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Virtual identities in interactive broadcasting

M. Greef *and* V. Lalioti

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Marde Greeff and Vali Lalioti

Abstract

“The story was the bushman’s most sacred possession. These people knew what we do not; that without a story you have not got a nation, or culture or civilisation. Without a story of your own to live, you haven’t got a life of your own.” [22]. Since our childhood we are exposed to stories in a variety of forms and they reflect the richness of our civilisation. Movies, cartoons, television series, advertisements, multimedia and computer games are all built around narrative structures. However, the potential of interactive narratives has not yet been fully explored by interactive television in comparison to its many uses in virtual environments and computer games.

In a previous paper we proposed the virtual identity approach for authoring interactive experiences in Virtual Environments. With this approach the user is experiencing virtual environments through the eyes of a virtual identity, resulting in different interactive experiences within the same environment. We used the approach and authoring tool to author the Cato Manor interactive experience. This paper focuses on the transition mechanism and the ways it can be used to enhance interactive experiences. It also proposes ways of using the approach with today’s technology of interactive broadcasting.

Key words: non-linear narratives, interactive storytelling, interactive TV, interactive edutainment

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Virtual Identities in Interactive Broadcasting

Marde Greeff and Vali Lalioti ¹

1 Introduction

“The story was the bushman’s most sacred possession. These people knew what we do not; that without a story you have not got a nation, or culture or civilisation. Without a story of your own to live, you haven’t got a life of your own.” [22]. Since our childhood we are exposed to stories in a variety of forms and they reflect the richness of our civilisation. Movies, cartoons, television series, advertisements, multimedia and computer games are all built around narrative structures. However, the potential of interactive narratives has not yet been fully explored by interactive television in comparison to its many uses in virtual environments and computer games.

In [9] we proposed the virtual identity approach for authoring interactive experiences in Virtual Environments. With this approach the user is experiencing virtual environments through the eyes of a virtual identity, resulting in different interactive experiences within the same environment. We used the approach and authoring tool to author the Cato Manor interactive experience. This paper focuses on the transition mechanism and the ways it can be used to enhance interactive experiences. It also proposes ways of using the approach with today’s technology of interactive broadcasting.

Section 2 provides the background on the use of interactive storytelling in virtual environments (VEs) and interactive television (iTV) broadcasting. Section 3 summarises the virtual identity approach and presents the transitions method in more detail, while section 4 proposes ways of using this approach to facilitate authoring of interactive narratives that can be broadcast under the restrictions of the available technology.

2 Interactive experiences in VEs and iTV

Interactive storytelling is a way of telling stories in such a manner that the user is actively involved and can interact with different objects in the story world. The author of the story world doesn't specify the actual events that take place as in more traditional linear stories, but only creates the rules under which the characters interact. The user then creates and experiences the events in the story world under the guiding rules of the artist.

The use of interactive storytelling for entertainment, education and art has resulted in a variety of systems and continues to motivate interdisciplinary research in Computer Graphics and Interactive Narratives [19]. Stories have been used in VR and multimedia or video art to create interactive experiences. The Kidsroom [16] guides children through an interactive, imaginative adventure where the story takes place in a real physical space that is transformed into an imaginative play space. The Round Earth Project [12] allows children to be immersed in the experience when they walk on the spherical surface of a small planetary body such as an asteroid in a VE. An earlier example of an authoring system is Oz [13] that allows authors to create and present interactive dramas.

¹ Marde Greeff is a Research Scientist at CSIR, icomtek, Scientia, Pretoria 0001, South Africa, mgreeff@csir.co.za and Vali Lalioti is a Senior Research Engineer at BBC R&D, Kingwood Warren, Tadworth, Surrey, KT20 6NP, vali.lalioti@rd.bbc.co.uk

Another important medium namely television and broadcasting have entered a new era with the delivery of interactive services. The viewers are able to actively participate in a variety of services that fall into the following categories [1]:

- Digital text that provides information services (i.e. news, weather, etc),
- Enhanced TV that provides additional services to complement audio/video service (i.e. a recipe for a food programme) and
- Interactive TV, which involves one-to-one interaction with the viewer (i.e. interactive quiz, audience vote, sale of goods).

Three programmes that fall into the category of enhanced Television were recently made by the BBC, namely the Wimbledon Interactive [11], the children's "Voyager" [11] and the "Walking with the Beasts" [4] programmes. The Wimbledon Interactive programme, provided viewers with the choice of which game to watch out of 4 parallel ones at any moment. Four video streams, one from each court were sent in parallel to people's homes, taking advantage of the Digital Terrestrial Television multiplexing (DTT multiplex) mechanism. Over a million viewers have used the service on all platforms and over 4.2 million on the Sky platform alone [3]. Textual information, video and audio were synchronised as described in [11]. Other recent interactive TV programmes include the interactive voting of the Big Brother, where 35% of all votes came through Sky Interactive. The British Open Golf Interactive Service was also used by 1.2 million viewers.

In "Voyager" another level of synchronisation was used to provide a richer interactive experience, such as broadcasting an interactive quiz. This additional "applet" starts after about 20 minutes and presents the viewer with the opportunity to take part in a quiz. This was done based around a third-party playout system that is used by BBC Knowledge. It makes use of triggers to manage playout of the correct programme at the correct time and includes an Automation Trigger Interface (ATI) which, combined with a broadcast application running in the receiver, allows pre-build spool files to be transferred over the application playout system depending on the trigger received. As each trigger is received the correct spool file is played out.

In the DVD production for the Interactive programme "Walking with Beasts", BBC Technology developed an authoring system for interactive DVD authoring, that uses authoring packages such as Daikin' Scenarist Professional [18], which was recently acquired by Sonic, and Spruce's DVD Maestro. This provided the accelerated performance that was needed for the particular production. DVD authoring tools targeting the consumer and personal computer market such as Apple's iDVD and DVD Studio Pro, provide support for creating menus, buttons, backgrounds and preview for navigation and flow. Professional DVD authoring tools also include full creative control in terms of active sub-pictures and non-seamless and seamless multi-angle video tracks.

Another technology that can be used to provide interactive services to viewers is the TV-Anytime [7], [17]. In this case, local storage can be explored to allow additional services such as navigational aids, and new forms of content such as non-linear viewing of programmes (i.e. news). Work has also been done in terms of describing an interactive service. Information is classified into four categories, content (image, text, graphic), template (layout, design), navigation and structure (page numbering, information hierarchy, virtual book), behaviour (user events, timer, triggers, targeting menu, quiz, game or live events) [3].

Finally, projects that are important to mention since they approach interactive video art from the storytelling perspective are Rosa Freitag's "Mixed Emotions" [21], and Greg Roach's "The Wrong Side of Town"[18]. In Mixed Emotions, real actors are used and the main protagonists try to convince the viewer to follow the story under their particular point of view. The main plot resembles that of a traditional film structure. If viewers choose not to interact, they will watch a complete linear story, which however might leave a lot of ambiguity. This stimulates viewers to

play the film again and intersect with characters to explore all sides of the story. The fortune of characters could be changed, so the final outcome reflects and depends on the interaction.

In “The Wrong Side of Town” a technique called perspective switching is used, which allows the viewer to watch the action filtered through the perceptions of each of the characters in the film. The viewer clicks on characters and the movie then changes, in real time, to reflect how that character perceives of events. Every element in the scene is re-rendered according to that character's orientation to the action and other characters. The structure is quite simple. There are a number of simultaneous tracks to the film, representing the main (or neutral) thread and each of the character's perception of events. The viewer navigates between these threads in real time. There is no interface other than the content of the frame itself; thus the content (actors) is the interface.

Finally, in the Hotel Lamp concept [14], a story is happening in parallel in 4 different rooms and the viewer is capable of choosing between the 4 video streams that reach his/her television set. Each room tells a self contained story and the sound from other rooms provide the motivation to the viewer for switching between rooms.

From the above discussion it is evident that a number of interesting programmes are already exploring the possibilities and are stretching the limits of the technology to provide innovative interactive services. Also evident is that there are many issues remaining to be resolved before interactive stories can be authored and delivered effectively in a day-to-day basis, or before the complexity and power of interaction of virtual environments can be reached in the existing broadcasting platforms. The major problems are obviously ease of creation and delivery under the limitations of the existing technology; that is the authoring tools and the technology that would allow interaction. In [9], we presented the virtual identity approach to enable authoring of multiple interactive experiences out of the same virtual environment. In this paper we proposed ways of using the approach to facilitate authoring of narratives for the interactive television. The next section briefly presents the virtual identity approach, and then focuses on the transition's method, which is used in section 4 for interactive television.

3 Virtual Identities Authoring Approach

The virtual identity approach allows the user of a virtual environment to experience the interactive story through the eyes of a virtual identity. To author such an interactive experience out of the same virtual environment a number of virtual identities are defined by their characteristics; namely the knowledge about themselves, their perception of the environment and their virtual embodiment. The approach provides a framework that relates virtual identities to real identities, in accordance with socio-psychological, gender and embodiment issues and research [5][6].

We developed an authoring tool (described in more detail in [10]) with the AVANGO [21] software framework and tested the approach by authoring a Cultural Heritage Virtual environment application. The story world is a shebeen (township tavern) in Cato Manor [15], that was once a vibrant Southern African community that was torn down to enforce racial segregation and open up a prime piece of real estate for white occupation. We created three virtual identities, namely a Zulu man, a Zulu boy and a shebeen owner. By using the same model (see shebeen Figure 1) and defining interactions in the shebeen depending on each virtual identity's characteristics, the users were able to explore and experience the shebeen through the eyes of each identity.

However, there is one more key feature of the approach that has not been fully explored, namely the transition mechanism. Cato Manor interactive experiences were mainly exploiting the differences between the interactions that each identity was allowed to perform, and transitions from one identity to another through transition in time. For example, a memory flashback of the Zulu man would turn him into the Zulu boy identity with the consequence of lowering the viewpoint as the height of the man decreases to that of a boy.



Figure 1. The model of a Shebeen (township tavern)

To provide a richer interactive experience for the user and allow the authoring of more complex stories, we introduce transitions that are from one virtual identity to another, from one characteristic to another or both. Some examples in virtual environments are given below:

Time transitions

In a sense the memory flashback transition is a change in the virtual identity's age characteristic and it causes the identity to experience a time transition. When a time transition takes place it is important that the interactions of the identity are consistent with the identity at that specific point in time. For example, if the age characteristic of a male virtual identity has changed then it would behave as a boy identity and therefore only be allowed to enter places and interact with the virtual environment in the way that a boy virtual identity is allowed.

Emotional transitions

When a virtual identity's emotion characteristic changes, the identity can experience an emotional transition, e.g. an identity that is in a good mood can see an object that brings back memories and makes the identity sad. To convey the emotions and mood of the identity to the user of a virtual environment the motion of the virtual identity is manipulated. For example, making the identity walk in an almost bouncing and hopping manner when s/he is happy and shuffling slowly when s/he is sad.

Identity transitions

When a virtual identity's personality changes, the identity can experience an identity transition, e.g. an experience in the identity's life can cause the identity to change into another identity with a different personality for example a more reserved one and can cause many of the identity's characteristics to change.

Accommodation transitions

An identity can experience an accommodation transition, e.g. when the identity is living in a shack (informal housing) and the South African government reconstruction and development program (RDP) builds a new house for the family.

Occupation status transition

When the occupation characteristic of a virtual identity changes, s/he can experience an occupation transition, e.g. if the company that the identity is working for is experiencing financial difficulty, the identity can get retrenched and suddenly be unemployed.

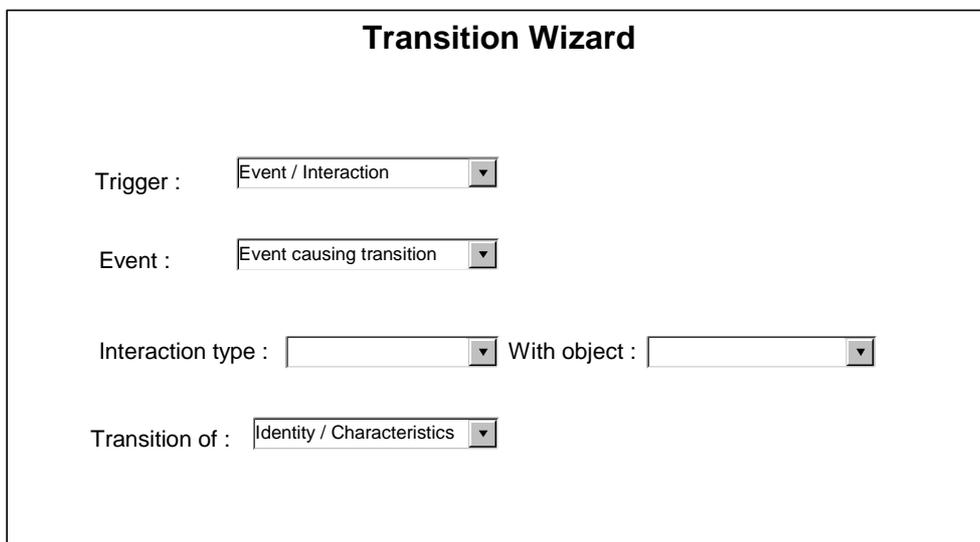
Political affiliation transition

A change in the virtual identity's political affiliation characteristic can cause an identity to experience a political affiliation transition, e.g. if the identity's beliefs and viewpoint change, it will also affect his/her political affiliation.

Class transitions

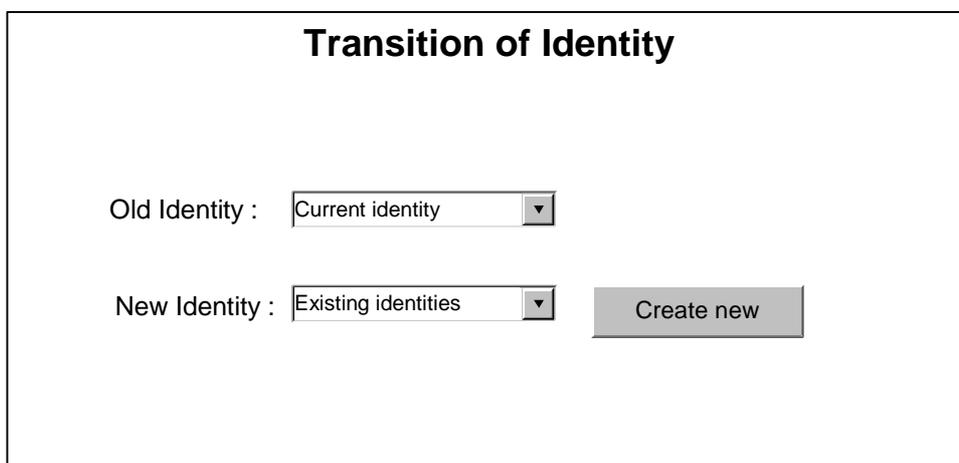
An identity can experience a class transition when the class characteristic of the virtual identity's background changes, e.g. when the identity is from the working class and suddenly inherits money, then the identity's class might change from working class to upper class. Therefore the identity's belongings, clothing and habits can change to reflect this.

Many of the above transitions are of course much more difficult to happen in the lives of real identities. In virtual environments it is much easier to make these changes and therefore play with "what if" scenarios that would be most of the time impossible to materialise in the real world.



The image shows a form titled "Transition Wizard". It contains four rows of input fields, each with a label and a dropdown menu. The first row is "Trigger : Event / Interaction". The second row is "Event : Event causing transition". The third row is "Interaction type : [empty] With object : [empty]". The fourth row is "Transition of : Identity / Characteristics".

Figure 2. Schematic for transitions



The image shows a form titled "Transition of Identity". It contains two rows of input fields and a button. The first row is "Old Identity : Current identity". The second row is "New Identity : Existing identities". To the right of the second row is a button labeled "Create new".

Figure 3. Schematic for transitions of an identity

Transition of Identity's Characteristics

Identity :

Characteristics

<input type="checkbox"/> Characteristic 1	<input type="checkbox"/> Characteristic 3
<input type="checkbox"/> Characteristic 2	<input type="checkbox"/> Characteristic 4
...	...

Figure 4. Schematic for transitions of an identity

Figure 2, Figure 3 and Figure 4 illustrate a schematic representation of a possible GUI for transitions. In Figure 2 the user can select what caused the trigger of the event, i.e. either an event or an interaction. S/he can then choose the event or interaction that causes the transition to take place. If it is a transition of an identity, then Figure 3 will be displayed. Otherwise, if it is a transition of certain characteristics of an identity, Figure 3 will be displayed.

4 Virtual Identities in Interactive Television

From the overview of existing authoring tools and interactive services in broadcasting in section 2, it is evident that a lot of the fundamental work that allows delivery of interactive services, such as the synchronisation of audio/video and text and switching between parallel running video streams, is already in use. There is also the possibility of pre-loading different files and the sequence of what would be viewed depending on a number of triggers that result from the viewer's interactions. However, there is minimal support for producing interactive content in the sense of a coherent, engaging interactive story that allows high degrees of presence and interaction from the viewer.

Many of the difficulties of interactive storytelling in virtual environments are also shared by storytelling for interactive TV. For example, internal consistency, narrative flow, time and ease of creation are all important if we are to author interactive stories in a day-to-day fashion either for virtual environments or for broadcasting [8]. Any story needs to be coherent, therefore in virtual environments as well as in broadcasting it is important to ensure that the viewer has a high degree of freedom and yet the story remains coherent at every instance of the experience. In interactive narrative a problem of narrative flow may also appear, since it is difficult for the creator to ensure that when a dramatic climax takes place in the story, the user is there and ready for it.

Another important issue to resolve when authoring interactive narratives is that of time. In interactive TV programmes, dealing with the time of the narrative and the time of the broadcasting is essential, because of the use of the technology of multiplexing as explained in section 2. Finally the ease of creation is essential for the proliferation of interactive narratives and experiences. In [9] we described ways that the virtual identity approach is resolving these issues when used in Virtual Environments to author interactive experiences.

4.1 Theoretical approach

In this subsection, we propose ways of using the virtual identity approach in conjunction with digital broadcasting to allow more engaging and interactive narratives to be authored. It is important to stress that the solutions proposed are by no means taking full advantage of the virtual identity approach nor are they comparable to the richness of interactive storytelling in virtual environments. Rather they are targeting facilitation of production and delivery, closely coupled with the limitations

imposed by the current broadcasting technology. We are also only concerned with stories that use real actors and video streams rather than virtual environments and synthetic actors, since the latter was addressed in previous publications.

Two issues are explored for each solution; firstly how this approach can generate interactive experiences for the viewers and secondly how the approach can facilitate the production of these experiences. In VE we assumed that the 3D environment exists and only the virtual identities and their interactions and transitions need to be defined. Similarly, we assume that the video fragments that represent the story world (that is all fragments of content) from the perspective and actions of each virtual identity exist. In terms of providing the interactive experience, the viewer should be allowed to make choices/interactions, which trigger transitions in the form of switching from one video fragment to another. In terms of authoring, a mechanism is needed to define the transitions that relate the characteristics of an identity and its interactions to different video fragments.

Transitions between Parallel Narratives

One straightforward way to use the virtual identity authoring approach is to design narratives that allow switching between different identities represented by separate video streams that are multiplexed. This allows switching and therefore similarly allows choosing the identity through the eyes of which the viewer would like to experience the story.

Transitions in Time & Space

There are however, more innovative ways to explore the approach even under the current limitations of digital broadcasting. The obvious ones are in terms of space and time. In these cases, interaction and production is made in terms of the space or the time that the virtual identity acts. Transitions then happen depending on the interaction of viewer in terms of choosing a different space, or a different time in the day of an identity. Space for example has been already used in many interactive TV programmes to view events that are happening in parallel in different physical locations (i.e. Wimbledon interactive). In the simplest level video streams from different spaces (rooms, camera positions etc) are multiplexed and the viewer is allowed to follow a narrative that is happening in many different places in parallel. However, even more complex stories can result from these simple interactions. For example, change into a different room might also mean change in the identity, if that room is its favourite one, or in time if something critical has happened in that room, and so on. Authoring these complex stories is not adding any more complexity since it is again a matter of defining the transitions triggered and the relevant video streams associated with them.

Other Transitions

The transition mechanism can also be used to allow points where depending on the viewer's interaction there is a change in the virtual identity in terms of its characteristics. As with interactive experiences in the Virtual Environment, this will similarly transfer the viewer to another phase of the interactive narrative, being that of another identity or point in time or space, or will provide more complex changes. For example, change in financial or professional status of the virtual identity might change the activities that the identity is involved in and thus the video fragment of a more expensive holiday might be incorporated into the interactive experience.

Finally, we should note that this approach is not limited to virtual identities that have human characteristics, since identities can be defined according to any set of characteristics, i.e. animals, synthetic avatars, or imaginary creatures, or creatures that do not exist anymore (beasts/dinosaurs). Equally important is to note that transitions can be abstracted to relate to these new identities and their characteristics.

4.2 Technological approach

Under the current constraints of DTT multiplexing or of TV-Anytime, it is important that the stories from each identity's perspective and the authoring tool should incorporate a time controller. The controller ensures that the combined video fragments are of the same duration for each identity. Additionally, the time controller either automatically or by suggestion helps the director/producer identify the specific points where the story from the perspective of one identity reached the same time in the narrative from the perspective of another and the viewer could be presented with the possibility to change. Also if multiplexing is used the authoring tool should additionally ensure that at any given time the total number of available streams is limited to the number that can be multiplexed and broadcast.

In case local storage is made available it is possible to pre-load all video streams, together with the data that describe interactions linked to each virtual identity. At the viewer's site a broadcast application is running on the receiver that can relate further interactions of the viewer and trigger different spool files to be played. This technology allows authoring of even more complex and engaging stories, since there is no limitation on the number of parallel video streams.

Finally, the way the viewer is interacting is important. This approach, in conjunction with a suitable interaction device, could enable a navigation/interaction through the choices without fear of breaking the sense of presence and engagement of the viewer. Examples to avoid are choices appearing as text and mechanistic ways in proceeding with the story (such as option menus for example). Simple sensing technology or use of smart remote controls can enhance the experience by making the content become the interface and thus provide a more intuitive transition between the different story paths. Also, we are currently designing extensions of the authoring tool so that it can support the new type of content and its delivering platforms (video fragments and iTV), as well as abstracting the definition of characteristics and transitions so that narratives are not restricted to human-like characters.

5 Conclusions

In this paper, we have extended the virtual identity approach to authoring of interactive experiences, by looking more closely on the transition method and on how this can be used not only in virtual environments but also on interactive television. We also focused on stories that involve use of real actors and video rather than synthetic avatars or virtual scenes.

One important advantage of using this approach is that one can author interactive experiences for the PC or web user as well as the TV viewer, out of the same material or the same storyboard. It also makes it easy to add more interaction in the platforms that support it.

Since the approach supports automatic transitions, a viewer that chooses to be passive is not penalised by any inconsistencies in the story. S/he can still be exposed to the benefits of a consistent linear narrative in the same way as in Mixed Emotions and similarly be motivated to use interaction next time. This approach also ensures that a linear version of the interactive stories can be broadcast to non-digital viewers too.

Finally, some of these ideas could be used for navigation in digital broadcast. The word navigation in the terminology of broadcasting is used differently than in Virtual Reality and Interactive Environments. Navigation in a virtual environment means the interactive movement in a 3D space and thus the navigation by the user towards a desired 3D point or part of the environment. On the other hand navigation in broadcasting terms relates to navigation through the different available programmes and menus by the viewer. In this sense we would like to explore if personalisation of the navigation can happen via mechanisms similar to the virtual identities.

6 References

- [1] A. Arthurs, A. Collins, *Delivery of Interactive data services by multiple networked content providers*, IBC 2001, International Broadcasting Convention, Amsterdam, 13-18 September, 2001, IEE Conference Publication.
- [2] O. Balet, P. Kafno, F. Jordan, T. Polychroniadis, *The VISIONS project*, International conference on Virtual Storytelling, 2001. Using Virtual Reality Technologies for Storytelling, September, 27-28 2001 - Avignon, France
- [3] R. Bradbury, R. Cartwright and T. Steel, *Delivering Interactive DTV services to Multiple Target Platforms*, IBC 2001, International Broadcasting Convention, Amsterdam, 13-18 September, 2001, IEE Conference Publication.
- [4] BBC Technology Press Release, *Interactive DVD Production for Walking with Beasts* broadcast on 15th November 2001, <http://www.bbctechnology.com/> and http://www.bbctechnology.com/searchable/dms_mm_tech.htm
- [5] G.J. Craig, *Human Development*. Prentice Hall, New Jersey, USA, 1996.
- [6] C. De la Rey, N. Duncan, T. Shefer, A. Van Niekerk, *Contemporary issues in Human Development: A South African Focus*, International Thomson Publishing (Southern Africa) (Pty) Ltd, South Africa, 1997.
- [7] S. Draper, N. Earnshaw, E. Montie, S. Parnall, R. Tol, D. Wilson, G. Winter, *TV Anytime*, International Broadcasting Convention (IBC 99), Amsterdam, 10-14 September, IEE Conference Publication, pp. 103-108.
- [8] R. Freitag, *Mixed Emotions*, Performance, in 4D Dynamics Conference on Design & Research Methodologies for Dynamic Form', Editor- Alec Robertson, Proc.4D Dynamics, De Montfort University, Leicester. UK Revised Edition (1996) ISBN 1857211308. <http://www.hyperbole.com/lumiere/mixed-emo.html>
- [9] M. Greeff and V. Lalioti, *Interactive Storytelling with Virtual Identities*, IPT/EGVE 2001, 5th International Projection Technology Workshop and 7th Eurographics Workshop on Virtual Environments, Stuttgart, Germany, May 16-18, 2001.
- [10] M. Greeff and V. Lalioti, *Authoring Interactive stories using Virtual Identities*, EUROIMAGE 2001, International Conference on Augmented, Virtual Environments and 3D Imaging, Mykonos, Greece, May 30-June 1, 2001.
- [11] J.R. Hunter, H. Lau and D.J. White, *Enhanced Television Service Development*, International Broadcasting Convention (IBC 2000), Amsterdam, 8-12 September, IEE Conference Publication.
- [12] A. Johnson, T. Moher, S. Ohlsson, M. Gillingham, *The Round Earth project – collaborative VR for conceptual learning*, IEEE Computer Graphics and Applications, Virtual Reality, 19(6), Nov/Dec 1999.
- [13] M.T. Kelso and P. Weyhrauch, *Dramatic Presence*, Presence: Teleoperators and Virtual Environments, 2(1):1-15, 1992.
- [14] C. Lecouteur, The Hotel Lamb, http://home.gateway.bbc.co.uk/imagineering/html/proj_lamb.html
- [15] B. Lynch, *Cato Manor Development Project*, <http://www.cmda.org.za>
- [16] The MIT Media Lab, *KidsRoom: Action Recognition in an Interactive Story Environment*, October 1996. <http://vismod.www.media.mit.edu/vismod/demos/kidsroom/>
- [17] A. McPriland, J. Morris, M. Leban, S. Rarnall, A. Hickman, A. Ashley, M. Haataja, F. de Jong, *myTV: A Practical Implementation of TV-Anytime on DVB and the Internet*, IBC 2001, International Broadcasting Convention, Amsterdam, 13-18 September, 2001, IEE Conference Publication.
- [18] G. Roach, *The wrong side of Town*, <http://www.hyperbole.com/lumiere/wrongside.html>
- [19] SIGGRAPH 2001 Panels, *Video Game Play and Design: Procedural Directions and Game-Stories: Simulation, Narrative, Addiction*, Los Angeles, 14-17 August 2001.
- [20] Sonic Scenarist DVD Authoring Tool, <http://www.sonic.com/daikin/>
- [21] H. Tramberend, *AVANGO: A Distributed Virtual Reality Framework*, In Proceedings of the IEEE Virtual Reality '99, JW Marriott Hotel, Houston, Texas, USA, March 13-17, 1999.
- [22] L. Van der Post, *The Lost World of the Kalahari*. Penguin Books, UK, 1962.