 3D INTERACTIVE SCENES

The fulcrum of the re-organization of the production environments will be *content*.

[1] We base our analysis on VRML-based 3D worlds due to its wide availability and suitability in a Web environment.

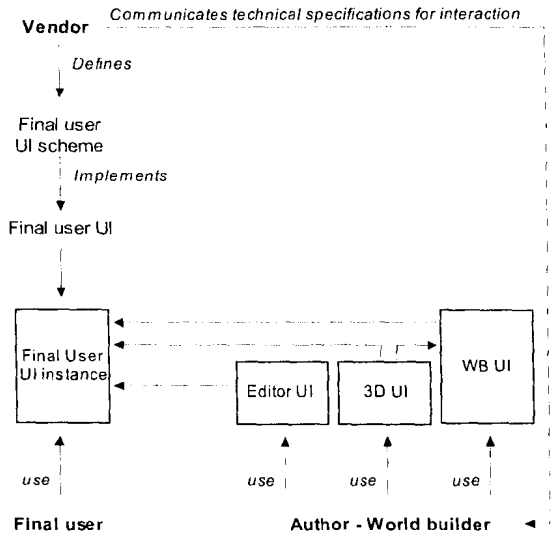

Fig. 1. The current production methodology for 3D interactive worlds

Final user	Author	World builder
familiar with the represented domain	expert in the particular author domain	expert in the geometric building of 3D worlds
able to navigate in 3D scenes using high level interaction objects	able to author the scenes with high level interaction objects	able to build complex behaviors using fine-grained languages that relate geometry to low level interaction objects

Fig. 2. The author's skills: a comparison with the final user and the world builder

We feel that in the recent story of interactive media too much emphasis has often been made on the technological side, even assigning to computer science technicians the role of experts in domains not belonging to their experience.
Our position is that a new range of subjects should be more involved in 3D environments, taking advantage of the 3D media without being constrained by low level technological issues. Our aim is to design a new generation of environments that could be defined *content-centered*, that is environments that take full advantage of interactive technology but, most of all, of the active participation of content experts.

We consider the concept of author in a new way: *authors are users expert in some particular domain (not necessarily in computer science) that want to build an interactive 3D experience for final users, using a given 3D world that they can manipulate through high level interaction objects belonging to their domain.* Figure 2 shows the skills of the re-defined author figure compared to the main roles of the traditional methodology.
The new methodology for designing interaction environments will follow the redefinition of author, including a different organization of phases and development tools matching the skills of the subjects. Figure 3 illustrates the proposed life cycle of the 3D interaction design with the new roles.
The term *interactive 3D experience* is used here to emphasize that the key point of a 3D simulation often is not only the represented geometry, but the whole simulation planned by the author and composed by the geometry, behaviors of objects and, in the case of a multi-user environment, even contributions of other actors in the scene. This is similar to what happens in the real world. For example a certain place, i.e. a square, has some geometric features given by the morphology of the square itself and of the buildings surrounding it, but most of all it is a scene where people can live different experiences.

The subjects involved

The *meta-author* has a deep knowledge of the content domain and didactic skills too; he/she interacts with the *interface designer*, a technician expert in low level interaction mechanisms, whose task is to build interfaces for authors and final users. The *meta-author* communicates with the final user too, in order to focus on didactic aspects of interaction. The focus of the *meta-author* activity is the definition of *typologies* of interactive experiences, resulting in a library of *classes of experiences* that can be instantiated by the authors.
The *author* has a deep knowledge of the content domain, and is concerned mainly with the communication of *contents*. He/she takes advantage of the meta-author design, chooses among the available classes of interactive experiences available the one that fits the application requirements, and fills it with contents. In addition the author searches the iconographic and the bibliographic bases as raw sources for the interactive presentation. Authors may need the support of editors for formatting text and images for the interactive presentation.
The *world builder* builds the animation for the 3D world and the widgets to activate them, following the technical specifications given by the interface designer, while the *3D modeler* is the responsible for the production of static 3D models for the interactive world. The *editors* are support figures that edit graphic and textual materials needed for the interactive worlds according to the author requests.

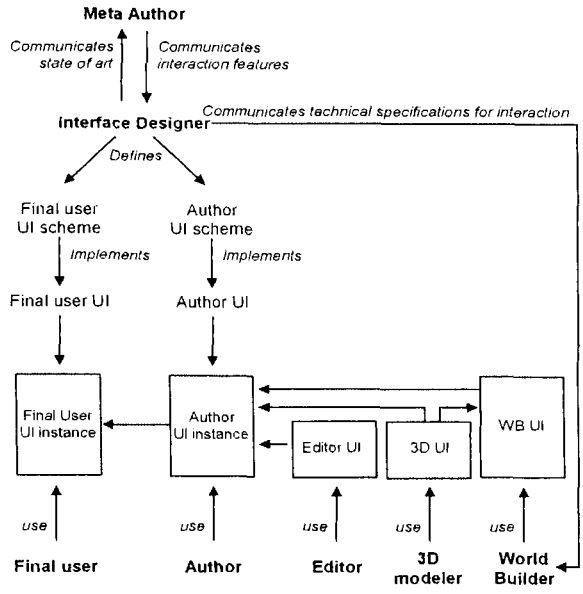

Fig. 3. The life cycle of 3d interaction design

A CONTENT-CENTERED METHODOLOGY

As evidenced from the definitions given above, there is a strong component of content specialists, shifting the attention from technical roles to content, in order to produce more meaningful virtual worlds. Besides, this introduces another fundamental element for the definition of the new methodology: the concept of *class of experience*.

This concept denotes a typology of general enough interactive experience that can be used as a template for particular uses. For example, in a virtual museum context meta-authors may introduce the class *Guided tour* to be subsequently specialized by authors with particular paths, in different museums and showing different artworks, still having the same basic interaction mechanisms: same walk modalities, artwork presentation, information detailing, and so on.

The purpose of this definition is to give a high level metaphor that can be easily understood by the authors. The subsequent user interface is based on the concept of experience, specifying the allowed behaviors for authors and final users. The aim of this re-formulation is to give authors and users a more intuitive metaphor for building worlds, opposed to the old methodology based on the composition of low level objects.

Besides, the concept of class of experience in the context of the new methodology is a consistent step towards modularity and code re-use; actually re-use is not limited to the 3D static models, but thanks to the libraries of classes of experiences even behaviors can be instantiated.

Finally, from the final user's point of view, the concept of experience helps to smooth the learning curve of 3D worlds: final users are presented the same interactive objects (widgets) for performing the same typology of behaviors in different instances of the same class of experiences.

A FOUR PHASES METHODOLOGY

For a better understanding of the role of the subjects involved, we briefly discuss the four main phases of the production methodology. The phases can be conceived as sequential, even if the feedback among them is fundamental, in order to improve the quality of the results, according to the principles of iterative design ([2]).

Conceptual phase

This phase is characterized by the identification of the content and interaction requests, in order to build a conceptual scheme for the author and the final user interfaces. The main role of this phase is interpreted by the meta author; this subject must have a deep knowledge of the contents domain and didactic skills too. The meta-author interacts with the interface designer (the technical counterpart of this phase) to take advantage of the current interaction technology, and communicates with the final user in order to focus on didactic aspects of interaction.
The conceptual phase has, as a result, the production of user interfaces (UI) schemes useful for defining a class of interaction experiences (for example the class *guided tours*). UI schemes are produced both for the final users and the authors, i.e., people instantiating the classes of experience.

Implementation phase

The interface designer, who has a deep knowledge of low level interaction mechanisms, builds the final user interface and the author interface on the basis of the UI schemes produced by the meta-author. The results of this phase are available for the authors who want to build interactive experiences belonging to the specific implemented class.
It is important to note that this implementation phase can be a personalization or a sub-setting of the capabilities of existing tools rather than a complete development of software from scratch.

The interface designer communicates to the world builder the technical specifications in order to coordinate the implementation efforts. The interface designer and the world builder have both technical roles, but the interface designer works at the level of classes of experiences supporting the meta-author, while the world builder works for the specific instance of a particular class, supporting the author.

Content development phase

Authors are the main protagonists of this third phase; they choose among the available classes of interactive experiences and instantiate the one that fits their particular needs. They take advantage of the skills of a number of complementary subjects to build the interactive experience.
In particular they usually need: a writer, for formatting textual information belonging to the interactive experience, since the 3D worlds we are talking about are often complemented by the presence of hypertextual material; a 2D graphic artist, for formatting bi-dimensional graphics; a 3D modeler, for shaping the 3D objects of the interactive worlds

Besides, the author may need to instantiate some particular interactive behavior designed by the meta-author. For example, the author may need to instantiate the behavior *history*, conceived by the meta-author to show the evolution of a venue belonging to the 3D world through time. In this case the author, who is aware of this feature existence through the author

interface, communicates to the world builder the particular animation he/she needs. The world builder, following the technical specifications given by the 2D designer, builds the animation and the required widgets.

Final user interaction phase

In this phase, the final user takes advantage of the efforts of all the other people involved, interacting with the contents of the 3D world composed by the author, through the interface implemented by the interface designer.
The final user interaction is monitored in order to improve both the usability of the user interface and, most of all, the effectiveness of content communication.

APPLYING THE METHODOLOGY TO GUIDED TOURS FOR CULTURAL HERITAGE

We applied the methodology to the domain of guided tours for cultural heritage applications in an educational context, referring to interactive experiences designed by one of the authors [3, 4] for Palazzo Grassi, a cultural institution in Venice, Italy. In recent years it has hosted several important exhibitions accompanied by virtual tours in 3D worlds related to the exhibitions themes [5].

Conceptual phase

The theme chosen for the validation of the methodology was general enough to originate a possible class of interactive experiences in 3D worlds.
The meta-author discussed with the interface designer the current state of art of technology, limiting the discussion to VRML worlds. In this reciprocal information exchange the interface designer received information about the kind of content and education techniques of the meta-author; reciprocally, the meta-author received a complete information about the interactive features offered by VRML language that best fit his/her needs for the development of guided tours. The use of VRML derived from the open standard and interoperability requisites of this language and from the availability of a number of tools and run-time engines.

In order to have a wider contribution for the definition of the interface schemes, we chose to write a first formulation of the interaction problem; this description was then given to a number of testers, splitting in this case the responsibility and the point of view of the meta-author for the definition of this crucial passage. The meta-author was then given the task to unify in an unique proposal all the different points of view.

The interaction problem relative to the class *guided tours for cultural heritage applications* was formulated in the following terms:

> *Your task is to prepare a guided tour in a virtual exhibition of some kind for students Start your tour from a given starting location and advance step by step to a sequence of ordered key locations to visit; you have the faculty to go on and to turn back to the previous location. You can reach the beginning and the end of the tour directly, e.g. by clicking over start and end buttons. You can also navigate without constrains using the four main directions.Entering specific locations can automatically activate sounds, spoken comments, animation sequences and information pages. Besides, clicking over selected objects belonging to the scene you may play sounds and animations or display information pages.*

The testers were given a certain amount of time to perform the task; they were asked to list in a written form the verbal sentences they would have used to de-

scribe the actions related to the guided tour, as if they should describe their point of view to a computer science technician for implementation.
This experimental approach produced, as a result, a number of phrases that reflected the subjects' view on the authoring of a guided tour. The results were then given to the meta-author that summarized them in a list of actions such as " set this view as the starting point of the tour", " change location *x*", " start/stop animation when user gets to location *x*", and so on. Some visual schemes on paper were also drawn by the meta-author to have a first rough visualization of the interfaces for the final user and for the author.

Implementation phase

The written sentences and the paper schemes were then used by the 2D designer for the implementation phase. These basic materials were analyzed in order to establish consistency between the features of the final user interface and the author interface.
Then the 2D designer implemented the user and the author interface. For this experiment only the final user interface was fully implemented, while the author interface was given as a partially functional front end.

Content development phase

The author interface resulting from the implementation phase was at this point filled with content to create the *Einstein Tower guided tour*: the 3D model of the building, texts and iconography were used as raw materials to simulate the application of the new methodology.
The simplified interaction mechanisms provided by the author interface were proficiently used by the authors, who found implemented here the interaction modalities described in the first phase (conceptual phase) by the meta-author in the form of verbal action and visual schemes on paper.

The prototype demonstrated to be suitable to produce experiences similar to those ones produced before with the old methodology. This is an important result: in particular the key point is that using the interface resulting from the proposed methodology a new class of authors (as previously defined) was enabled to produce significant 3D experiences collaborating with a pool of computer science experts and other collaborators, but without knowing the peculiarities of VRML language and low level implementation details.

Final user interaction phase

The production of experiences similar to those previously obtained in the first implementations of the 3D worlds for the exhibitions of Palazzo Grassi resulted, not surprisingly, in similar user feedback. Even in this case we registered benefits in terms of simplification of navigation and augmented the usability for the concurrent use of visual and audio information, and hypertext.
Nevertheless it is important to notice that the availability of these tools should take additional benefits even for final users: in particular the definition of classes of experiences and the subsequent definition of a unified interface for each class (like the class *guided tours for cultural applications*) gives final users a standardized way to interact in order to perform similar tasks.

CONTENT CENTERED AND USER CENTERED APPROACH: A COMPARISON

It is worth to compare our approach with the *user centered* approach [6]. The *user centered* design is characterized by a strong attention toward the user; it was born as an alternative approach to the development practice which assumes that the understanding of the user needs is im-

plicit in the design of products. Unfortunately this assumption is misleading: applying this philosophy, only technology guides the development of projects and this often generates products that are not easy to use, unsatisfied customers, difficulties on technical support and training and so on.
Quoting [7], "*User centered design is a method for designing ease of use into the total user experience with products ... It calls for a multidisciplinary team to design everything the user sees and touches and to gather user input and feedback during each stage of the development process ... User centered design focus heavily on understanding users and gathering input and feedback from them throughout the development cycle*".

In other words *user centered* design involves users in all the phases of the development process in order to obtain a better result. Our methodology recognizes the benefits of the user centered approach and goes a step beyond; if according to the user centered methodology users are *consulted* all through the development process, the content centered approach encourages users to *actively participate* in the process of creating the product.

We have emphasized in the previous discussion that the direct involvement of authors, supported by the creation of tools that can be manipulated without a deep knowledge of the computer science world, can greatly improve the quality of contents, especially in computer supported education. That is the reason why in our approach the content expert is not an external consultant, but is the key figure of a content centered methodology, an active part of that multidisciplinary team required by the user centered methodology. We can say that our methodology doesn't want to substitute, but rather to integrate the positive results of the *user centered* methodology with a more active role for users in order to improve the quality of content.

CONCLUSION

In this paper we have discussed the weakness of the current process of building virtual worlds for interactive experiences. We have analyzed the difficulties to exploit the full potential of the 3D media, related to the persistence of an old authoring model characterized by the constant requirement of high level technical skills all through the 3D building process, and to the absence of tools for experts in the content domain to build 3D experiences without being involved in low level technical details;
We then have formulated a new methodology based on an approach that we defined *content-centered*, because of its strong attention towards professional skills of content experts. This approach is characterized by a re-definition of the author and by an enlargement of the skills required by the new potentialities of expression offered by the concurrent advances in hardware and software technologies.

The methodology was then applied to the class of experiences of guided tours for cultural heritage applications in an educational context. The methodology was tested generating a guided tour for an experience previously built with the traditional approach. The experimental results demonstrated that this methodology enables authors to produce significant 3D experiences collaborating with a team of computer science experts and other technicians, but without entering into technical details about 3D modeling language and tools.

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