From Memoria Futura to i2TV: A technological framework and two models for new forms of cultural participation and production in Mixed Realities

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ABSTRACT

The merits of information technology for the archiving of cultural heritage have been long acknowledged. The challenge now is to realise the communicative potential of information technology for the development of new structures. This is exactly the concern of Mixed Realities as communication levels between reality and virtuality, which offer an open space for visions and creative ways of dealing with the past. The i2tv (interactive Internet-TV) concept addresses this issue as an electronic arena combining interaction in real space with actions of Internet participants into a new framework of cultural participation and production. The i2tv system integrates Internet-based multi-user interaction and awareness with broadcast technologies such as Internet streaming and Virtual Studio, and with technologies for mixed reality in shared physical space. This paper presents two concrete models for cultural events enabled by i2tv and discusses the experiences with their public trials: (1) The Memora Futura Symposium extends the historical format of public discussion into a networked Mixed Reality situation visualising a memory space of collective experience; (2) The "Ottos Mops" distributed play based on sound poetry of Ernst Jandl, develops a model of distributed participatory theatre making on-line participants active producers of new content and an integral part of the situation on-site. The combination of 3D Internet environments with digital TV, mobile communication interfaces and medial staging on-site, demonstrates the integration of the participatory model of the Internet and the passive broadcast model of TV into a new convergent unit - interactive Mixed Reality TV.

KEYWORDS: Mixed Reality, Interactive TV, Digital Storytelling, Interactive Environments, Media Art

ELECTRONIC ARENAS AND CULTURAL PRODUCTION

The promise of interactivity is that the experience of cultural production can be

something the viewers do rather than something they are given. This requires rethinking conventional concepts of content. In interactive media the interface decisively shapes the experience of content by defining how one perceives and navigates that same content. A number of different approaches focusing on real-time participation of remote participants in "media-rich" cultural events can be referred to under the term "electronic arenas" [1]. Approaches demonstrating this understanding of electronic arenas include Inhabited TV, Mixed Reality Stage and TV shows integrating contributions of Internet participants on one hand, as well as a range of approaches to shared virtual environments (CVEs, MUD/MOOs, etc.) on the other.

Inhabited Television is based on broadcasting interaction from collaborative virtual environments (CVE) on TV. Online participants take part in TV shows staged in a virtual world. The action of participants within the virtual world is transmitted to a conventional viewing audience, either as a live event or as edited highlights. The objective is to produce interaction between participants, which is interesting as broadcast content for TV viewers [12][7]. CVE technologies (e.g. MASSIVE-2, MS Virtual Worlds) are combined with broadcast technologies [7] [12].

The Mixed Reality Stage [18] is a model for electronic arenas bringing together several participants in physical space with participants from the Internet, in a combination of shared physical and three-dimensional virtual space. Their interaction creates new forms of social experience, as well as content that is experienced by the physically present audience. The virtual space is realised as an interactive field of audio-visual objects, which are triggered by users movement and emitted into the physical space. The objective is to create a situation, which brings the participants into mutual play by amplifying their bodily awareness of space and of each other [18][11]. The Mixed Reality Stage is based on the e-MUSE system (Electronic Multi-User Stage Environment) [18] and an example of a concrete realisation is the Mixed Reality installation "Murmuring Fields" [11].

Many television transmissions involve the audience through questions and comments by telephone, fax or Internet (e.g. CNN's Q&*A* [2]). Kulturserver [3] combines Internet streaming and TV broadcast by feeding users' streams from the Internet (live performances or pre-produced material) into the Berlin Open Access cable channel. The video stream is accompanied by a simultaneous chat of the Internet viewers, which provides a basic form of interaction for the audience. The TV show *Ich sehe was, was du nicht siehst!* (I see something that you don't see) [4] allows the children watching the show to create a 3D set for the Virtual Studio [6][20][8] using a web-based interface. The newly created virtual set is sent to the production team of the transmission and can be subsequently embedded into the transmission set during the live broadcast. Reality shows combining Internet and TV (e.g. BigBrother [5]) use interaction of selected participants as broadcast content for TV & Internet viewers, with the latter in a position to watch the non-edited broadcast and

select between multiple-camera perspectives. This approach is comparable to that of Inhabited TV, with the difference being that the participants are here playing on a real stage, not as avatars in a virtual world.

With respect to participation models represented by the above aproaches, there are different ways that can be used to analyse them. As noted in [7] the previous research in the field of participation is focused mostly on reflective experience, especially in theatre. Besides real-time interaction in the event and the involvement of audience in the creation of content, another issue is the visualisation of the experience of participants involved in the event. This is also a point of departure for addressing the challenge of involving the audience not only for the physically duration of the event but also after its end, as a result of the shared context and experience created by the participation in the event. Sharing this experience is often considered an essential part of understanding interactive communication [17].

BASIC CONCEPT OF i2TV

i2tv (interactive Internet-TV) is a basis for medial integration of Internet participants into events taking place at a real physical location: a symposium, conference or live artistic production. The challenge is to create a situation in which on-line and on-site participants feel present and involved, while retaining the specifics of both situations (on-line, on-site). The basic questions addressed by this approach are: What is the added value of bringing the two situations, on-line and on-site, together? How can the conflicts of "real-time vs. delay" and "immediacy of involvement vs. distance for reflection" as intrinsic qualities of the on-line/on-site situation, provide fertile ground for new communication models? What new models of cultural production can be developed?

Connecting the two different situations (on-site, on-line) means creating a meaningful relation between the participants on-line and the live situation in real physical space. The goal is to enable the production of scenarios in which on-line participants become active producers of new content and an integral part of the live situation on-site. This requires relating to each other two different social situations, with its own experiences of space and time, and finding ways for making all parties feel involved, even if not in the same way. Rather than merely "bridging the distance" the characteristic roles, formats and participation models, intrinsic to a connected on-line/on-site situation need to be examined.

Developing models which integrate multiple on-line participants as active producers of content requires theatrical staging as a strategy for organising many simultaneous inputs. The action in real space needs to be integrated with action and content representation in networked shared space. This requires relating to each other many different layers of representation and interaction to new dramaturgical formats. In developing such concepts one can draw from lessons and experiences from different fields of the arts: from traditional theatre to participatory performances of the 60's, to the mixed reality stage.

Understanding the strategies of the theatre becomes a crucial pre-requisite. According to Derrick de Kerckhove the discourse which tells us that our life is basically organised in a theatrical way, is an epistemological illumination: we behave like actors and spectators as a basic structure of our existence in literate cultures [15]. The premise of the connected situation (on-site/on-line) is to create an occasion in which the participants are simultaneously immersed into the situation and trying to find a reflective distance. This raises several important questions: What roles can be recognised ? What participation channels are suitable for these roles ? How are they put in relation ? How can the theatrical means be employed in an interactive situation, where participants are actors and spectators at the same time ?

THE i2TV SYSTEM

In order to enable empirical exploration of these issues the i2tv system combines the technologies for multi-user interaction and awareness with broadcast technologies such as Internet streaming and digital TV, and with technologies for mixed reality in shared physical space. It is built as a modular system providing independent levels of implementation for broadcasting the live situation on-site to on-line participants, for supporting presence and interaction of on-line and on-site participants, for different input and display devices, and for medial staging on-site.

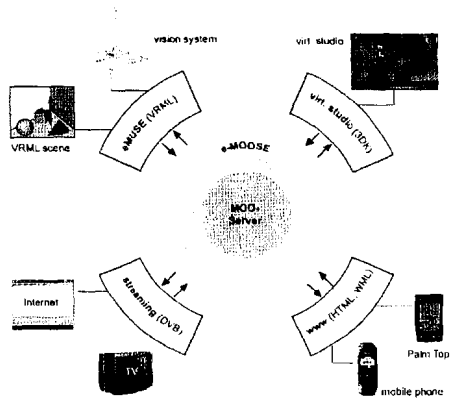

Figure 1: Basic structure of the i2tv system

The i2tv systems consists out of the following parts:

- MOO server - platform for networked multi-user environments [9][14],
- RealServer - platform for streaming video over Internet,
- e-MUSE - system for multi-user interaction in a combination of shared physical and virtual space [18],
- 3DK Virtual Studio - distributed Virtual Studio system [20][6],
- eMOOSE - interface layer connecting individual elements of the i2tv system,
- Display and input devices - Web browser, handhelds, free body interfaces.

The MOO system [9][10][13] provides support for multi-user communication and awareness, event propagation, spatial structuring, behaviour scripting and shared virtual space. i2tv extends the text-based MOO system into a framework for spatial structuring of hypermedia elements. The MOO is employed as an abstraction layer for

generic representation of a shared virtual space, independently of the format of content representation (text, 2D, 3D). It serves as a universal layer for modelling interactions between on-site and on-line participants.

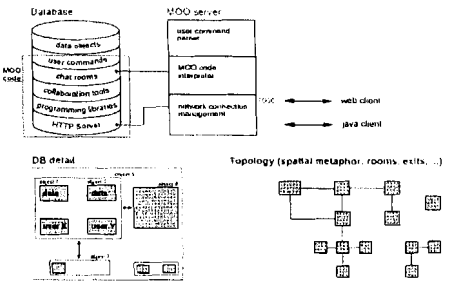

Figure 2: Structure of the MOO system in i2tv

This is fundamentally different to 3D virtual environments which are built on structures describing the rendering of the shared space. In contrast, i2tv builds on a layer describing data structures, interaction models and behaviours, independently from the layer describing how the content is to be rendered.

The integration of the e-MUSE system provides two important functionalities: attachment of various interfaces such as vision systems, electric field sensors and handhelds, and integration of VRML-based virtual spaces combined with multi-user interaction in a shared physical space.

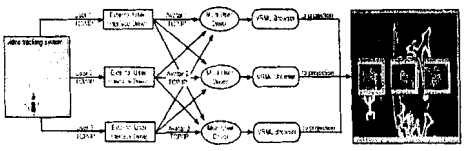

Figure 3: Structure of the e-MUSE system

The 3DK distributed Virtual Studio system [20][8] enables the composition of video images of a real broadcast camera together with 3D computer generated scenes, as well as the insertion of virtual objects into real scenes, with individual facilities distributed over an ATM network.

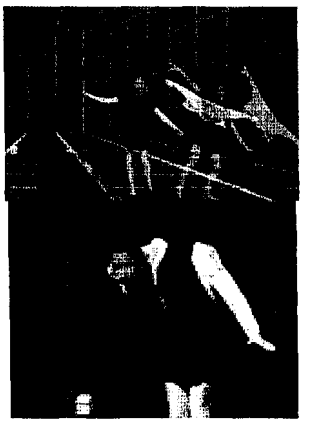

Figure 4: Compositing real actors with a 3D virtual set using Virtual Studio

e-MOOSE is a java-based interface layer connecting the individual elements of the i2tv system (MOO server, streaming, e-MUSE, 3DK, displays and input devices) into an integrated whole. It consists of a server-side java application and client-side applets. The client-side applets communicate with display systems and with interfaces to usersë input devices. The server-side component communicates with the MOO server and with the e-MOOSE client-side applets of individual users. The eMOOSE layer also takes care of mapping the MOO events into events suitable for a given display formats and input devices, and vice versa.

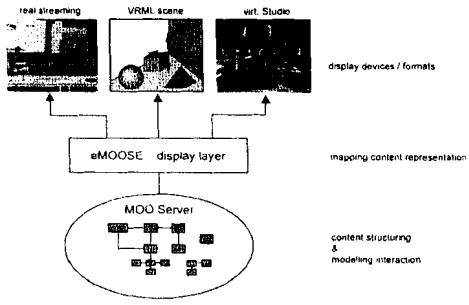

Figure 5: Different levels of content representation

The described multi-layered architecture enables the combination of different levels of content representation, interaction and communication channels, based on the situations on-site and on-line, and depending on bandwidth, input and display devices of individual users. This distinguishes i2tv from other systems such as 3D shared virtual environments (e.g. MASSIVE) tele-conferencing systems (e.g. SunForum, MS Flatland), or web-based distance education systems (e.g. MS Telep).

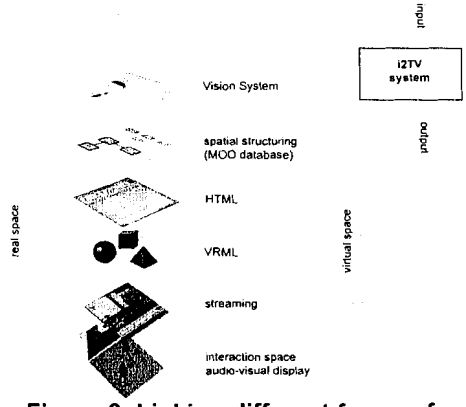

Figure 6: Linking different forms of real and virtual space in the i2tv system

INTEGRATING ON-LINE/ON-SITE DISCUSSION: MEMORIA FUTURA SYMPOSIUM

The i2tv trial at the Memoria Futura Symposium[1] in December '99 at GMD worked with the common conference format as a point of departure in developing new models for connected on-line/on-site events. The goal of the experiment was to explore a minimal set of requirements needed to integrate on-line participants into the situation on-site. To achieve this a group of invited experts[2] was integrated into the discussion on-site as Internet participants through the minimal version of the i2TV system. Live audio and video from the symposium were streamed to remote participants as Internet streaming and as digital TV broadcast via satellite.

On-line participants could intervene into the symposium by means of text which was made visible on-site by projecting the Internet view into the real space of the symposium. Additionaly, most important questions from the online participants were selected by the on-line moderator and displayed on the fly in large letters. These selections were also propagated to the web interface of individual on-line participants in order

[1] The symposium "Memoria Futura: Information Technology and Cultural Heritage § A New Perspective ?" took place from December 11-12, 1999 at GMD in Schloss Birlinghoven. Four thematic sessions combined four on-site speakers and five invited on-line participants per session. On-line participants connected from Germany, Italy, Denmark, Croatia, and the USA.

[2] Internationally known experts from interactive technologies, TV, media art and theatre.

to provide a feedback of the moderator's actions.

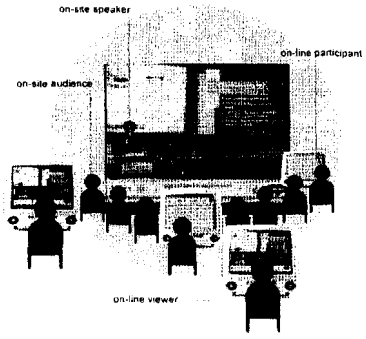

Figure 7: Layers of participation in the i2tv trial at Memoria Futura Symposium

This concept focused on the interaction between on-line participants and the on-site speaker. The on-site audience had no active role, except during the discussion slots when they could ask questions either to the speaker on-site or to the participants on-line. In addition to invited active on-line participants, there existed on-line viewers who were completely invisible to other participants in the event. These restrictions were consciously made in order to isolate critical parts of the situation: the interaction of the on-site speaker and on-line participants on one hand, and the observations of the on-site audience and on-line viewers, retaining their passive roles.

The technical realisation of this restricted model combined three basic elements of the i2tv system: the MOO server, the Real Server, the prototype eMOOSE client and the web interface. Additionally, a DVB streaming solution was used for the satellite broadcast[3]. This offered the on-line participants the possibility to use digital set-top boxes for receiving no-delay and high-quality video from the symposium, while interacting through the Internet interface.

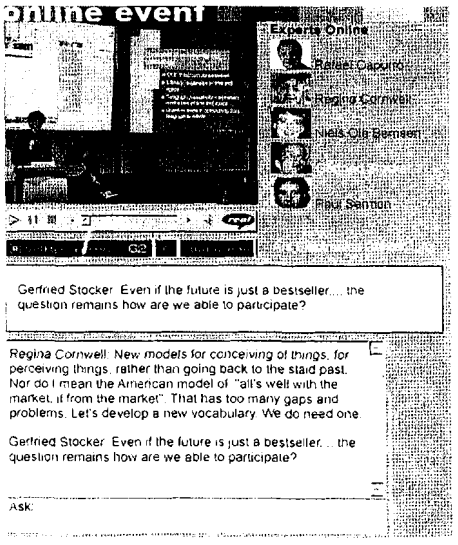

Figure 8: i2tv interface at Memoria Futura symposium

Evaluation of the Trial and Lessons Learned

In evaluating the trial we used the method of subjective analysis such as informal interviews with audience and participants, and written evaluations of professional observers. This was accompanied by objective analysis based on the video recording of the event and on the log files of on-line participants' contributions. The most important lessons include understanding the specific roles inherent to on-line and

[3] Via EUTELSAT.

on-site participants and audience, the notion of two social situations, the idea of memory space, and the notion of theatre as organising principle for many simultaneous inputs.

Understanding the Roles

The analysis of the event points to very specific characteristics of the four elements constituting an on-site/on-line event. They can be represented by the following roles:

- on-site speaker: the actor,
- on-site audience: the passively involved,
- on-line participants: the commentators,
- on-line viewers: the analysts.

The on-site speaker finds himself in the situation of both exposure and control. His goal is to lead the audience along his way. Hence the metaphor of an actor performing a piece. Being physically present and subject to the speaker's verbal action, the on-site audience is the only party really immersed into the situation. This implies a lack of distance for reflection. The only real possibilities of participation remain that of emphatic involvement, and immediate reactions rather than reflective considerations.

The inherent nature of the situation of on-line participants is the feeling of not being exposed, since physically not "being there". This is reinforced by symbolic representation through photo-icons, rather than live video streams. As a result, on-line participants turn out to be more prone to open discussion and critical remarks. Not being immersed into the situation created by the speaker on-site gives them the power to act reflectively. On the other hand, being able to make themselves noticed only through active production, results in the urge to act, which diminishes the objective part.

The Internet viewers are the most uninvolved participants. They are invisible on-site, and consequently distant and cold. They can stop, rewind and replay at will, and do not feel obliged to follow the speakers flow. Hence the "analysts" metaphor.

Two Social Situations

The existence of two different social situations, the one on-line and the one on-site, is shown by the fact that on-line there are always comments such as personal remarks, jokes or technical questions. This requires separate public and private channels for discussion related comments and those necessary for the creation of a social situation on-line. The role of the on-line moderator becomes crucial.

Making the on-line discussion visible simultaneously with the talk delivered by the speaker on-site is a straightforward but ineffective way of visualising activity and contributions of on-line participants. The audience perceived it as a good indicator of on-line participants' activity, and hence of their presence, but not as means for conveying actual information.

Having only selected on-line contributions projected in large letters by the on-line moderator, was appreciated as interesting side comments, providing a different point of view to what the speaker was saying. It was regarded as "amusing" and therefore helping to keep the attention to the speaker's talk, rather than as distracting.

Propagating these selections to on-line participants was regarded by them as a very welcome feedback that enhanced their sense of involvement. Most speakers considered projecting these selections during their talk as an unwelcome distraction. Only a few tried to establishing some kind of communication with participants on-line.

Long talks by the speakers as well as the slow turnaround cycle of discussion, favoured parallel discussion on-line with a life of its own. The 15-20 seconds delay by the streaming technology was reported as disturbing and requiring mental adjustment, but not jeopardizing the involvement at large.

The Presence Paradox and Desire for Action

The on-site audience perceived on-line participants as being in the advantageous situation due to their active participation, in spite of their physical absence. This shows that available channels for active participation can be more important than physical presence. An equilibrium of participation channels for all parties involved is needed. The concept of video annotations as a model for non-disruptive audience participation throughout the event addresses this issue.

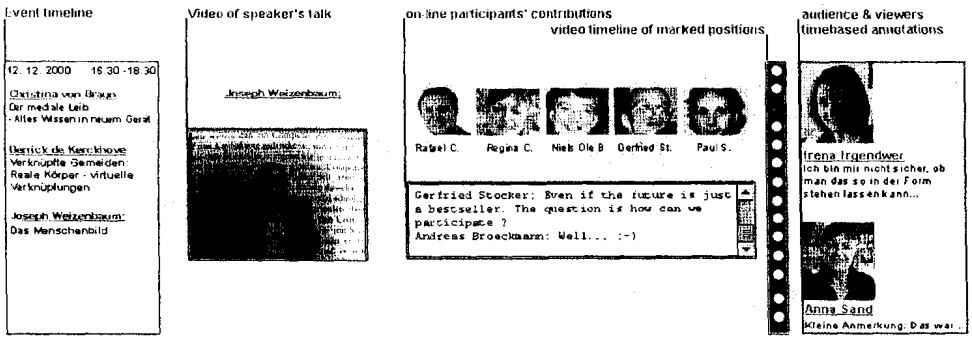

Figure 9: Visualising the history of the event as a collection of personal impressions

Is It Archive or Memories ?

The archive of an event commonly comprises only visible manifestations of participants' actions. What is missing is a dynamic account of the audience reception. What personal imprints did the event leave with them? How was it different for the audience on-site, from the audience on-line? Integrating asynchronous interaction into creation of content during a particular live situation becomes an important issue in this respect

To address this issue, subsequent development of the i2tv system extended the notion of a time-based hypermedia archive to an individualised memory space. The audience on-site and viewers on-line can make

annotations to the video stream of the live situation, using their cell phones, palmtops or home PCs. They assume the role of commentators.

Instead of a linear timeline the history of the event is visualised according to the timepoints set by the viewers' actions. These provide the structure onto which all the individual elements of the event are mapped: the recorded video, the contributions of on-line participants, the comments of on-line viewers and of the on-site audience. Instead of an archive, a space of individual memories is built up. It can be visualised by the moderators, or looked up by the on-line viewers and participants, in real-time during the event not only at its end.

This fundamentaly transforms notion of an archive. Rather than a collection of "objective" facts captured by the camera or text logs, the hypermedial archive of the event is visualised as a collection of personal impressions (Fig. 9). A space of individual memories creates a memory space of collective experience.

Theatre as Organisational Principle

The crucial issue in integrating on-site and on-line participation is the question of appropriate organisation of on-line input for the participants on-site. We compare the problem of organising many simultaneous inputs on the same stage, possibly coming in different media formats from different actors (text, audio, video or 3D), to the theatrical staging of a piece: the actions of multiple actors need to be organised in one space.

As noted in [15] theatre can be seen as a hypermedium: a Mixed Reality concept bringing together different realities through text, bodies, architecture, sounds, etc. This realisation enables us to incorporate lessons from our previous work on theatrical models for Mixed Reality in shared physical space, such as the Mixed Reality performance *Murmuring Fields* [18]. Abstracting the situation of on-line/on-site discussion by applying theatrical strategies is demonstrated by the *Ottos Mops* distributed play that we developed in sequence to the Memoria Futura trial.

THEATRICAL MODEL: "OTTOS MOPS" DISTRIBUTED POETRY PLAY

"Ottos Mops" is a model for a live artistic production integrating on-line participants with participants at a real physical location. It exemplifies an on-line/on-site scenario in which on-line participants are an integral part of the situation on-site and crucially determine the content produced. "Ottos Mops" brings together an on-site performer and multiple on-line participants in a real-time distributed play based on sound poetry of the Austrian poet Ernst Jandl.

Jandl's phonetic poem is split into individual words in this Mixed Reality television game. Participants on-site, in Internet cafÈs or outside in the street, are equipped with mobile phones, palmtops, PCs or touch screens, in order to send their word contributions into the Virtual Studio. The moderator in the studio becomes a conductor who binds the incoming words into a new phonetic poem. Beyond the real-time interaction, the individual contributions of the participants are related to each other and visualised in the form of a Memory Space.

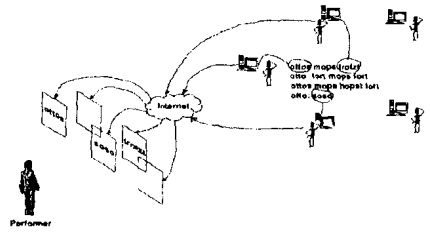

Figure 10: Basic concept of the "Ottos Mops" distributed poetry play

The realisation of *Ottos Mops* deploys the following i2tv configuration: the MOO server, real streaming, eMOOSE, WWW, and Virtual Studio. On-line participants and viewers can use the web interface both for interaction and display, or watch the TV broadcast for high-quality video while using the web interface only for interaction.

The audience on-site experiences the situation of a Virtual Studio enhanced by the projection of the resulting Mixed Reality Stage. They can watch the actor in the blue box, or the composed Mixed Reality stage on the projection screen, with the resulting soundspace combining the inputs from the actor and from the on-line participants.

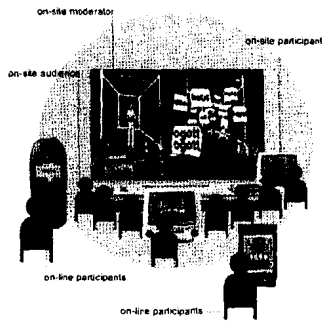

Figure 11: Layers of participation in the "Ottos Mops" distributed poetry play

Structuring Real-time Interaction

The sound poetry of Ernst Jandl is taken as a starting point that exemplifies an open structure suitable for networked scenarios. It provides a structure which is inherently mutable and re-composable, rather then conditioned by fixed relationships between the elements. This makes it an appropriate basis for the creation of new content through real-time interaction of multiple participants. Involving an on-site performer with the task of binding the on-line contributions into an aesthetic whole demonstrates artistic alternatives to the role of a moderator.

Establishing Engagement and Involvement in the Creation of New Content

Metaphorically, the choice of the poem *Ottos Mops* addresses the notion of "communication" as the discovering of possible meanings, rather than that of "equal interpretation of meaning" by the involved parties. The playful element of the poem helps to avoid the participants' need of establishing meaning. It entices playful exploration in discovering

alternative constellations of what is recounted by Jandl - "the stories of the story".

The roles of on-site and on-line participants relate to the specificity of their respective situations. On-site is emphatic, immersed into the situation, "close" to the experience of the poem read as written. On-line is distant, reflective, that which puts apart the predefined structure, helping uncover the inner workings of the poem as "stories that could be told". Substituting the performer by participants from the on-site audience, extends the situation to a kind of Mixed Reality karaoke.

A Model for Interactive Narratives

Staging *Ottos Mops* as a distributed play can be understood as creating a situation in which the participants develop strategies for exploring interactive narratives. This concept points to possible approaches for developing participation models for networked scenarios which go beyond traditional models such as game shows, quizzes, or social chats in 3D space. Rather than merely a combination of underlying technologies, *Ottos Mops* demonstrates the abstraction of different cultural models from everyday life (TV, Internet) into an artistic production.

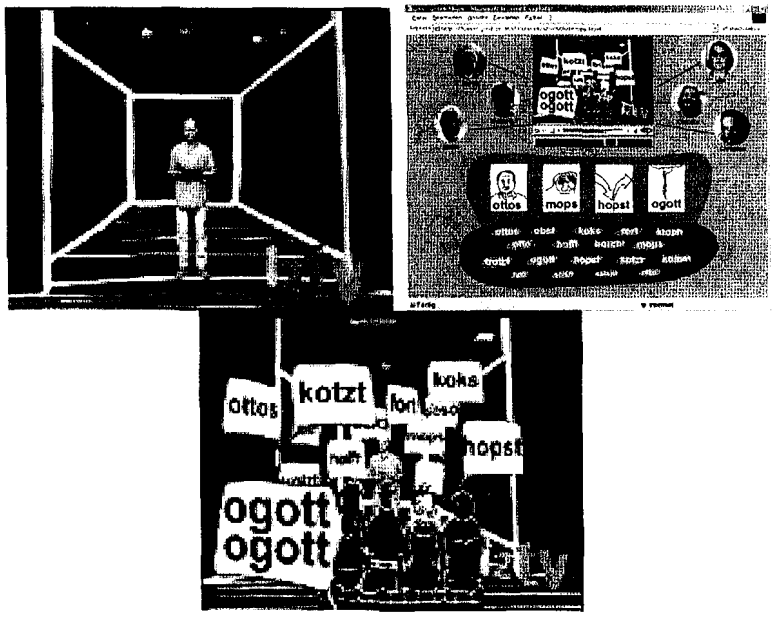

Figure 12: Web interface and medial staging in Virtual Studio of "Ottos Mops" distributed play

CONCLUSIONS

In this work we have explored new forms of cultural participation and production based on Mixed Realities as communication levels between reality and virtuality. We have developed, applied and evaluated the i2tv system as an electronic arena for participation in cultural events integrating Internet and physical space.

The system combines networked multi-user interaction and awareness with medial staging on-site and with broadcast technologies such as Internet streaming and Virtual Studio. Rather then placing the participants as avatars in a shared virtual world, or creating a mixed reality performance confined to the physical space of the theatre, the i2tv system enables the development of networked Mixed Reality productions linking physically present and remote participants while retaining the specifics of their respective situations.

The two concrete i2tv dramaturgical models demonstrate new forms of cultural production and participation. The historical format of public discussion is extended to integrate on-line participants into a networked Mixed Reality situation at the Memoria Futura symposium. This exemplifies a point of departure for uncovering the intrinsic characteristics of the connected on-line/on-site situation as a fundamentally new form of cultural experience.

The distributed play *Ottos Mops* represents a theatrical model integrating on-line participants as active producers of new content and an integral part of the situation on-site.It demonstrates a participation model based on four roles specific to the connected on-line/on-site situation: the actor (on-site performer), the passively involved (on-site audience), the commentators (on-line participants) and the analysts (on-line viewers).

The concept of video annotations and the visualisation of participants experience as a space of "collective memory" are employed as non-disruptive channels for active participation of the on-site audience and on-line viewers. Integrating real-time Virtual Studio facilities allows to visualise a Mixed Reality situation for all parties involved, while reaching large audiences through live TV broadcast.

The i2tv combination of broadcast technologies with interactive media channels demonstrates models for integration of the participatory model of Internet and the passive broadcast model of TV into new forms of cultural spaces based on Mixed Realities.

REFERENCES

1. http://www.nada.kth.se/erena
2. http://www.cnn.com/q&a
3. http://www.kulturserver.de/
4. http://ichsehewas.khm.de/
5. http://www.big-brother.de
6. http://imk.gmd.de/dmp
7. Benford, S. et al.; Evaluating Out Of This World: An Experiment in Inhabited Television, In Second Year eRENA Deliverables, 1999, Stockholm, ISBN 91-7170-466-3

8. Breitender, C. et al.: Distributed Video Production on ATM, Proceedings of ECMAST ë96, April 1996

9. Curtis, Pavel and David A. Nichols, "MUDs Grow Up: Social Virtual Reality in the Real World," Proceedings of the 1994 IEEE Computer Conference, pp. 193--200, January 1994

10. http://lingua.utdallas.edu/encore/

11. Fleischmann, M.; Strauss, W.; Novak, J.; Murmuring Fields Rehearsals -Building up the Mixed Reality stage, Proc. of KES 2000, Brighton, August 31-September 2

12. Greenhalgh, C.; Benford, S.; Taylor, I.,; Bowers J.; Walker G.; Wyver J.; Creating a Live Broadcast from a Virtual Environment, in Proc. ACM SIGGRAPH'99 pp.375-384, ACM Press

13. Haynes, C.; Holmevik, J.R. (eds.); High Wired: On the Design, Use, and Theory of Educational MOOs, University of Michigan Press, 1998

14. ftp://ftp.lambda.moo.mud.org/pub/MOO/

15. Leeker, M.; Theatre, dance, performance and information technology: The role of actors and audience in mixed realities, In Proc. of the Memoria Futura Symposium, Dec. 11-12, 1999, GMD, St. Augustin (to be published)

16. Novak, J.; Development of Paradigms and Models for Interactive Environments, Master Thesis, Faculty of El. Eng. and Computing, University of Zagreb, July 1999, and GMD Research Series, ISBN 3-88457-372-1

17. Scott J., If Memory then Multimedia Fantasy, In Schwarz H.P., Shaw J., Perspektiven der Medienkunst, Ostfildern/Karlsruhe, 1996

18. Strauss, W.; Fleischmann, M.; Novak, J. et al.; Linking between real and virtual spaces, In eRENA Second Year Deliverables, 1999, Stockholm, ISBN 91-7170-466-3

19. Vellon, M. et al.; The Architecture of a Distributed Virtual Worlds System, Microsoft Research, 2000

20. Vonolfen, W.; Virtual Studios for TV Productions § Limits and Chances, Proceedings of the eight IEEE international workshops on enabling technologies: Infrastructure for collaborative enterprises, Stanford, USA, June 16-18, 1999

21. Strauss, W.; Fleischmann, M.; Novak, J. et al.; Staging the space of mixed reality - reconsidering the concept of a multi-user environment, Proceedings of VRML 99, 1999, Paderborn, Germany, pp. 93-98

22. White, S.; Gupta, A.; Grudin, J.; Chesley, H.; Kimberly, G.; Sanocki, E.; Evolving Use of a System for Education at a Distance, Proc. HICSS-33, CD-ROM

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