

An Authoring Tool for Interactive Digital Storytelling

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Abstract

Stories that are read are usually linear and fixed in their form and structure. Stories that are told are often flexible in these respects: the storyteller can change order and content in response to the audience reaction and participation. Interactive multimedia and digital storytelling technologies now make the presentation of interactive stories possible, with non-linear narrative flow and dynamic character definitions and developments. Authoring such interactive stories has thus become a new challenge for authors and artists.

We report on the development and initial tests of a prototype authoring support tool that is intended to support authors in the design, construction and specification of Digital Interactive Stories for multimedia presentation platforms. This Authoring Tool is part of the art-E-fact project- a collaborative project funded by the EU- in which it serves as an experimental platform for understanding how artists and authors want to create these new kinds of "Digital Stories".

Categories and Subject Descriptors (according to ACM CCS): D.2 [Software engineering]: H.5 [Information interfaces and presentation]: J.5 [Arts and Humanities]:

1. Introduction

Storytelling is the way people have communicated for years. Stories and storytelling remain in our memory since early childhood. Who does not remember the stories we were told when we were young? The enchantment of such stories comes, in part, from the presence of the storyteller.

A storyteller, more than just reading a text, uses the voice, the facial expression, and appropriate gesticulations and posture in order to convey the ambience and the content of the story [SRP03]. The virtual storyteller is a synthetic character, immersed in a 3D virtual world, which narrates the content of a story in a natural way, expressing the proper emotional state adapted to the progress of the story.

But storytelling is not only narrating a text in a compelling way. It also involves understanding the audience, reacting to it and even adapting the story and the way the story is told to the cues given by the audience. Real human storytellers do not always tell the story in the same way. They observe their "audience" and adapt the way they are telling the story to better respond to their reactions. This means that the storyteller gets feedback from the audience and uses this feedback to shape the story the way it should be told at that particular moment.

The most common conception of story is a linear sequence of scenes, like a book or a movie. But, in recent times, people and Information and Communication Technologies are providing new means for a more sophisticated way of stories. The participant should be free to decide which part of the story he/she is interested in, and only receive the information about it.

The Authoring Tool presented in this paper has been designed to create interactive stories by artists and authors, and show them in art exhibits. These stories provide participants in these exhibitions with information about the art pieces shown in the exhibit. Interaction in this project means that, besides all the things that the artist must define for a linear story, he/she has to define the way the story flows regarding to the actions of the participants.

The first sections of the paper present related work concerning authoring tools and digital storytelling, and a brief introduction to the art-E-fact project. Section 4 presents the requirements of the artists concerning the Authoring Tool, meanwhile the following three sections explain in depth the components of the tool. Finally, the evaluation process of the Authoring Tool during a project Workshop is described and some final conclusions and future work are listed.

2. Related work

Multimedia authoring can be used to create anything from simple slide shows to full-blown games and interactive applications. Multimedia authoring tools are used to create interactive presentations, screen savers, games, CDs and DVDs.

Many implemented projects have dealt with authoring multimedia files. For instance, DINAH is an authoring tool used for the creation of interactive narratives [VB02] that dynamically selects the most appropriate small story clips from a relational database and prompts the user to play the role of the avatar, thus building the story. Another example could be MPEG-Pro [DKRS01], a software dedicated to authoring 2D multimedia compliant with the latest MPEG-4 systems specifications. It allows the content creator to compose together spatially and temporally large numbers of objects of many different types: video, voice, music, text, 2D and 3D graphics.

Although 2D and 3D authoring environments have been one of the most intensively explored topics in desktop and Virtual Reality interfaces, there are far fewer attempts to develop authoring interfaces for Mixed Reality. The Tiles system [PTB*01] provides users with different interaction techniques so that they can manipulate virtual objects using the same input devices they use in the physical world—their two hands. Moreover, the European funded project AMIRE [GHP*02] has defined and implemented a software system that allows content experts to easily design and implement Mixed Reality applications.

Concerning non-linear interactive storytelling, research has developed in a spectacular fashion over the last few years, due to the growing interest in its potential applications in training or entertainment. Schneider et al [SBH03] have developed a Storyengine as a part of a storytelling system that has been evaluated within an edutainment application during a real city tour. On the other hand, the Virtual Theatre project [HR99] aims at providing a multimedia environment in which users can play all of the creative roles associated with producing and performing plays and stories in an improvisational theatre company.

Finally, there are also commercial packages that offer some storytelling approaches, such as Virtools Software for the implementation of 3D interactive applications for industry and games, or EON-Reality for the creation of 3D models for different sectors such as automotive, defense or learning.

3. The art-E-fact project

The aim of the art-E-fact project (IST-2001-37924) is to create a generic platform for Interactive Storytelling in Mixed Reality that allows artists to create artistic expressions in an original way within a cultural context between the virtual and the physical reality.

With the means of Interactive Storytelling and Mixed Reality of virtual autonomous characters, multimedia, physical props and devices, and multimodal human-oriented interactions for artistic expression are enabled. The target platform is both a new medium for the communication of informational content, and a new form of act. The main objectives of the art-E-fact project are:

- to develop a generic platform for Interactive Storytelling in Mixed Reality that allows artists to create artistic expressions in an original way, within a cultural context between the virtual ("new") and the physical ("traditional") reality,
- to use the platform to actually build a compelling Mixed Reality installation that facilitates the access to a knowledge base of inspirational material of art history—reflecting the way humans created art since at least 4000 years,
- to involve artists and the analysis of artistic methods, on from the beginning of the project through all project phases, as well as
- to create a showcase within an interdisciplinary team that can be used for the evaluation of artistic methods, as well as for the diffusion and exploitation of the results, leading to more accessible tools for artistic expression in the future.

Artists can create a Mixed Reality exhibit by using the generic system to shape a specific instance of expression (Figure 1). They make choices of specific interaction devices and physical props to be used for anthropomorphic interactions, as well as corresponding interaction metaphors; they define dialogues with a degree of autonomy and behaviour of virtual characters, and they create multimedia elements to be accessed during run-time.

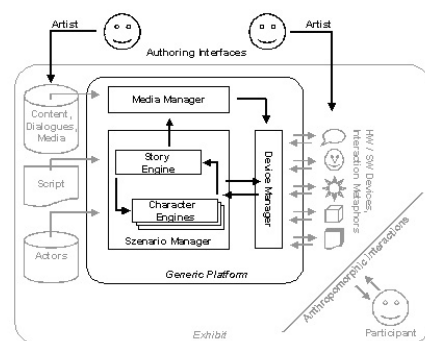


Figure 1: Generic platform (black, including authoring interfaces) to be used by the artists who create an exhibit (grey), which is an interactive storytelling application in Mixed Reality.

art-E-fact aims at the provision of Mixed Reality technology addressing two directions: firstly, to provide a generic

platform for artistic expression to enable interactive exploration of artworks, and secondly, to ease the task of artwork creation by providing a standard VRML compatible VR framework enhanced with interaction and sensor features.

The Mixed Reality generic platform for Interactive Storytelling serves as an experimental platform allowing authors with artistic or humanistic backgrounds to make design decisions that go beyond the state-of-the-art creation systems of digital media. In summary, it is possible for artists to include anthropomorphic interactions such as gestures, body poses into their design of Mixed Realities, and to direct life-like avatars in order to act.

4. Requirements of the Authoring Tool

A major feature of the methodological approach within the art-E-fact project has been the direct involvement of the specific content experts from the beginning of the project. As the focus is on the creation of artistic expressions in an original way, artists have played a key role in the definition of the requirements for the Authoring Tool.

- User-centred approach. The artist is the key player in the whole process, since he/she manipulates the 3D geometry, defines the virtual characters and organises the content. He/she is directly responsible for designing all the aspects of the application, from the style of presentation to the interaction model.
- Content-based approach. There is a strong component of content specialists, shifting the attention from technical roles to content, in order to produce more meaningful experiences. Authors are provided with a more intuitive metaphor for building interactive stories.
- Generic platform. The architecture of the generic platform is independent from the artistic content of different databases. Although the art experience is based on a subset of the existing artworks, the Authoring Tool is generic enough, so that it can handle new art experiences based on other existing artworks of the content providers.
- Multilingual application. At each point of the authoring process, the artist can view the menus in his/her own language. Thus, the author is always overtly working in the language he/she knows.
- Personalization of the Authoring Tool. It is important that users with different levels of skills are able to use the platform. The authoring interfaces for the art-E-fact project overcome these problems. They provide both novice and advanced users a single system on which to implement the art experiences, with the opportunity for novice users to smoothly migrate to creating more complex applications.
- Extensibility and modularity. The system is able to cope with new hardware and emerging Human-Computer Interaction (HCI) technologies with minimal changes to its architecture. The system remains consistent in the way it is used.

Although some of the existing applications are clearly connected to one or more of the objectives of the art-E-fact project as previously described, most of them comply with a part of the requirements of the Authoring Tool. Moreover, it is not possible to integrate different functionalities to these applications in order to develop a new complete interface.

Therefore, we have decided to build our own Authoring Tool, so that to have a complete control on the implementation phase and fulfil all the requirements of the artists. The basic modules of the Authoring Tool have been implemented in Java as the best approach for a generic platform which should be independent of the platform on which is being run.

5. Writing the script: the Story window

The terms narrative and story have been interpreted differently by different people. Story is frequently used as a reference to some general or abstract description of a collection of events, people and/or things, which have a causal or temporal linkage. To tell a story means, therefore, to choose a medium for the telling.

Digital storytelling provides tools for the creation of non-linear stories based on narrative pieces or scenes. A story model defines abstract morphological functions that provide dramatic closure based on predefined structures represented in order to certain occurrences.

A scene is an elementary entity, which is roughly equivalent to a dramaturgic understanding of a "scene" concept. These scenes on their own do not constitute a single narrative path, but instead act as building blocks for constructing many different narratives (Figure 2). The different paths between scenes define the script of the story.

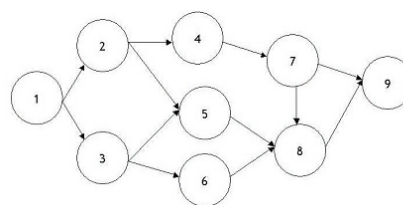


Figure 2: A representation of the non-linear narrative as a network of connected scenes.

Any story must be coherent; that is, at any point in the story, the circumstances at that specific point must be consistent with everything that happened beforehand. This does not mean that stories must be predictable, rather than they should make sense in a satisfying manner. The difficulty with using interactive storytelling is to ensure that a high degree of participant's freedom is combined with the story in a coherent way at every instance of the art experience.

In order to facilitate the process of building the story model, artists are provided with a graphical interface where the script is represented as a collection of bubbles (Figure 3). Each node of the graph represents a scene and the links between nodes represent the networking of the scenes. The diversion of the narrative flow is completely based on the interaction of the participants.

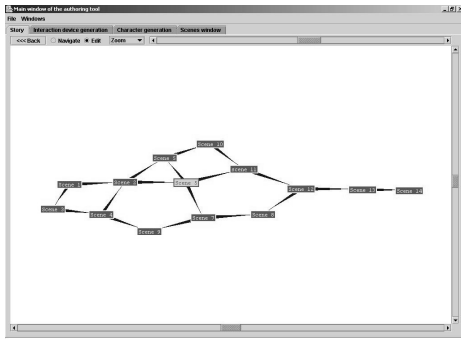


Figure 3: Screenshot of the graphical editor for non-linear interactive storytelling applications (Story window).

A great effort has been put on the selection of the graphical editor in order to fulfil the usability requirements of the artists. Therefore, the implementation of the graphical interface is based on the open source graph editor Touch Graph Link Browser. In order to create a new story, it is enough to click and insert the name of a new scene. The rest of the scenes are created just by drag-and-drop.

6. Accessing the content: the Content browser

Artists using the platform have to create stories or experiences concerning one or more selected artworks, including their main features, technical data, historical context, and so on. All this information is included within the cultural content concept. This cultural content must be easily available for the artists, so they are able to browse it in a user-friendly way. For the art-E-fact project, this material is provided by the Ormylia Art Diagnosis Center (OADC) and the Academy of Fine Arts (AFA).

In order to retrieve this material from the database in a simple way, which kind of tools should be implemented? It is obvious that just accessing a database to retrieve data without any further information could be a difficult task. Artists require both an overview of the content stored in the database and the possibility to access data that could be useful for them in order to build an interesting story or experience.

The Content browser provides artists with transparent information about the concepts and other related issues concerning the cultural content. If the artist requires concrete

content associated to any of the concepts displayed in the Content browser, another query is done, this time, on the content database using semantic web techniques. In such a way, the artist gets the information requested with the precise content to build the story.

The Content browser relies on an ontology that has been defined for the art-E-fact project. This ontology is a description of the concepts related to the specific application domain of the project and their relationships. Since there are many different profiles of partners involved in the project (art historians, artists, curators), the ontology comes as a formal basis for understanding between the several perspectives.

The scope of the ontology has been defined mainly on two brainstorming sessions with the content providers. These brainstorming sessions allowed gathering a vast majority of the potentially relevant concepts. One main issue that arose during these sessions was the terminology differences among different art styles involved in the project (traditional Greek iconography, European painting schools).

The Content browser editor has been adapted from a user graphical interface implemented within the semantic web application of the WIDE project [SPS*04]. The editor has three different areas: the area for the selection of the desired artwork on the left side, the browser itself in the middle area and the area of documents in the bottom side of the screen (Figure 4).

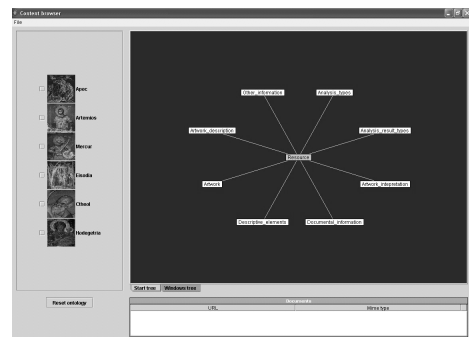


Figure 4: Screenshot of the Content browser editor.

Artists can navigate through the cultural content visualizing concepts and relations. For each concept, artists can search for information associated to that concept using semantic techniques for querying relational databases in a transparent way. In the low part of the screen, artists are provided with the paths or URLs of the concrete content stored in the database for the selected artwork.

7. Defining each scene: the Scene window

Each scene must have three main components (Figure 5): the virtual characters (avatars) as the actors taking part in this scene, the background or the setting of the scene, and

the way the story goes from one scene to the following one depending on the interaction of the participant.

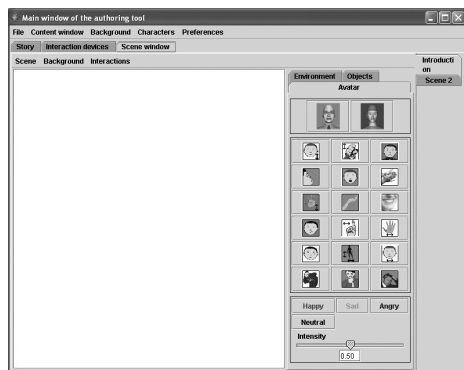


Figure 5: Screenshot of the graphical editor for the Scene window.

7.1. Virtual characters

A basic element within the art-E-fact project are the virtual characters. In order to provide a convincing stage presentation and interaction with participants, the Authoring Tool integrates conversational virtual characters and animation principles that provide those characters with believable actor behaviour. The Virtual Character component has been implemented from scratch, integrating the possibilities of the RRL language [PKS*02].

The first task when using this module is the definition of the roles of the characters that will take part in the scene. To generate effective performances with believable dialogues, virtual characters have to be implemented as distinct individuals with their own areas of expertise, interest profiles, personalities, and audiovisual appearance, taking into account their specific task in a given context.

Two main characters have been defined for this prototype: Professor Leo and Johnny. The latter can be the closest virtual character to the general participant, because he does not have any deep specialized knowledge as opposed to the former, who is an art historian.

Artists can define some aspects of the virtual characters that are listed below.

- **Personality.** When talking about the personality and affective state of a virtual character, the view of Moffat has been adopted. Five major factors or dimensions account for most of the variation in human personality [MJ92]. Extravert, agreeable and neurotic factors have been implemented in this Authoring Tool. Although default values have been defined for each virtual character, artists can easily manipulate them (Figure 6).

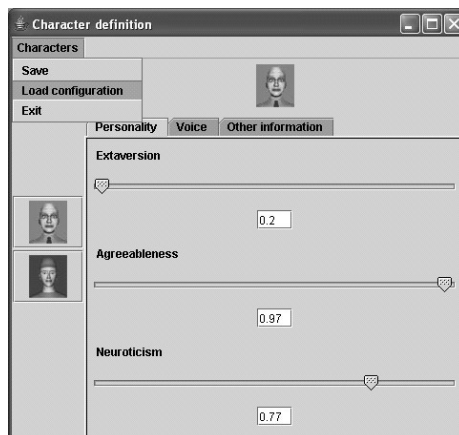


Figure 6: Defining the main properties for the personality of a virtual character.

- **Voice.** Artists can define the rate and pitch of the voice of the virtual characters using sliders.

Once the configuration of the virtual characters has been defined, artists can start typing the dialogues among virtual characters, and defining emotions and gestures associated with these dialogues.

- **Speech.** Clicking on its icon is enough to select the virtual character or characters for the scene, so that artists can start typing the text that will be said by the virtual character in an easy and user-friendly way, as shown in Figure 7.

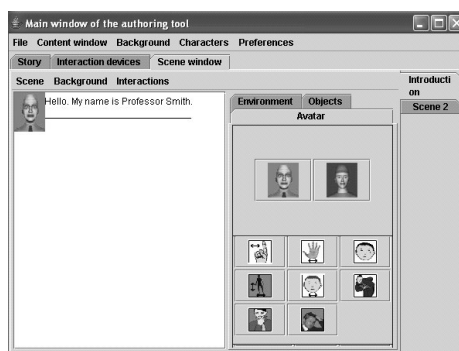


Figure 7: Inserting the speech for Professor Leo.

- **Emotions.** Whereas personality remains stable over a long period of time, emotions are short-lived. Moreover, while emotions are focused on particular events or objects, factors determining personality are more diffuse and indirect [OCC88]. An intuitive editor has been implemented for emotions. Artists select the words that should be "emotionally changed" from the text line with the mouse and define the intensity of the emotion using a scroll bar. Each emotion

has a colour attachment. For example, if the artist selects "Happy" as an emotion for the word "Hello" and red is the colour associated to "Happy", this word is highlighted in red (Figure 8). In this way, the visual appearance of the text provides additional information to artists.



Figure 8: Defining some emotions for the speech of Professor Leo.

- Gestures. The Authoring Tool allows artists including different predefined gestures for the virtual characters while they are speaking. These gestures can be defined in different ways: associated to words, when the virtual character makes a gesture while saying a word as shown in Figure 9, or related to other gestures, so that the virtual character makes a gesture some time after performing another gesture.



Figure 9: Defining a gesture for Professor Leo while he is saying "Smith".

7.2. Background

The Background component provides artists with the required tools for implementing the scene background. The created 3D world can be compared to the traditional stage in a theater representation. Although there are many packages and languages that can be used for modelling a virtual world, the Authoring Tool works on the standard modelling language VRML.

The Authoring Tool provides artists with different options to define the backgrounds, depending on the knowledge and profile of the artists. The first option for non-technical artists allows modifying some existing templates with information and pictures coming from the Content browser. Artists only have to click on the desired image and then click again over the texture they want to change in the pre-visualization window that appears on the left side corner, as shown in Figure 10.

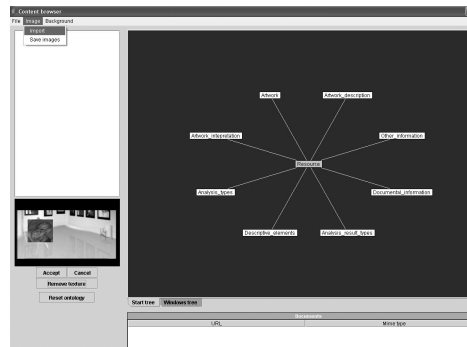


Figure 10: Choosing a background from the templates.

The remaining options include the possibility of creating and importing VRML backgrounds implemented by artists working with 3D modelling programmes.

Once the background has been defined, artists can define the position of the virtual characters in the scene. In order to place a virtual character on the scene, artists only have to drop its icon to the desired position (Figure 11). As a result, the position coordinates appear beside the icon of the virtual character.

Although artists can define the complete background for each scene, they may also want to change the existing objects in this background during the performance of the scene. For instance, during theater representations, chairs, tables or other physical objects change their position from scene to scene, or even during one scene. This option has also been implemented in the Authoring Tool.

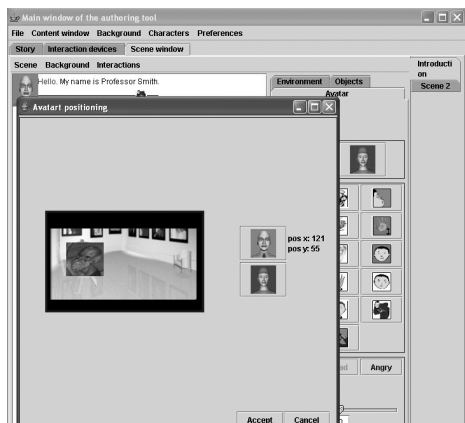


Figure 11: Positioning the virtual characters in the first moment of a scene .

7.3. Interacting with participants

Interactions are used to describe the dynamic operations of the participants, the objects and the environment. They define how participants interact with the environment and the objects. This means that the scenes are not going to be displayed in a linear way, but depending on the interactions.

Especially addressing the artistic application domain, where the participant should not be forced to interact via traditional input devices like keyboards, mice or others, new forms of interaction have been explored. Artists are provided with different interaction metaphors such as gesture and position recognition, in order to define the transitions among different scenes.

It must be pointed out that this feature of the Authoring Tool is clearly dependant on the Physical Set-up for each exhibition and the current technological research in order to implement natural interfaces. Concerning the interaction metaphors implemented for the art-E-factor project, three different options are provided.

- **Pointing.** This interaction metaphor is based on the definition of different areas on the projection screen. Therefore, it can only be used for a Physical Set-up that includes a screen with an associated tracking system for pointing recognition.

The tracking system recognises the area at which the participant is pointing in the real environment. Rules are defined depending on the area that is pointed at. Artists can define square areas on the screen using the 3D modelling open source tool ArtofIllusion as shown in Figure 12, so that the participant can point to a concrete region of the screen.

- **Visited scenes interaction.** One possibility when writing the script is that artists may only want participants to ac-

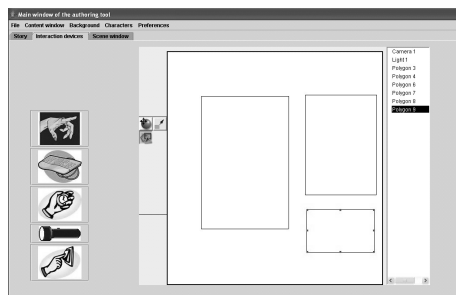


Figure 12: Defining different areas for the pointing interaction metaphor.

cess one scene only if they have already experienced other scenes connected. Therefore, the transition between two scenes is only possible if this kind of rule is fulfilled.

- **Timeout.** There could be cases in which no interaction takes place, because whether the user does not know what to do or it is defined like that. In these cases, artists can define the gap of time the system waits until next scene is displayed

8. Evaluation

The Authoring Tool was tested and evaluated during the first art-E-factor Workshop that took place in the Technological Park in San Sebastian during the 18th and 19th of February 2004. The main objective of the Workshop was the testing and evaluation of the Authoring Tool in order to gain feedback for further developments of the project.

The Workshop included different activities. First of all, two groups of artists with different profiles and backgrounds (historians, curators, painters, multimedia and electronics artists, fine arts students) interacted freely with the Authoring Tool (Figure 13).



Figure 13: Detailed introduction to the Authoring Tool.

Then, a mixed group of specialists was invited for a complete demo session in order to show them all the possibilities of the Authoring Tool. This session was conducted by one of the artists that participates in the art-E-factor project.

Finally, the members of the consortium also had the opportunity to interact with the Authoring Tool as a "non-expert" evaluation group. This mixture of evaluators provided the consortium with a wide range of evaluation results.

The Authoring Tool was installed on three different computers, allowing three different couples of artists for the evaluation. Each couple was assisted by a technician from VI-COMTech (Figure 14). Artists were encouraged to create simple stories (no longer than three or four scenes for each story due to time restrictions) in order to assess the usability and user-friendliness of the Authoring Tool.



Figure 14: Artists working on the drafts for their interactive stories before implementing them in the Authoring Tool.

The methodology for the evaluation of the tool started with the creation of the story on a piece of paper, so that artists had a clear idea of the story they were going to implement beforehand. Once a sketch including the main features provided by the Authoring Tool has been defined, artists started with the digital implementation as in Figure 15.

Some questionnaires were prepared in order to collect the impressions and sensations of the artists when using the Authoring Tool for further evaluation. The questions were related not only to the Authoring Tool, but to the whole art-E-fact project.

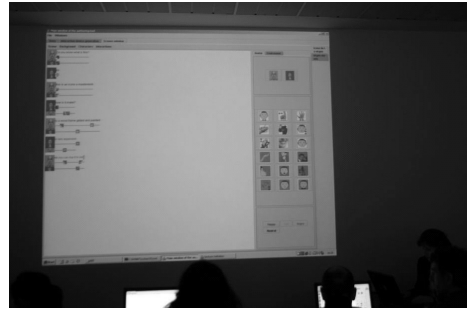


Figure 15: Screenshot of one of the stories created and implemented by artists for the evaluation of the Authoring Tool.



Figure 16: Discussion groups after the testing of the Authoring Tool.

The main conclusions concerning the Authoring Tool were the following ones.

- Artists required a user manual of the Authoring Tool, as some of them (specially art historians and curators) had little experience with computers.
- Stability of the software was criticized during the trials. It must be pointed out that this Workshop was the first massive evaluation of the Authoring Tool with real users.
- Artists found especially interesting the possibility of adding a pre-render option to the Authoring Tool, so that they do not have to wait until the final rendering and implementation in the Run-Time environment.
- Artists were looking for a very flexible tool, so that every aspect of the creation process of a story could be changed.

Some of the issues that were pointed out during the Workshop have already been solved. For example, a detailed user manual for training future users has been developed and is already available complemented with a demo story. The problems concerning stability of the software were also solved successfully.

In order to gain more feedback, mainly about the Physical Set-up, but also about the Authoring Tool, the second Workshop of the project will take place during the 15th and 16th of November in the Technological Park of San Sebastian.

The input from this Workshop should validate the changes that have already been implemented.

9. Conclusions

The art-E-fact project aims at developing a generic platform for interactive storytelling in Mixed Reality that allows artists to create artistic expressions in an original way. This platform facilitates the access to knowledge bases which content will be used as an inspirational material for them.

The implemented Authoring Tool allows artists to build art experiences. Within the art-E-fact consortium, we believe that artists must contribute in significant ways to the design of new technologies and applications for artistic creation. Therefore, this work has been possible thanks to the co-operation of an interdisciplinary team with artists and computer scientists. During several meetings, different issues from the conceptual phase have been discussed in order to gain a compromise between the requirements of the artists and the current technological constraints.

As a conclusion, it can be said that the Authoring Tool has been implemented in a generic way, allowing us reusing it for similar applications in other areas such as medicine, e-commerce, e-learning, video authoring and Cultural Heritage.

Further work on the Authoring Tool will include the adaptation of the prototype to Cultural Heritage institutions. The possibility of managing and storying multimedia information provides these institutions with new opportunities for the documentation and interpretation of their collections. The Authoring Tool can be used as a communication tool for the interpretation of artworks and collections, both within the institutions (multimedia guides, Mixed Reality environments) and over Internet.

10. Acknowledgements

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References

- [DKRS01] DARAS P., KOMPATSIARIS I., RAPTIS T., STRINTZIS M.: Mpeg4 authoring tool for the composition of 3d audiovisual scenes. In *Proc. DCV '01* (2001).
- [GHP*02] GRIMM P., HALLER M., PAELKE V., REINHOLD S., REIMANN C., ZAUNER J.: Amire-authoring mixed reality. In *The First IEEE Augmented Reality Toolkit Workshop '02* (2002).
- [HR99] HAYES-ROTH B.: Smart interactive characters. *Web Techniques 4(9)* (1999), 59–66.
- [MJ92] MCCRAE R., JOHN O.: An introduction to the five factor model and its implications. *Journal of Personality 60* (1992), 175–215.
- [OCC88] ORTONY A., CLORE G., COLLINS A.: *The cognitive structure of emotions*. Cambridge University Press, 1988.
- [PKS*02] PIWEK P., KRENN B., SCHRÖDER M., GRICE M., BAUMANN S., PIRKER H.: Rrl: Rich representation language for the description of agent behaviour in neca. In *Proc. AAMAS '02* (2002).
- [PTB*01] POUPLYREV I., TAN D., BILLINGHURST M., KATO H., REGENBRECHT H., TETSUTANI N.: Tiles: A mixed reality authoring interface. In *Proc. INTERACT '01* (2001), pp. 334–341.
- [SBH03] SCHNEIDER O., BRAUN N., HABINGER G.: Storytelling suspense: An authoring environment for structuring non-linear interactive narratives. *Journal of WSCG 11* (2003).
- [SPS*04] SMITHERS T., POSADA J., STORK A., PIANCIAMORE M., FERREIRA N., GRIMM S., JIMENEZ I., DI MARCA S., MARCOS G., MAURI M., SELVINI P., SEVILMIS N., THELEN B., ZECCHINO V.: Information management and knowledge sharing in wide. In *European Workshop on the Integration of Knowledge, Semantics and Digital Media Technology* (2004).
- [SRP03] SILVA A., RAIMUNDO G., PAIVA A.: Tell me that bit again...bringing interactivity to a virtual storyteller. In *Proc. ICVS '03* (2003).
- [VB02] VENTURA D., BROGAN D.: Digital storytelling with dinah: Dynamic, interactive, narrative authoring heuristic. In *Proc. IWEC '02* (2002), pp. 91–99.