System Dynamics as Story Engine for Interactive Video

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ABSTRACT

This paper will discuss visualization of system dynamic models, particularly the use of video, as a method for designing interactive multimedia learning tools. Although traditional media productions may capture elements of natural and social development as well as the underlying causal structure, such productions do not often match well the complexity of this structure and typically does not explain well how such a structure produces the development observed. Therefore, we design interactive multimedia environments that allow for the presentation of the relationship between the underlying structure and the resulting behaviour of natural and social systems in the form of narratives produced and presented on demand. Using video in the visualization of simulation models raises practical and theoretical questions such as: How is the immediacy of a simulation game affected when pre-recorded video of a past event is integrated, and could this be done without limiting the openness of the simulation? Departing from prototype examples, these are questions to be explored in this paper.

KEYWORDS

Simulation, immediacy, interactive video, interactive documentary, representation, hybrid media forms

INTRODUCTION

This paper will discuss visualization of system dynamics models, particularly the use of video, as a method for designing interactive multimedia learning tools. Traditional system dynamic models have been developed for a broad range of applications – from urban planning to management of factory floors. The problem faced by many users of system dynamic models is their graphic complexity for users not specifically trained within the field. This is the problem addressed by the VOCS (Visualization of Complex Systems) project – a collaboration between researchers at the Department of Media Studies, the Department of Information Science, and InterMedia, University of Bergen, Norway. Through prototype design, the project develops visualization methods intended to increase the user's motivation and understanding of results.

The purpose of such multimedia productions is to outline and illustrate insights gained into sustainable and non-sustainable operating conditions in natural and social systems. Moreover, the purpose for our target audience is to "experience", through simulation, how these conditions of sustainability change in response to various policies and implied decisions suggested and employed by that audience. The goal of our research is two-fold: 1) to explore how or whether video, including documentary footage, can successfully be incorporated into simulation, and 2) to explore whether an underlying simulation model could work as a "story-engine" for interactive documentary.

Using video in the visualization of simulation models raises practical and theoretical questions such as: How is the immediacy of a simulation game affected when pre-recorded video of a past event is integrated? Could this be done without limiting the openness of the simulation? Departing from prototype examples, these are questions to be explored in this paper.

Before going into the prototypes developed, we will briefly contextualize this cross-disciplinary project. First, we will give a brief description of system dynamics and simulation modeling, and then discuss previous relevant research on "interactive video".

SYSTEM DYNAMICS AND SIMULATION

The field of system dynamics was founded by Jay W. Forrester at MIT in the 1960s [13]. System dynamics is a methodology for analyzing and understanding how complex systems change over time, by way of computer based modeling and simulation. Problems related to such diverse systems as a city, an ecosystem, or a family may be analyzed by the means of the system dynamic method. By changing variables the user can experiment with the model and experience different simulation outcomes. In simulations you create and look for answers to "what if" scenarios, such as: Given certain conditions, what would happen to the air quality of a city if we build more highways? What would the effects be in three months, in one year, in three years? System dynamics study the interdependence of different variables of a system, how different parts of the system are connected, and how problem behavior can be understood and predicted by exploring a system's underlying structure.

When constructing the structure of system dynamic models it is difficult to determine which real system variables to include and omit. It is important to have a clear objective for making the model and to base the modeling process on a problem, not on a system as a whole. Focusing on a problem aids the modeler in deciding which variables to include. The focus on a problem also establishes one foundation for assessment of the model, as the model can be evaluated based on how well it addresses the problem.

Any complex system can be modeled based on system dynamic principles. In a complex system the relationship between the variables is non-linear. This means that the force or effect that one variable has on another changes over time. The variables are interconnected, meaning that the change in one variable may lead to a change in another. This process may continue in a feedback loop. A basic concept in system dynamics is the integration of stock variables into flow variables. A stock such as people changes based on the birth/ immigration rate (inflow) and the death/ emigration rate (outflow). It takes time for a stock to accumulate, and delays are thereby created in the system. The effect of a change in a stock variable cannot be observed instantaneously, but must be studied over time. The characteristics of complex systems make them generally difficult to understand and control, and the aim of system dynamics is to enhance the understanding through representing the systems through models.

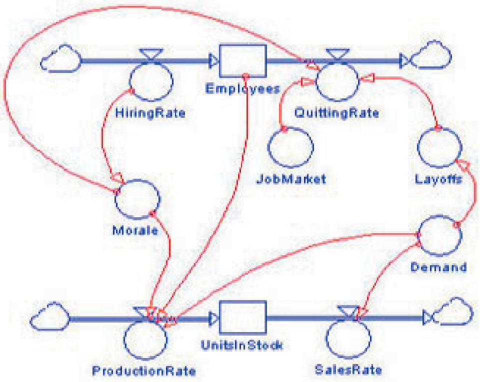

Figure 1: Example of System Dynamics structural map

System dynamics offers a number of graphical ways to represent structure; all centered around the integration (accumulation) processes that cause systems to behave dynamically and the causal relationships that influence *how* such systems behave. These structural maps constitute a framework for multimedia presentations of system structures. Moreover, they allow for efficient navigation within such structures. The graphical representation of existing system dynamics simulation software is however not intuitively understood by novices within the field. In Powersim™, the software utilized in this project, the underlying structure is represented as in Figure 1, and the behavior of the system is represented by graphs and diagrams.

SIMULATION GAMES

With the expansion of computer technology, computer simulation spread within science and education, especially within natural sciences [2]. Will Wright's groundbreaking *SimCity* [8] brought system dynamics into commercial game design. When Wright designed the popular simulation game, he was inspired by Jay Forrester's [12] work on urban planning [32].

The pleasure of playing a simulation game consists in figuring out the underlying rules. *SimCity*, for example, has been criticized for its underlying economic model, and critics have feared that the computer technology masks ideological bias [15, 17, 36]. Instead of rejecting simulations because of their biases and simplification of reality, Sherry Turkle proposes an alternative response to simulations in her book *Life on the Screen* [37]. The response Turkle [37] envisions

> ”would take the cultural persuasiveness of simulation as a challenge to develop a more sophisticated social criticism. This criticism would not lump all simulation together but discriminate among them. It would take as its goal to develop simulations that help players question the model's built-in assumptions. This new criticism would use simulations as a means of consciousness-raising” (71) cited in Frasca [15].

In our learning applications we intend to mix simulation with *documentary*. Within film and television documentary has traditionally been considered a genre whose *raison d'être* is to represent critical thinking and create debate. Representation of “reality” and how documentary creates or encourages critical thinking is a central concern within documentary theory (see for example Nichols [31]; Winston [38]). This debate is useful for discussion of simulation games and is one of the focuses of the project's theoretical work. Within the limits of this paper, however, we take on this question in the following section in connection with the discussion regarding the different types and tasks of simulation models.

INTERACTIVE VIDEO – FICTION AND DOCUMENTARY

According to Aarseth [1], the term “interactive fiction” made its entry in the computer press in 1981, and was introduced to literary studies a few years later (48). “Interactive fiction” is a term that has been used about everything from Cortazar's *Hopscotch* to the VR fantasy of *Star Trek*'s Holodeck, and Aarseth is among the theorists who have discarded the term “interactive” as a meaningful analytic term [1]. The concept of “interactive video” is more media-specific, but is still a broad term where every application containing some digitized video clip and offering some degree of user interaction could potentially be included.

In cinema, most films get their final shape in the editing room, where individual shots are put together and take on meaning from the context[1]. The hypertext approach to interactive cinema (see for example Sahwney and Balcom's *HyperCafe* [34]) explores linking between video clips in a hypertext structure (see Miles [26] for a comparison of film edits and hypertext links). In interactive storytelling illustrated by computer rendered 3D graphics, simulation and AI could be applied in the construction of space and characters (see for example Mateas and Stern's ’interactive drama’ *Façade* [24]). When dealing with video, however, the images are pre-recorded. The user's interaction can then generate contextualization, not creation, of the images.

The work of Glorianna Davenport's Interactive Cinema Group at MIT includes various approaches to interactive video and storytelling systems. Several interactive documentary projects have focused on finding ways of browsing or navigating through a database of documentary material. After the final edit, documentary filmmakers are often left with extensive material that will not be used. In the project “ evolving documentaries”, systems and interfaces that open for user navigation through a growing video database have been developed [29]. A more recent project at MIT involves context sensitive interactive movies. The user can bring a handheld video device with her on a tour and receive information depending on where she is [6]. The context for the images, e.g. a particular café that is part of a multi-threaded story, is then created by that location.

Documentary, Simulation and Ideology. In linear documentaries, the rhetoric relies heavily on editing. The images are carefully put together by the director in order to construct an argument. The crosscutting in Michael Moore's documentary *Bowling for Columbine* [27] has both humoristic and argumentative effects. Bordwell and Thompson [5] distinguish between narrative and non-narrative modes of storytelling and editing in film. However, they emphasize that these should not be seen as absolute categories and that many films cannot be placed in only the one or the other. In the narrative mode of storytelling, the film's structure relies on the causal chain of events driven by goal-oriented characters. In the four non-narrative modes described by Bordwell and Thompson, the film's structure relies on other principles: The '*categorical*' mode divides its subject into categories; the '*associational*' creates visual metaphors through juxtaposing loosely connected images; and the '*abstract*' draws attention to abstract visual and sonic qualities of the things depicted. In the '*rhetorical*' mode, the editing creates a persuasive argument, not necessarily a coherent narrative [5].

In an interactive documentary, the editing principles or contextualization of individual clips must be programmed. The clips must be annotated and follow some logic that allows for meaningful user navigation, such as linking clips that are similar in theme or form – or organizing them according to categorical or abstract principles, following Bordwell and Thompson's [5] terms. In the project described in this paper, simulation models are thought of as possible story engines for interactive documentaries. The logic of the underlying structure in the simulation will then become the logic that binds the documentary video clips together.

Within media studies, researchers analyzing cultural expressions from a Marxist perspective have criticized 'mass media' for creating consensus and avoiding structural criticism. More recently, scholars shifted the focus to how varied audiences actually respond. Within some media genres, however, there is less tradition for social criticism than in others. In the tabloid news broadcast format, dramatic events are broadcasted but deep analysis of these events and long-term processes do not reach the headlines [25][2]. Similarly, Gonzalo Frasca has discussed how particular characteristics of some computer game genres make dealing with certain moral issues problematic [16].

Compared to broadcast news journalists, a documentary filmmaker does normally not have to tell a story in two minutes and has more room to develop an argument. Filmmakers have done this in a variety of ways. Michael Moore's *Bowling for Columbine* is playful, however not in the game-meaning of the word. He uses humor and naïve questions mixed with strong war images to strengthen his arguments. He tries, however, to go beyond the rhetoric that dominated North American public debate immediately after the Columbine shootings (see Jenkins [20] for a discussion of this debate) and asks questions: "What went wrong?" "What could be the underlying reasons?

These are questions also asked when playing a simulation game. Would simulation games where the user has to figure out the underlying structure be suitable as story-engines for documentaries dealing with complex social problems? In order to find the causes of a problem in a simulation, the user has to investigate through trying and failing, much like in scientific research. However, the answers are imbedded in the simulation through the authors' programming of the rules. Gonzalo Frasca [15] envisions the possibility of creating simulation games as a tool for critical thinking and debate. He suggests that such a game should let the user change the underlying assumptions.

We can identify three types of simulation games in relation to the user's access to their underlying model: 1) Simulation games where the underlying rules are hidden, and cannot be changed. One example of such a game is *SimCity*. 2) Simulation games where the underlying assumptions are accessible to the user, but cannot be changed, and 3) Simulation games that allow the user to change the underlying assumptions of the model. Different kinds of simulation games might aim to accomplish different or overlapping tasks [3]. One task might be to teach the user to manage a real system, as in flight simulators. The underlying model will then be of little interest to the user. A more conceptual task might be to argue for a particular hypothesis of how a real system works. Another conceptual task, following the system dynamic methodology, might be to teach how to interpret real world phenomena as results of underlying structures. Audiences of a traditional linear documentary, familiar with the genre conventions, can probably identify the techniques that the filmmaker uses to construct the argument. When simulations attempt to teach about real-world phenomena and real systems, the users must be familiar with the genre in order to question their representation of "the real". Frasca [15] and Turkle [37] suggest that simulations of the third type listed above (where the user can change the underlying assumptions) have the greatest potential of becoming tools for critical thinking. We will argue that also simulations of the second type have such potential. If the hidden rules underlying the simulation are de-mystified and made accessible through explanation, these rules can also be evaluated and criticized by users.

Within education, ranging from K12 education to business and management training, simulation modeling – where learners construct their own models – has been used in a constructivist approach to learning [3, 15]. The visualization techniques being developed in our prototypes are going to be implemented in simulation software, so that users can build similar models themselves and include their own media material. The focus of this paper will however be on how we envision that audiences engage with already authored video based models and how they might learn from them.

To clarify this discussion further, two of the prototypes developed in this project are presented in the following section of this paper. A primary concern is simulation models as interactive documentaries. The greatest space is given to a prototype of an urban planning simulation with documentary footage included. As a way of introducing system dynamic models and their possible visualizations, we will first describe a simpler model that we developed in order to experiment with formats and editing techniques.

SIMULATION GENERATED VIDEO IMAGES – THE TWO-SHOWER MODEL

"The two-shower model" was chosen for visualization because it is often used in teaching as an introduction to the field of system dynamics. The model has few variables but illustrates some basic and central system dynamics principles[3]. The simplicity of the model also made it suitable as case for a first video visualization experiment. The system dynamic model itself was originally presented in Morecroft et. al. [28].

In the model, two persons, unaware of each other, share the same hot water tank for showering. To understand the model more graphically, imagine the following scene: You arrive at a new hotel for the night and tired from an exhausting journey you long to take a refreshing shower. The bathroom looks OK and the shower as well – until you turn on the water. You struggle to find the right temperature, desperately adjusting the tap with no

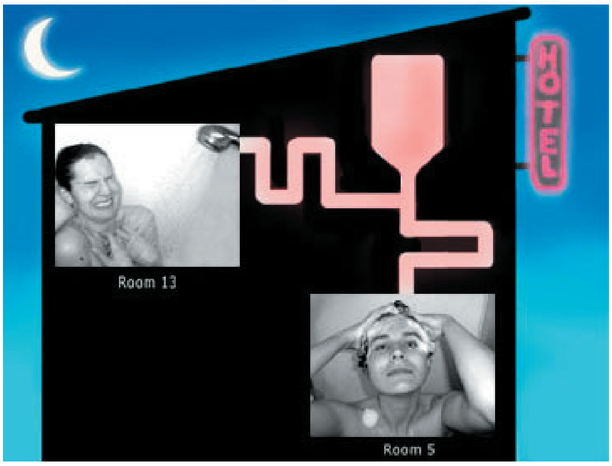

Figure 2: Interface – presenting the scenario

immediate results. Finally, you may realize that waiting patiently for the temperature to change before you turn on even more hot or cold water helps more than cursing. Then you hear the shower in the neighbor room being turned on and the story repeats itself. What happened?

Having problems with the hot water supply when showering is a scenario most people can relate to. This seemingly trivial model may however be seen as a metaphorical model for more complex organizational and natural resource sharing. The model illustrates the causes and consequences of interdependence in resource allocation: If two actors share a scarce resource and both try to exploit it without regarding themselves as part of a system (with other actors), a probable outcome is that none of them will experience optimal results.

The opening interface (Fig. 2) presents the problem-scenario:

In the two "windows" of the hotel, the user sees sequences of video clips from the showers[4]: The video images are triggered by the underlying model and change along with the shower temperature in the simulation.

When the user has run the demonstration, she will be asked if she wants to try herself and her role will then be changed from observer to player. Before entering the shower, the user can choose which hotel guest she wants to be by selecting one of two pictures. The choose-player device is used in many computer games and anticipates a game scenario. Inside the simulated shower (see Fig. 3), the system responds based on input from the user. As the user manipulates the temperature tap, the behavior of the system is illustrated by changing video sequences, colors, and animation:

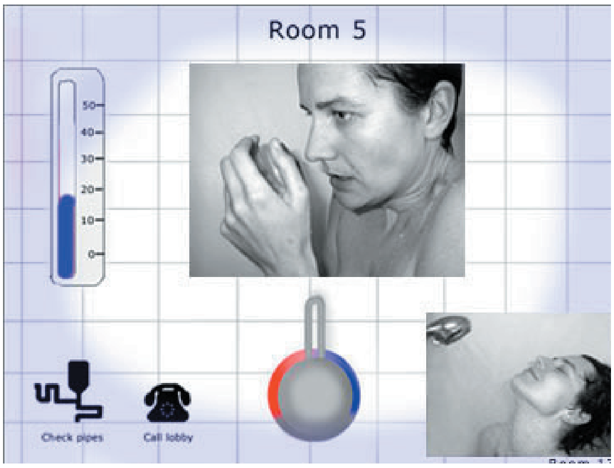

Figure 3: Interface "Inside the shower"

Use of Video Images in the Two-Shower Model
The underlying simulation model (and the user's interaction with it) generates short real-time (if the simulation is run in real-time) video sequences that represent the actual conditions of the system. The video sequences run in window(s) during simulation (see Fig. 3). The sequences will be composed by a combination of short clips from a library: close-ups of hand moving the temperature tap, water streaming from the showerhead, faces with varying expressions (accompanied by sounds), screaming mouth, jumping feet etc. How the video clips are combined depends upon the user's interaction – for example how fast the user turns up or down the heat in the shower.

Video is a realistic medium with its inherent photo-

Figure 4: Example of simulation-generated video sequence

realism and the images will probably cause a greater emotional impact on the user than straight statistics or graphs showing that the temperature curve rises. The intention is to increase the user's motivation and understanding of results. A longer model-generated sequence passing through changing temperatures may look like this:

By using short clips as building blocks for model-generated videos, it was not necessary to film and pre-edit a large number of sequences representing all possible simulation outcomes. Instead, a library of single clips was created. The clips could then be combined in numerous ways, creating different "stories".

The Two-Shower Model has a limited number of variables and the "world" the model represents is accordingly simple. The main model or "game" scenario is limited to one location (the two showers) and includes only two actors. The simulation scenario stages the user in the role of the protagonist with a goal to pursue – the ideal shower temperature. The second showering character (a second user or the computer) is the antagonist that might prevent the protagonist in reaching her goal, unless they find a way to cooperate. The "stories" generated by the simulation could then be seen as simple narratives.

Editing Techniques. We have relied on cinematic conventions such as techniques of 'classic continuity editing' (see for example Bordwell and Thompson, [5]) in order to create a coherent, seamless story from several individual video clips. The famous shower scene in Alfred Hitchcock's *Psycho* [18] inspired the framing of the clips. In the scene, the main female character is never revealed in a long shot. The scene is composed of close-ups and shoulder shots edited together in an accelerating rhythm. The female character is disembodied through the framing of the shots, and the body is reconstructed through the editing. The Russian filmmaker Lev Kuleshov showed through experiments how spectators

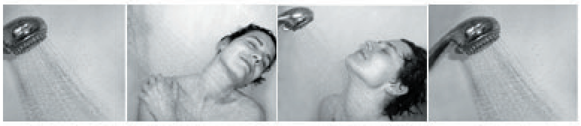

Figure 5: OK-temperature loop

read connections into previously unrelated shots when showed in sequence [5, 26]. An illusion of continuous space and time could be created simply by the juxtaposition of shots.

What causes screams and drama in the Two-Shower Model is not a Mr. Bates but scolding hot or ice-cold water. As long as the shower temperature remains

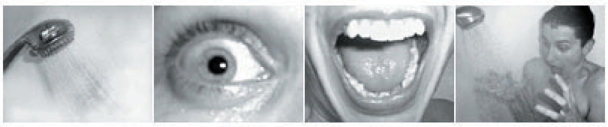

Figure 6: Too-hot-temperature sequence

unchanged, the generated sequence would enter a loop. If the shower temperature stays pleasant, the following pictures/ clips could loop:

If the temperature turns very hot, the following sequence could be activated:

For dramatic effect, the clips should be shorter in duration, in contrast to the clips in the more relaxed 'ok temperature' sequence above (Fig. 5). The "too hot water" sequence would loop until the user does something to try to change the temperature. However, the sequence continues with a "still-hot-water-loop" until the temperature actually changes. New temperature loops (for example shifting from "ok" temperature to "too hot") will always start with a "neutral" image, called *cutaways* in editing terminology, such as a close up of the showerhead (see Fig. 5 and 6), or the hands changing the temperature tap when the user does the same thing during simulation (see Fig. 4). In this way *jump cuts* and sudden shifts in mood are avoided when the temperature does not shift abruptly and the illusion of continuity is maintained.

Time and Immediacy. Many simulation models simulate changes that develop over a large time span, such as the construction of a city. Others simulate processes that happen extremely fast. In simulation, time is therefore often subject to manipulation. Juul [21] presents game time as a duality between *play time* (the time the player takes to play the game) and *event time* (the time of the game world). Many simulations let the user speed up or slow down the event time [21]. The Two-Shower Model, however, simulates a process that very well could be played in real-time – event time equals play time. The images edited together in real-time video sequence would follow the user's actions, as would a graphic rendered-on-the-fly representation of the same scenario. The video sequences are being "edited on the fly". Since event time and play time coincide, the video images may take on a sense of "liveness" instead of "pre-recordedness".

The relation 1:1 in play time and event time is common in action games. When the user's interactions have an immediate effect in the game world, this provides immediacy and the sense of "now" of the play [21]. In the Two-Shower Model, when the user turns the temperature tap, it will have an immediate effect in the game world[5].

As pointed out previously in this section, the Two-Shower Model is based on a relatively simple underlying model and the simulation scenario presents one type of location and a limited range of character actions. In more complex models it would be complicated to use continuity editing as principle. In the following section we will present how the basic techniques of model-generated video were transferred to a more complex system dynamics model.

Representing more complex systems does not only pose technical challenges. All simulation models are simplified representations of real systems[6] but the relation between the model and its real-world referent becomes more of a concern as the complexity of the system increases. While the Two-Shower Model is not likely to cause debate and controversy over the accuracy and realism of the rules underlying the system, the simulation of a city – especially if it is a real city – will inevitably be both less realistic and more controversial[7]. There are conflicting theories and views upon how cities and societies should be managed, as well as conflicting interpretations of widely shared values (see Starr [36]). In the presentation of the next prototype, the Quito model, this problem will reemerge.

SIMULATION WITH DOCUMENTARY FOOTAGE – THE QUITO MODEL

A more complex model uses the city of Quito as case study. The project was developed for and presented at the UNESCO World Heritage Center 30th Anniversary Virtual Congress [35].

There are many examples of simulation models developed for use in urban planning and management [2]. System dynamics or simulation models have been used in urban planning education for several reasons: Simulation allows experimenting, enhances understanding of the interconnectedness of elements in a system, and encourages long-term thinking and planning. In the construction of the Quito prototype, we are drawing on classic pure system dynamics models [12], learning environments [2, 3], interactive documentaries, and of course, Will Wright's SimCity [7,8]

The City of Quito

Quito is both an historic and a modern city. We wanted the simulation to represent the challenges of managing a city for mixed use: a city for locals, tourists, different social groups, commerce, and housing. In a first, simplified prototype, we have focused on a selection of issues that are frequently listed as problem areas for the historic center of Quito and subject of planning and future regulations:

• Traffic: The narrow streets of the colonial center are often congested with cars and heavy vehicles such as old buses. As a result follows noise, air pollution, and damaged buildings.

• Unorganized street sellers – *vendedores ambulantes*: The street sellers are mainly poor people offering food and products to by-passers from improvised stands. This unorganized commercial activity contributes to the lively character of the historic center but is also considered to cause chaos and disorder, such as garbage left on the streets by the end of the day, blocking of sidewalks, and smoke from preparation of food using charcoal.

• Maintenance: Many of the old houses of the historic center are in poor shape because of lacking maintenance and renovation.

The level of simplification depends on the purpose of the model. In the first stage of prototyping for the Quito model, we have concentrated on the visualization aspect and reduced the complexity and accuracy of the underlying system dynamic model.

The Intended Audience

The intention behind the Quito model was to create a heritage management tool that could be used not only for planning and management but also as a tool for planners to present policies to citizens as well as a learning environment in education. Traditional system dynamics simulation models have been used, for example, in business management training to help managers understand the complexity and workings of their organizations. Many of these models, however, require the users to go through a time demanding introduction to system dynamics. The Quito model is intended for users without such skills.

Another user group for the Quito model could be the inhabitants of the city. One could imagine a scenario where the Quito model was available to interested citizens on public computers, for instance in public libraries, in *Casa de Cultura* (public building for exhibitions and other cultural activities) or in Universities. Its public use might generate discussion among citizens on urban development and future scenarios for their city. Another example of public use of the model could be to apply it in schools, especially the public schools of areas where the children are directly affected by problems treated in the model, such as pollution[8]. The aim of using the model in educational contexts would not so much be the elaboration of complex development plans but to use it as a tool to create discussion and awareness of problems, consequences, and possible solutions, and to raise citizen consciousness. The interface, described in the following, where results are displayed through video images and color animations instead of graphs and equations, makes the model accessible and engaging for a wider range of users than just professional city planners.

Use of Video Images and Animation in the Quito Model

The city of Quito is represented with a two-dimensional map. When the user changes variables in the model and press "run simulation" the development is shown with animations on the map (see Fig. 7). Expanding or diminishing colored areas or dots represent increasing or decreasing rates of pollution, number of street sellers, etc.

Figure 7: The Quito Model – screenshot with running video clips and one clip enlarged

In addition to animation, this model also uses video to illustrate the behavior of the system. The video clips are activated using the same technique as in the Two-Shower Model. As the simulation unfolds, short running video clips (20-30 sec), called up from a library of clips, will pop up as feedback. The model-generated sequences represent the actual conditions of the system. The clips are triggered by the values of the variables of the underlying model. When, for example, the pollution reaches a certain level, clips related to contamination will be triggered, such as a taxi driver complaining about smog during rush hour. The video clips work as comments on the simulation results, showing for example what consequences the user's choices might have for the citizens. The openness of the simulation is however not dependent on the display of these video clips. A limited number of video clips, even if combined, could not alone account for all possible outcomes. Combined with the animated graphics on the map, however, unexpected scenarios could still be represented.

Integrating Video in Simulation. The video clips are implemented in a manner that does not interrupt the simulation. The clips keep appearing and disappearing on one side of the screen, unless the user herself chooses to interrupt simulation to take a further look at them. If the user selects one of the clips that pop up, the simulation will be paused and the clip be replayed in a higher resolution (see Fig. 7). The possibility to pause the simulation – or, returning to Juul's terminology [21], to pause 'event time' – lets the user change from the interactive play mode to 'watch mode', from 'lean forward' to 'lean back' mode. The user can choose one specific clip and pay full attention to it. This design choice was made also for practical reasons. If the simulation had continued, the relevance of the selected clip would probably have passed when the user had finished watching it – and so would the possibilities to adjust the policy according to what the user learned from the clip.

During simulation several processes take place in the simulated city simultaneously. The user must try to keep track of and control pollution, maintenance, and the well being of different population groups at the same time. In film – if relying on traditional story telling and editing techniques – the audience is only allowed to follow the action in one place at a time. Early on in cinema history, however, this problem was dealt with by using techniques such as crosscutting. Filmmakers discovered that the fact that the spectator could follow the action in two places almost simultaneously could also be used to create suspense. A further development of editing technique, the use of split-screen, reveals a double parallel space.

Mike Figgis' *Timecode* [10] exploits the possibilities of digital editing. Parallel stories are presented in *four* simultaneous windows on the screen. Manovich calls this '*spatial editing*' [23]. This technique is also used as an aesthetic device in television, for example in the series *24* [14]. Unlike *Timecode*, however, in which the four screens are used throughout the film, most of the action in *24* is told in traditional single window screen. Spatial editing is used predominantly between scene transitions to remind the viewer of the continuous parallel plots. In television, divided screens are also a convention in live transmissions such as news and information shows. To show simultaneous action and insist on the "liveness" of the events, the news presenter in studio or on location and the war correspondent reporting live from the battlefield are shown simultaneously on the screen in separate windows [4]. In the Quito model spatial editing is used in order to evoke this sense of simultaneity, or immediacy, and to be able to show clips related to different processes at the same time.

Representing the Particular. Video can present aspects of reality that is not easily quantified as a number in a model. In the Quito model, we could have parameters that indicate the degree of welfare of the street sellers as a group. A video clip with the response of one individual street seller telling how a displacement would affect her personally would probably be a more illustrative way to show the consequences of a policy.

In the first versions of SimCity, the inhabitants of the cities simulated in the game, 'the Sims', are represented in an anonymous way[9]. In GIS visualizations, population groups are normally represented as colors or dots. UNESCO focuses on the importance of including the needs of often-marginalized habitants of historic cities in urban planning. Video testimonies are an often-used device in documentary and television news shows to personalize a story. In the Quito model the video testimonies are intended to give the audience a better understanding of the situation of individual citizens – or rather, to give voice to individual representatives of different groups of citizens and allow them to become more than a number in a model.

According to Bolter and Grusin [4] our mediated culture strives for immediacy – making audiences "forget" the medium and achieve a sense of "being there". Whenever one medium has convinced its viewer of its immediacy, other media may borrow its styles and techniques to achieve the same effect. This mix of styles, which draws attention to the medium itself, is the logic of *hypermediacy*. Bolter and Grusin [4] describe the double logic of immediacy and hypermediacy as central in the process of *remediation* – the refashioning and blending of existing and emerging media forms. The prototypes described in this paper could be analyzed, using Bolter and Grusin's terminology, as examples of remediation. While the video images in the Two-Shower Model try to achieve immediacy through borrowing the transparent Hollywood continuity editing style, the Quito model draws upon the hypermediated simultaneous-windowed style of television's news shows, whose claim to immediacy is their insistence on "liveness" [4]. The use of video images, in both cases, borrows existing visual conventions in an attempt to match the immediacy of simulation games.

The Quito Model as Simulation Game

> "There is an inherent conflict between the *now* of the interaction and the *past* or '*prior*' of the narrative. You can't have narration and interactivity at the same time; there is no such thing as a continuously interactive story." Juul [22]

One crucial difference between games and narrative is related to *time*. This includes simulation. Friedman [17] describes simulations as a "maps-in-time". In Frasca's words, "Narrative is about what happened; simulation is about what could happen" (DAC 2001). The video images in the Quito model do not constitute a narrative but they still represent "what happened". In simulation games such as *SimCity* and *The Sims* [9] graphics are rendered on the fly. Video, however, is with exception from live transmissions a pre-recorded medium.

In the Quito model the user takes the role of a city-planner, or more precisely, an all-powerful mayor. Friedman points out that in *SimCity* the player takes a number of decisions that no single person would do in real life [17]. In the Quito model the user can interact with the system, change variables etc. The clips that appear can however not be interacted with. No matter how the user manipulates the variables of the simulation, the real characters' lives will not be changed. The user will only be shown different clips, different excerpts of a recorded reality. The street seller complaining about her economic situation will not suddenly smile and say she is grateful if the user changed her mind about throwing them off the street.

The sense of being immersed in the game world, lost for hours in front of the computer, is an experience described by many players (see for example Jenkins [19]). Friedman sees immersion in a simulation game as a process of identification with the "computer itself", with the system [17]:

> "We could see playing SimCity, then, as a

constant shifting of identifications, depending on whether you're buying land, organizing the police force, paving the roads, or whatever. This, I think, is part of what's going on. But this model suggests a level of disjunction – jumping back and forth from one role to the next – belied by the smooth, almost trance-like state of gameplay. Overarching these functional shifts, I think, is a more general state of identification: with the city as a whole, as a single system."

Friedman argues that because of this depersonalized frame of mind in which simulation games puts the player, these games "can tell their story in the abstract, without ever bringing it to the level of individual experience" [17]. In The Sims, where the player can choose her characters and then try to control different individual avatars alternately, identifications are shifting. Will Wright describes how players change between thinking of their Sim as 'me' or ' 'he/ she' depending on whether the character "obeys" the player or not. Wright observes how players play several characters, seemingly having no problems with shifting points of view and identification [32]. The Quito model offers the user an all-present God-like overview through the map, where animations show the current state of the simulation. The documentary clips present a view from bottom-up – like the man-on-the-street interview commentaries to the headline story in the news broadcast. However, if the viewer may identify with any of the persons in the video, this would be a different kind of identification, since the user cannot try to control them as the (obstinate) avatars of *The Sims*.

Immersion is often described as a state of mind opposite to reflection and limiting the critical potential of what is displayed on screen (see for example Ryan [33]). In the Quito model, when the user pauses the simulation to watch a specific clip she ends what, following Friedman [17], might be an immersive experience and identification with "the simulation itself". The video clips might have a Brechtian alienation effect that makes the user reflect upon the simulation and possible real world consequences and dilemmas. Jenkins argues [20] that news footage and newspaper stories are more frightening to young people than video violence. Video violence is not frightening because it belongs to fiction and genre conventions. Frasca [16] suggests that because of the always-present possibility to restart or replay a game, actions in a game world do not have real consequences and neither would then moral dilemmas presented to the player. A simulation with documentary footage incorporated the way we have described will then constantly point to the real world where choices do have consequences.

A simulation model such as the Quito Model might then inspire users to become aware of and think of solutions to problems in their own city. The aim is to help the user acquire a deeper understanding of complex structural relationships through engaging with the model. Without a critical distance, however, the user might be led to think that the consequences of a certain policy in the simulation will also have the same consequences if applied to the real city.

The Quito Model as Interactive Documentary

In the paper "Factual Hybridity: Games, Documentary and Simulated Spaces" Bernadette Flynn [11] compares *The Sims* and the TV show *Big Brother* and how both invite their audience to a 'God's eye view' upon the characters and their simulated trivial activities in a household. Flynn argues that animation or digital imagery should not be seen as an inferior representation of reality and suggests a lineage back to cinema's very beginning with Méliès' reconstruction of an historical event in *The Coronation of Edward VII*. According to Flynn [11], hybridity does not necessarily represent a threat to the documentary genre:

> "I would suggest instead that simulation does allow for a factual hybridity based on potential events and probabilities – the 'what if'. This then opens up other possibilities and types of 'realism' away from the monocular camera lens." (52)

We consider the Quito model as such a factual hybrid. The documentary clips do not make the simulation model more "real" or "objective". However, as Flynn [11] points out, their "assumed closer indexical relationship to a real-world referent" (51) places them within the tradition of factual representation. The simulation represents the fictional in the sense that the future "what if" scenarios emerging from the user's manipulation with variables are fiction. The underlying system is modeled based on factual information and variables from the actual city of Quito. However, as in every simulation, it is still just a representation based on the assumptions of the modelers. The documentary clips are video representations of actual people living in Quito, and their appearance cannot be manipulated by the user's interaction. To the naïve user this may disallow the realization of the constructedness of the simulation model.

To avoid this problem – that the video clips instead shorten the distance in the user's mind between the representation and its real referent – the fact that the documentary clips are representations may be emphasized. Documentary filmmakers wanting the audience to be aware of the subjectivity of representation moved away from the observational "fly-on-the-wall" style [31]. Self-reflexive form where the filmmaker puts herself in front of the camera is one example. *Bowling for Columbine*, discussed above, does not on the surface present itself as anything more than the filmmaker-protagonist's subjective, however convincing, interpretations of reality. Using a somewhat different technique, Errol Morris' documentary *The Thin Blue Line* [29] plays with representation to argue that a man was wrongly convicted for murder by a corrupt justice system in Texas. The witnesses' inconsistent versions from the crime scene are reconstructed, using fiction film language to emphasize the subjectivity and the conflict between the versions of reality presented.

In the Quito model, interviews with inhabitants with opposing views upon the consequences of future scenarios may be included to present different perspectives. The videos may help the user to become aware of the existence of different perspectives on the simulation results – both when it comes to whether consequences are experienced as positive or negative by different population groups and whether these consequences are likely outcomes of the policies applied. Video can point to such multiple viewpoints better than graphs or numbers.

Users not experienced with either simulation models or documentary conventions, however, may also be made aware of the fact that the simulation is an interpretation in other explicit ways, through for example text. Further research is needed to explore ways of achieving such awareness.

FURTHER DEVELOPMENT OF THE MODELS

> ”Understanding the assumptions that underlie simulations is a key element of political power. People who understand the distortions imposed by simulations are in a position to call for more direct economic and political feedback, new kinds of representation, more channels of information. They may demand greater transparency in their simulations; they may demand that the games that we play (particularly the ones we use to make real life decisions) make their underlying models more accessible”. Turkle [37] (71)

Turkle [37] argues that through a critical understanding of the underlying models of simulations we would be able to question the underlying models behind real life decisions. The main purpose of the first learning environment/ prototype described in this paper (the Two-Shower Model) is simply to enable understanding of the model. The second (the Quito model) is designed not only to create understanding of the model, but also to inspire questioning of its relation to the real system. Neither prototype will be ‘black box’ simulations where the underlying rules are hidden. Paul Starr [36] emphasizes the importance of transparency of models in an essay about simulation and politics. He is among those who criticize the underlying assumptions of SimCity but is more concerned about the implications of what he sees as misleading premises in SimHealth as this program claims to simulate the effects of real world health care proposals. According to Starr [36], SimHealth and similar programs’ problem is not primarily the simplifications but that “the model is never clearly explained and the basic architecture is beyond reach”. Revealing a system dynamics stock and flow diagram (as shown in Fig. 1), however, risks being more confusing than instructive [3]. Therefore, we plan to implement additional features that will help the user to understand the dynamics of these models.

A further step in the development of the models described, and similar prototypes, would be to let the user not only observe the behavior but also be able to backtrack her choices and find out what caused this behavior. For this we imagine a “why button” that would take the user back through the decisive points in the simulation history or trace the origin of a particular development[10]. One possible way to illustrate this graphically would be by modifying the stock and flow diagrams. The dominating feedback-loops would be highlighted or animated and the user would then access an explanation of these feedback-loops. This explanation would then be presented as a model-generated story following the formula “A leads to B and this caused C to…” The user can then not only observe the behavior of the system – the simulation results – but also get her choices analyzed through the backtracking mechanism. This should enhance learning and understanding.

Further research is needed to explore efficient ways of revealing the underlying structure. The challenge will be to balance the need for transparent models – that opens for investigation of their underlying assumptions – with the degree of complexity that a learner can be expected to digest. Revealing a stock and flow diagram with thousands of variables in all its detail does not help the user if it is too complex to be understood.

CONCLUSIONS

If we evaluate the prototypes described in this paper as simulation games the use of video might be seen as an element interfering with the gaming experience in ways that a player who is playing for fun will not find rewarding. Similar to cut-scenes in video games, the pre-recorded video clips risk drawing the player out of the “simulation mode” of identification and engagement (as described by Friedman [17]). However, the same features – being drawn out of the simulation by video clips that work as comments to the play – might be desirable if the goal is to learn about the simulation’s possible consequences in a real world as well as the simulation’s constructedness.

Our goal is not primarily to create an immersive experience or an entertaining game. The focus of the project is to develop learning environments that utilize existing and new media material for creating awareness of the complexity of problems. Combining documentary footage with the creative try-and-fail process in simulation games is an interesting approach for creating engaging interactive documentaries.

As discussed through this paper, in simulation of very complex systems the real world consequences cannot be accurately predicted. Nor should a simulation model representing a real system give the user the impression that it has such predictive powers. Based on available theories and data the simulation can however point to trends and possible outcomes. If the underlying model is explained to the user, she is in a better position to evaluate the underlying assumptions, the models limitations, and its relevance for real world problems.

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ENDNOTES

1 Exceptions are films that consist of one or very few takes. One example is Sokurov's Russian Ark (Russia/ Germany, 2002), a 96 minutes long film that was filmed in one digital take.

2 If we analyze across different programming in television, the picture might be different.

3 Within system dynamics, water and pipes are often used as metaphors to describe the dynamic elements of a system. System elements may be described as flows of water (in a population model this would be birth- and death rate), valves controlling the flow (variables such as access to health and education), and the water level of a basin (total population) changing according to the in- and out-flows.

4 In a final version of the model, two different persons will appear in the windows.

5 A central system dynamic concept to be understood in the model is however delay – the water coming out of the showerhead will not immediately change temperature because of a delay in the system. The introductory scenario presentation (Fig. 2) might decrease the risk that the user will misinterpret this as a technical delay in the display of video, instead of a delay in the game world.

6 A simulation could also lack a real-world referent. As long as it has a set of underlying rules that govern its behavior, it will not cease to be a simulation (see Frasca [15]).

7 Pers. comm. This important difference and its implications were first pointed out by one of the anonymous reviewers.

8 For most public schools in Latin American cities such as Quito, this would demand funding to ensure computer access. However, working collaboratively in groups, only a few computers would be needed per school.

9 In SimCity 4, you can let Sims from The Sims move in.

10 This would be possible when applying a specific mathematical method that can identify dominating variables and decisive points in the simulation history. See Saleh, M. The Characterization of Model Behavior and its Casual Foundation. PhD dissertation, Department of Information Science, University of Bergen, 2002. Software that enables computerized analysis of dominating model variables is under development by Kristian Kastet as part of the VOCS project.