Creating Web3D Educational Stories from Crowdsourced Annotations

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Abstract—3D representation and storytelling are two powerful means for educating students while engaging them. This paper describes a novel software architecture that couples them for creating engaging linear narrations that can be shared on the web. The architecture takes advantage of a previous work focused on the semantic annotation of 3D worlds that allows the users to go beyond the simple navigation of 3D objects, permitting to retrieve them with different search tools. The novelty of our architecture is that authors don’t have to build stories from scratch, but can take advantage of the crowdsourced effort of all the users accessing the platform, which can contribute providing assets or annotating objects. At our best knowledge no existing workflow includes the collaborative annotation of 3D worlds and the possibility to create stories on the top of it. Another feature of our design is the possibility for users to switch from and to any of the available activities during the same session. This integration offers the possibility to define a complex user experience, even starting from a simple linear narration. The visual interfaces of the system will be described in relation to a case study focused on culture heritage.

I. INTRODUCTION

3D representation for the web has been available since the advent of the first VRML specification [1]. From 1995 to present different specifications have been proposed. Millions of users have accessed 3D worlds using both open-source and proprietary browsers and platforms, in some cases sharing the experience with remote users, as it happens for 3D multi-users environments such as Second Life. Usually the access to these environments is realized using browsing paradigms that allow the users to navigate the 3D worlds walking, flying or rotating around viewpoints chosen by the content authors. Unfortunately this access model enables often only a partial exploitation of the 3D world that results from a complex and time-consuming modeling work. That is the reason why in recent years a number of researchers have proposed the use of annotations for exploiting further the potential of 3D worlds. The association of high-level descriptions to geometric entities has enabled the access to content through searching paradigms, retrieving specific components of the 3D environments after a keyword-based search or more sophisticated queries involving also spatial operators. Besides, the introduction of folksonomic annotation styles has enabled common users to describe the 3D components with their own words.

In this work the term annotation will be referred both to the use of keywords belonging to an ontology/taxonomy, to free tags belonging to a folksonomy and even to extended description associated to 3D entities. The novel approach presented in this work builds on a previous research work related to 3D annotation [2] but goes a step further, introducing the opportunity to use the annotation work done by the users of the ToBoA-3D platform for creating 3D narrations that can be shared on the web. The shift is paramount: from the free navigation and search paradigm to the possibility to design and share linear narrations through a 3D environment. In particular, in our proposal, stories don’t start from scratch, but from the annotation work done by the users of a shared platform for annotating 3D environments. The overall workflow is novel as well. While some proposals described in literature take advantage of tools for enabling single content experts to annotate 3D objects [3], no workflow includes the crowdsourced annotation and the possibility to create a story on the top of it. This approach opens a number of interesting opportunities for the educational domain, starting from the creations of engaging lessons delivered as narrations. The software architecture described in this work can be seen as a form of sentient multimedia system, because it allows people distributed over the network to gather, annotate, process and retrieve distributed Web3D resources, taking advantage of the crowdsourced effort done by many users that play different parts (e.g., content provider, content annotator, content browser, story creator and listener) even in the same session. The rest of the work is organized as follows: Section II will consider the related work; Section III will describe the features of the annotation architecture where we started from; Section IV will describe the requirements of our storytelling system, focusing in particular on the crowdsourced approach and the integration of the different user activities; Section V will present the user interfaces for the creation and the navigation of stories; Section VI will draw the conclusions.

II. RELATED WORK

Among the different proposals for describing 3D objects and worlds on the net, a special role for their longevity is reserved to VRML and to its heir X3D [4]. VRML and X3D plugins associated to web browsers have allowed millions of web users to navigate Web3D worlds. The latest implementations permit even to play X3D worlds using only standard web browsers compliant with WebGL [5], enlarging further the number of platforms and users that can access 3D representations on the web. While the representation of 3D geometrical entities on the web is an interesting opportunity for communicating knowledge, their annotation permits to exploit
the potential of virtual representation, allowing users to go beyond the simple navigation of 3D worlds. For this reason in the last few years a number of proposals for adding semantics to the components of 3D worlds have been made, based on different specifications such as MPEG-7 [6], Collada [7] or X3D [2]. While most of these proposals focus on annotations referred to predefined ontologies, some researchers have focused also on the use of tags as a complementary means for annotating 3D entities with an informal approach more suited to common people [2]. The benefits of using social tagging in education and, in particular, in cultural heritage contexts have already been described in [8].

As noted by Scopigno et al. [9], the greater challenge for digital technologies is the creation of tools that use 3D models for supporting cultural heritage research. In this respect, the annotation of 3D models is only a first step for supporting more appropriately cultural heritage studies. We claim that the application of storytelling techniques to annotated 3D worlds belonging to the cultural heritage domain can bring great advantages for researchers and pupils. The benefits of storytelling for educational experiences have been demonstrated by several studies [10] [11]. As far as cultural heritage is concerned, in literature there are different examples showing how storytelling techniques can be profitably used for engaging students while learning. The techniques used can be different, relating the different fragments of the narratives to photos and videos [12], real environments [13] and virtual representations [14]. As far as the latter ones are concerned, most examples are focused on the delivery of linear and non-linear stories rather than on authoring tools. The proposals for the creation of stories can be split in two different categories: the “autonomous agents approach”, where a set of software agents influences the evolution of the story [15], and the “drama manager approach”, where a software architecture controls the narration on the basis of the story model and of the narrative choices of the author [16]. The approach described by Kriegel et al. [17] belongs to the first category. The authors present an authoring tool for the emergent narrative agent architecture FAtiMA, which powers the virtual bullying drama FearNot!. The system allows the creation of a story starting from the behavior of the characters. The authors specify the actions that the character can perform, the goal that he can reach and the way in which he interacts with the story events. The process starts with the decision on the story setting, and the placement of the characters and objects in the story. After the set-up of the scene, the author specifies the behavior of all the participating characters. Both the delivery and the authoring of the story happen inside a 3D environment. The approaches described in [18], [19] and [20] belong to the category of drama managers, with a stronger emphasis on the story structure rather than on the characters. Mehm et al. [18] describe a system named StoryTec which allows the creation of story-based serious games. This system is conceived for people with low skills in computer science. Teachers can use this tool for creating small educational games that can be played during courses; game programmers and content producers can take advantage of StoryTec as a prototyping environment for developing and testing ideas. The story is divided in units, which the author can link together in order to create a path through the story. Once the story path is established, the author defines the details by adding objects to the scene and specifies the events and the actions for each step of the story. The whole system is built on a hybrid 2D/3D framework based on the Windows Presentation Foundation libraries and provides different components for managing the creation of the narration: stage editor, story editor and resource center. The first one is a WYSIWYG editor and is required to define the details and objects of the single stage of the story. The author can take any object available on the resource center (for example a 2D or 3D asset, a sound file) and insert it into the stage using a drag and drop interface. The second component, the story editor, allows creating the story structure. This interface allows the author to specify the path through the story, connecting with arrows the visual objects that represent the stages. The author takes advantage of the story editor also for specifying complementary information for the playing phase, such as annotations or the expected time the user will remain in a given stage.

Robertson et al. [19] introduce the authoring tool named Adventure Author. The tool is based on a 3D game engine which gives to the story a graphical aspect similar to the graphics of commercial videogames. This tool has been
concepted for young students, who can experiment the creation of non linear interactive stories. The educational aspect of the tool relies on the fact that users are encouraged to use their imagination for structuring the possible evolution of the story. The system is made of two main components: the authoring interface for the definition of the interactive story and the game engine for rendering the story. The JGraph library [21] has been used for giving the author the possibility to define the non linear structure of stories. The nodes of the acyclic graph represent the scenes of the story. Each scene contains different information, such as textual descriptions which will be displayed to the player entering the scene and interactive conversations between the characters of the story. The author can also take advantage of a set of wizards for creating new characters, locations and story scenes. At the end of the story creation process, the user will take the role of one of the characters of the story and will interact in a 3D world.

Barrenho et al. [20] describe an interesting authoring tool for the InStory platform, designed for the development of exploratory geo-referenced activities. InStory has been developed for mobile devices and allows the user to interact with the story by moving inside a physical space of cultural, historical or natural interest. The system divides the creation work in two different phases. In the first phase the InAuthor component allows the user to specify the nodes of the story, corresponding to different activities, and to define the connections among them. The interface is articulated in different modules. The first one allows users to create the new nodes and to browse those ones that have been previously created. The second one allows users to position the nodes on a map and to link them for creating the story path. In the second phase the InContent component is used to assign the content to the nodes. The interface is composed by a workspace for the visual creation of content, with a list of the elements that can be used. Authors have just to drag and drop the desired media or interface elements on the workspace representing the client device screen and place them in the desired position. After the drag and drop operation, all the properties of the elements can be edited for reaching the final result.

The approach proposed in this work is compliant with the drama manager approach described above, because we were more interested in the development of a storytelling system suitable to educational purposes, more controllable for what concerned the number of choices and endings. As far as the delivery of narrations is concerned, we must point out that in a number of proposals available in literature stories can be published on the web, for maximizing the possibility of access by the users, but the potential of the net is not always exploited in terms of collaboration and content sharing. Our proposal differs from the others that we have analyzed, because it is strongly characterized by a web-based collaborative approach that allows the story authors to take advantage, for the story creation process, of the work done by the other users of the platform in terms of creation of assets and annotations. The authors of stories themselves can add assets and annotations, contributing to the growth of the repositories. At our best knowledge no workflow includes the collaborative annotation of 3D worlds and the possibility to create stories on the top of it. Finally, in the current implementation our approach is less complex for what concerns the structure of the story proposal, focusing on the design of linear stories that are easier to create for content experts not particularly skilled and easier to follow for pupils. In spite of this simplicity, the possibility to switch from and to the different user activities gives the possibility to create a rewarding user experience, as it will be explained in the following sections.

III. THE ANNOTATION PLATFORM

The tool for creating stories presented in this work is conceived as a significant step in the evolution of the ToBoA-3D platform for annotating Web3D environments, whose first design and implementation has been described in [2]. The client-server platform is entirely based on the use of web technologies, including X3D, XHTML, CSS and Javascript on the client side; Apache, MYSQL and PHP on the server side. The annotation platform can be accessed using a web browser and the BS Contact Player [22] for navigating the X3D worlds. 3D annotations are applied to a repository of 3D worlds compliant with the X3D standard, uploaded by registered users. The annotations result from the crowdsourced effort done by many users, even those ones that didn't upload the worlds, as it happens for the free tagging in the hypertextual web 2.0. Each user can add one or more tags to any simple or grouped 3D entity and she can even create new logical groups to tag, in the case the 3D modeler didn't define a given group of entities. While all the registered users are enabled to add tags, the owner of a given world can adopt also a more formal annotation style, referencing to a closed set of keywords belonging to a formal ontology. Because the space is an important component of the human experience, the system allows users to add annotations not only to 3D objects but even to spaces defined by them. Fig. 1 shows the selection and annotation of a 3D object, an external staircase annotated as an occurrence of the class “stair”, belonging to an ontology that describes architectural artifacts. In the example the user has inserted also a synonym, “staircase”, and an hyper textual reference to an external description. An additional field, partially visible in the figure, allows users to add one or more comma separated tags. At the end of the process the visual interface allows to record the annotated object and the reference to the identity of the user that has annotated it. The annotated components of 3D worlds can be searched using both a simple - Google like - keyword search (see Fig. 2) or a more sophisticated - yet simple to use -
visual interface that permits to specify also spatial relations (e.g., search all the objects, annotated as “ionic column”, embedded in spaces annotated as “atrium”, see Fig. 3). In both cases the system presents the query results as a clickable lists of items that can be selected for teleporting the user in front of the retrieved entities. Further details can be found in [2] and [23]. During the navigational phase the user can access directly any 3D world uploaded to the system and visualize the textual labels related to the annotated objects, as it will be explained in detail in Section V.

IV. DESIGN AND IMPLEMENTATION OF CROWDSOURCED STORYTELLING

The decision of building the storytelling module on the top of the annotation platform was one of the early choices of our design. The main reason was the will to break the traditional production workflow of interactive 3D worlds, where often the decisions about the user experience inside the 3D worlds are taken by the 3D modelers and by the interaction designers. This often leads to poor results from a narrative point of view. What we wanted instead was to design an architecture supporting the effort of a community of users, targeted at the creation of interesting educational stories. While some workflows described in literature take advantage of tools for enabling single content experts to annotate 3D objects [3], there is no workflow that includes the collaborative annotation and the possibility to create a story on the top of it. In our proposal the story creators don’t need to start from scratch, but can take advantage of the 3D assets and the annotations provided by a community of registered users that include of course content experts. In our vision the story creator is an active contributor to the assets as well, uploading 3D worlds and defining annotations that are functional to the story she's going to create, but that contribute also to the overall growth of the repository of annotated 3D environments.

We define a “story” as a sequence of stages that have a specific location and that are associated to different multimedia content, such as images, audio and video. While in literature there are more sophisticated story models (e.g., non linear models), we started from the linear structure because of its suitability to educational applications. Linear stories are easier to create and easier to follow for novices. Besides, they offer a constrained path that fits to educational needs. Even with these limitations, our storytelling application offers a significant potential, giving for example to a teacher the possibility to create a narration for her pupils and then to ask them to play and comment it, adding contextual annotations related to objects, spaces and story stages. As a matter of fact, as displayed by Fig. 4, a peculiar feature of our design is the integration of the different activities that can be made by the users of the platform (i.e., annotation, navigation, query, story creation and navigation) and the possibility to switch from and to any of them during the same session. The figure highlights also three categories of activities: information retrieval, information enhancement and storytelling. While the integration of the navigation and query activities (information retrieval) is recommended since the advent of the first web [24] for enhancing the “findability” of information objects, the advent of the hyper textual web 2.0 has brought the possibility for the web user to play a more active role, enhancing the information available on the web sites through different annotation techniques (information enhancement). In a typical web 2.0 session the user plays the part of the content reader and author, switching seamlessly between the two different roles. In the prior version of our annotation architecture [2] we brought to the Web 3D the same possibility, previously available only for the hyper textual web, to switch from and to the activities related to the information retrieval and enhancement.

In this work we introduce, with the novel architecture, the activities related to the creation and navigation of stories (storytelling), going a step further with the integration of the different activities in a rewarding experience. If the paths from the information retrieval and enhancement activities to storytelling seem interesting and even obvious, because stories are created from the annotated Web3D objects, the design choice of allowing the user to select the opposite path brings additional benefits. In particular the possibility to shift from the storytelling to the other activities can be interesting for the ordinary user wanting to explore a world he's hearing a story about or to add information he's aware of about one of the objects that are visualized. This chance is even more interesting for educational purposes: for example the user may be asked by the story teller (the teacher or another content expert) to explore the world starting from the locations of the story or to add annotations to the objects for proving their cognitive involvement and knowledge acquisition (see Section V). In this context, an interesting feature of our approach is that all the assets, annotations and stories are social but not anonymous. Resuming, the integration of the different activities gives the possibility, starting from a simple linear narration, to define a complex educational experience. The stories will be created...
and played through a set of interfaces that will be described in the following section. At any time the users of the platform will be enabled to switch seamlessly among the different activities, for playing different roles even in the same session.

V. THE VISUAL INTERFACES FOR STORYTELLING

After the definition of the requirements for the new storytelling modules, we designed the set of interfaces supporting the sequence of tasks functional to the creation and listening of the narrations: the gathering of interesting annotated objects and spaces, their selection and organization in an ordered sequence of story stages, the association of story stages to multimedia content, the preview and the final play. The design process gave as a result a new set of interfaces (Fig. 6 and 7). Also the set of existing interfaces (Fig. 1, 2, 3 and 5) underwent a consistent process of redesign as well, for introducing novel functionalities and for supporting the integration of the different activities. The technical implementation was completely revised, taking advantage of the Angular.js [25] and Bootstrap [26] frameworks.

As already underlined in the previous Section the architecture supports a number of user activities that make sense for different scenarios and personas: the 3D modeler wanting to contribute to the social platform uploading a new model, the casual user navigating and tagging the available 3D content, the art historian using the advanced visual search module for retrieving and examining specific architectural patterns. In this Section we will describe the visual interfaces for storytelling in relation to two different personas and use scenarios: the art expert creating an educational story for his class of students and the art student listening to the story.

1) The art expert creating an educational narration.

The art expert wants to take advantage of the ToBoA-3D platform for creating a narration for his class of students. His goal is to provide students with information about the features of the architectures designed by Andrea Palladio, one of the most renewed architects of the Italian Renaissance. He wants also to check what the students have learned listening to his narration. In the initial phase the art expert explores the 3D content of the platform, accessing directly the worlds available from the repository list (Fig. 2, left panel) or querying the system (Fig. 3). In both cases, as a final result, the art expert enters the navigational interface displayed in Fig. 5. The main part of the interface is occupied by the 3D representation. The expert explores the available 3D scenes for finding interesting locations and objects that will be part of the narration. When he selects a given object (e.g., the ionic column evidenced by the blue bounding box), a semi-transparent rectangle highlights all the annotations associated to it. The right part of the screen evidences all the information associated to the annotation currently selected, including the author and the reference to an extended hyper textual description. The interface features a button placed on the top right corner of the screen, for saving the current viewpoint as a visual bookmark and associating a label to it (i.e., by default the name of the annotation). If the annotation includes also an extended description of the object (in Fig. 5 the link to a Wikipedia page), this reference is saved for future uses in the story. The art expert defines also other visual bookmarks, associated to viewpoints derived from the simple navigation of the 3D worlds or from visual queries (Fig. 3). The visual bookmarks are gathered across all the set of 3D worlds that belong to the repository, enabling the expert to define narrations whose stages are localized in different 3D environments. A simple interface, accessible from the main menu of the web application, allows the author to manage the collection of visual bookmarks progressively gathered, allowing him to modify their order, change their labels or delete them. The expert accesses the initial interface for creating the structure of the story from the item “MyStories” of the web main application menu. This interface allows the story creator to define the general data associated to the story: the title, the name of the author and the summary. After filling in the initial data, the story author proceeds to the main interface for creating stories, displayed in (Fig. 6-1). The interface allows the story creators to define - through simple drag-and-drop operations - the sequence of the story stages. The stages, represented in the central panel of the interface, derive from a selection of the visual bookmarks that the author gathered before and that are represented on the left panel. The icons
The student then prepares, with a simple webcam, the set of videos that define the narrative content and uploads them using the right panel of the interface, deciding which video to associate to each stage. While some videos contain only narrative content, others contain also instructions for the students. For example, in some of the videos the art expert asks his pupils to navigate the 3D world around the location of the current stage and to tag certain architectural components, recalling the explanations given in the previous stages of the story. He will check later the work done by the students for verifying the acquisition of skills and knowledge. The story author can decide also to include in the stage the extended descriptions associated to the story annotations (e.g., the link to the Wikipedia page discussed before), for giving the pupils the possibility to read additional information after having listened to the narration. At any time the content author can visualize the result of his authoring effort, clicking the Preview button. The final result is a linear story spanning through a set of stages belonging to different 3D worlds, each one containing the model of a famous building by Andrea Palladio.

2) The student listening to a story and doing homework.

The art student uses the ToBoA-3D platform as a tool for remote learning that enables him to learn new concepts through storytelling and to send feedback to his teacher. The student receives an assignment from his teacher, as homework. The student is asked to listen to a linear story focused on the architecture of Andrea Palladio and to complete the assignments specified during the narration. The student accesses the visual interface for listening to stories from the main page of the web application, displayed in Fig. 2. The main page displays on the right panel a list of the last authored stories and of their authors. A full list can be accessed from the button placed at the bottom of the panel. The student, after having selected the story created by his teacher, enters the interface for playing the stories, displayed in Fig. 7. While the left area of the interface represents the 3D environment, the right area is reserved to the presentation of the audio-visual content. The lower part of the screen is reserved to the visualization of the story summary and to the controls for navigating through the different stages of the narration. The student presses the “play” icon for starting the narration. The engine plays the stages of the story, following the sequence defined by the teacher during the creation of the narration. The system takes care of downloading the required 3D environments for giving to the user a seamless experience. For each stage the application engine shows the related 3D location or object and plays automatically the associated video content. In Fig. 7 the teacher explains the features of the ionic column, relating it to a well-known building by Andrea Palladio, Villa Vigardolo. At any time the student can stop the automatic play of the story, for moving through the different steps at his own pace or navigating freely the 3D environment. In the example displayed, at the end of the narration of the stage the student is asked to navigate the 3D world around the current location and tag the architectural components around him, recalling the terms used by the teacher during the explanation.

After the completion the teacher will have the opportunity to verify the knowledge acquired by his pupils. For example the teacher might navigate the 3D world and select a given 3D object for visualizing the annotations, which are always associated to a specific author. Alternatively the teacher might search all the objects tagged by a given student, filling in the field “author” on the right panel of the search interface (see Fig. 3).

VI. Conclusion

The work done so far has led to the design and to the implementation of a storytelling system for creating narrations based on a repository of annotated 3D worlds. As far as the usability of the system is concerned, we plan to start an
experimentation with end users chosen among different categories, such as content experts, teachers and students, exploring also new educational scenarios characterized by the use of more complex narrative structures. The experimentation will be also an opportunity to have a feedback about the novel workflow for content production and delivery, measuring the users' appreciation and the impact on their activities.

REFERENCES


