Dramaturgical Design of the Narrative in Digital Games: AI Planning of Conflicts in Non-Linear Spaces of Time

Klaus P. Jantke

Abstract— **Dramaturgy is the design of emotional experience. For digital games that are intended to tell a story, game design includes the anticipation of the players' experiences which shall lead to excitement, fascination, thrill, perhaps to immersion and flow, but not to boredom or confusion. What players will experience takes place over time. Events that happen are linearly ordered and those that may potentially happen form a partially orderded space–the game's story space. Dramaturgical game design is the anticipation of varying experiences and their thoughtful arrangment in a partially ordered space of events which players may possibly experience when playing the game. This may be seen as planning as demonstrated in an original game design case study.**

The approach particularly applies to those digital games that bear the potentials of telling a story. The inductive approach to AI planning is introduced into dramaturgical design.

I. Motivation & Introduction

Game dramaturgy is the design of emotional experience which will take place when humans engage in game playing.

By its very nature, dramaturgical designs takes place prior to game playing. In game design, one anticipates potential future experiences of human players who will engage in playing the game currently under development. From this point of view, dramaturgical design is planning human experiences.

According to the dynamics of modern digital games, the planning of game playing experiences is planning beyond the limits of classical deductive planning as in STRIPS [1], e.g. Adequate plan generation has to be inductive in spirit [2].

Planning–whether deductive, inductive, abductive, or in whatever algorithmic way else–means to foresee the timely order of events which will possibly happen in the future. From a structural perspective, planning means the setup of a partially ordered space of potential events.

From the same structural perspective, game playing means finding some way through this story space. "Fundamentally, stories are sequences of events, each of which involves some form of action." [3] The crucial occurrence of time in storytelling is the order in which events happen.

The art of dramaturgical design is to construct the story space in such a way, according to the authors' intentions, that players going along such a way experience the game play as exciting, fascinating, frightening, or amusing, e.g.

The present paper introduces *inductive plan generation* into the practice of dramaturgical design for digital games. This AI perspective is new to games design investigations. *Story space* and *storyboarding* are key prerequisite concepts.

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II. Previous Related Work

Several authors of very recent approaches to the design of storytelling digital games have explicated the relevance of AI planning. Unfortunately, most of them stick with deductive planning which has dominated AI planning for some decades (see [4], [5], and [6], e.g., all three of December 2008). Though it is quite understandable that games researchers who are barely familiar with AI, in general, and with AI planning, in particular, tend to follow what seems to be the mainstream, there is an urgent need to go beyond the limits of deduction.

Inductive approaches to plan generation as in [2] are motivated by the difficulties of complex dynamic systems. In contrast to deductive approaches, it is no longer claimed that all future processes are under a complete logical control.

The ambitious task of anticipating human game playing behavior is well motivated by Andrew Stern [7] who claims that "[...] the first wish that most players, developers and researchers originally feel when first encountering and considering interactive story, is the implicit promise to the player to be able to directly affect the plot of the story, taking it in whatever direction they wish." Although every individual story that unfolds during game play appears as a linear sequence of events[1], the game design must foresee a potentially large variety of arrangements of actions in time. Potentially occurring events form a partially ordered space which may be visualized as a usually rather complex directed graph. Interestingly, this coincides with the fundamental concepts of plan generation and storyboarding chosen in [2] and [8], respectively. This remarkable coincidence bears evidence for the appropriateness of the approaches mentioned.

Time as seen in all of the above-mentioned approaches is the ordering of events. This point of view is sound with James Allen's work on time in AI research and applications (see [9], [10], and [11], e.g).

Now that we have a fundamental idea of what time in storytelling games might be–a partial order as long as events are only prepared to possibly happen and a linear order as soon as game play takes place–we may go and exploit time for dramaturgical design as intensively discussed in [12].

The present research relies on Jesper Juul's seminal work [13] which reflects the structural clarity of Chatman's earlier investigations [14], but the deeper insights into time as elaborated by Sir Arthur Eddington [15] are taken seriously. Time–so to speak–does not exist, it is an abstraction [16].

[1]Parallelism of events is no problem, because for any two events happening in parallel, there may be introduced a single event describing this local parallelism. In this way, linearity is preserved. Throughout the present paper, we avoid further finickiness of algorithmic detail.

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III. Time in Digital Games

Yes, indeed, time is an abstraction, as Ernst Mach in his criticism on Netwon's concept of "absolute time" elucidates: "Diese absolute Zeit kann an gar keiner Bewegung abgemessen werden, sie hat also gar keinen praktischen und auch keinen wissenschaftlichen Wert. [...] Die Zeit ist vielmehr eine Abstraktion, zu der wir durch die Veränderung der Dinge gelangen." ([16], p. 236) In other words, there is no time there outside, but change. To deal with change, humans abstract from reality and introduce concepts they call time. And there are varying concepts of time possible [15].

If time concepts are made up by humans for particular purposes, it is worth pondering the suitable time concepts of a digital games science or, at least, appropriate concepts for particular games studies.

It depends on the application which concept of time is appropriate. For grayhound racing, you need a terminology different from what you use in history or cosmology.

Which time concepts do we need when dealing with digital games that bear the potentials of telling a story? It depends. [12] provides a quite comprehensive introduction.

For the purpose of the present paper, we confine ourselves to the investigation of purposeful setups of conflicts in games where the order of events–i.e. time as seen here–is crucial

Studies on the effects of motion picture–seen as a precursor to the present field of interest–range from an artistic perspective [17] to neurophysiology [18]. It seems that for digital games comparable investigations do not yet exist.

Throughout the remaing part of this section, the author introduces a perspective at time in digital games which is appropriate to the description of the key phenomena in time-critical games such as Braid and Shadow of Destiny. For readability, the introduction will be largely based on examples taken from interesting digital games.

The approach to time will be used later on for game design with a particular emphasis on conflicts and cooperation.

The ordering of events is the elementary invention of humans when introducing concepts of time as in [11], e.g., based on [10].

The Xbox 360 game Braid has been praised in the media for its innovative treatment of time. Braid is mostly a Jump 'n' Run game. There are numerous opportunities for the player to loose her virtual life. The new quality of game playing in Braid is that the player has the possibility to turn back the wheel of time. But what does this mean precisely?

The answer is complicated by the fact that the possibilities of manipulating the game time change with increasing levels. It seems that the concepts of controlling time are becoming more and more sophisticated. To say it here in advance, this is not really the case. More complex time manipulation options are followed by those that are more simple. It obviously needs some scientific conceptualization to make the essentials of the game explicit.

The screenshot in the background of figure 1 shows the players avatar falling into a gorge because of failing to jump on a monster head at the right moment. The other screenshot on the foreground shows the whole game play moving backwards such that an earlier game state is reached from which the player has another trial. The wheel of time is turned backwards by pressing the X button on the game controller. When the X button is released, the player can try it again.

Fig. 1. Braid: Turning Back the Wheel of Time to Pass a Deadly Place

The implementation of the game Braid guarantees that all human players, although slightly depending on luck and skills, need to turn back the wheel of time several times during game play. Playing with time is an essential feature of playing Braid.

There is a variety of variants in Braid how to manipulate time. At the beginning of the game, the first opportunity for the player to manipulate time is to reverse his avatars moves by simply pushing and holding the X button. All the last actions of the avatar are rewind whereas the surrounding game environment continues to move forward. On a later level of game play, there occur situations like the one on display in figure 1. Not only the avatar moves backwards, but all other actors of the game episode do so as well.

Fig. 2. Shadow of Destiny: Sudden Death on the Market Square (left) and Preventive Time Travel to Abolish the Murder's Preconditions (right)

In the PC game Shadow of Destiny, you begin your virtual life in the virtual world by being stabbed to death on the road-fortunately only virtually. If you complete the game play, you virtually die at least nine times.

In this game, it is the players task to change the past such that a murder she just experienced does not take place the next moment when the same critical point of virtual game world time is passed again.

One of the occurring patterns is that a murder has a precondition which has been established earlier in time. For illustration, a murderer hiding behind a tree depends on the tree to hide behind and, thus, depends on the earlier action of planting the tree.

All the dramaturgy rests upon the ordering of events–the key concept of time in SHADOW OF DESTINY, in BRAID, and in a large number of other high quality digital games. This is the subject of the present investigation.

For more clarity, a few simple notions and notation will be introduced.

Assume we have a particular game under consideration. Whenever a reference is necessary, this game will be named G. In the most simple cases, there is a clearly distinguished set of actions that may be performed when playing the games. Those actions may be performed by a single player, by several players, or by the digital game, i.e. by a computer system. What is taken into account depends on the scientific interest driving our investigations. When a decision is made, M is used to denote the set of all considered actions-M is chosen as reference to the term "move"-in the game.

Playing a game means interacting intensively and extensively. One action follows the other. Abstracting from many details, one may represent game playing by sequences of actions from M. In theoretical computer science, it is common to denote the set of all possible finite sequences of elements from some set M by M^*. For theoretical reasons, the empty word ε is enclosed.

Given a game G and the actions M of interest, M^* is completely specified. But what is the game play we are interested in?

To keep it short and simple in the present publication, the concepts introduced focus mostly those games in which it makes sense to speak about a completed game play. This applies to most simulation and sports games, to all jump 'n' run games, to all point & click adventures, and to all games that tell a story. Some sequences of actions establish a completed game play whereas others do not.

Given a game G and the actions M of interest, the term $\Pi(G)$ denotes the subset of M^* of all those sequences that represent some completed game play, $\Pi(G) \subseteq M^*$.

$\Pi(G)$ consists of sequences of symbols from M. Every sequence $\pi \in \Pi(G)$ describes what happens during a particular game play. The choice of M reflects our decision about the granularity of game play descriptions. Two different sequences $\pi_1, \pi_2 \in \Pi(G)$ of game playing experience may describe game plays of different players or of one game player at different occasions. For interesting digital games, $\Pi(G)$ is usually infinite.

The conceptualization above provides a firm background of the present investigations in formal language theory [19].

The crucial abstraction of time is the ordering in which events occur in game play.

For most of the interesting digital games, game playing experience can be understood only if the regularities of mastering the game can be explicated [20]. Consider, e.g., the adventure game THE SECRET FILES: TUNGUSKA.

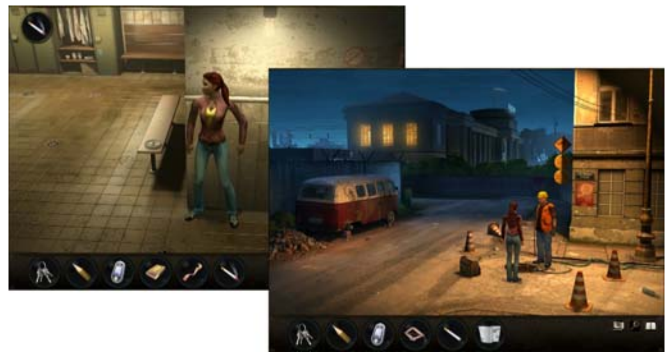

Fig. 3. THE SECRET FILES: TUNGUSKA–Two Instances of a Pattern

To exhibit the ghist of the story needs a suitable level of abstraction. There is about a dozen of obstacles in the game THE SECRET FILES: TUNGUSKA which can be overcome in a somehow uniform way.

There are four main actions to be performed in every of these cases: `[preparation]` `[trapping]` `[response]` `[solution]`. Everything begins with some "preparation" to find out how to set a snare for the players adversary (called "trapping"). The "response" is the adversary's reaction or the reaction of other virtual characters to the player's activity which leads to a "solution" of the current problem.

`[preparation]`, `[trapping]` and so on are actions that have to be performed in the right order. We may think of strings from M^* that have to occur in every successful game play, i.e. in every $\pi \in \Pi(G)$.

The two screenshots of figure 3 are taken from two different cases in the game where instances of the same pattern occur. (Note that the formal language concept of a string pattern in use is considerably more precise than the patterns investigated in [21].) The player always have to investigate the situation carefully to find out what to do. In the one case, putting some cigarette in the right place, in the other case manipulating a newspaper works as a trap. The female soldier or the worker, respectively, are lured away from their places. As a result, the player can continue towards a successful mastery of the game.

What is playable and what leads to success in playing the game G is summarized in $\Pi(G)$. However, such a formal language is difficult to treat and usually not so easy to understand. Structural representations may be more appropriate.

The ordering of activities according to the game mechanics which–hopefully–reflects an entertaining dramaturgical design leads to the concept of a story space.

IV. The Story Space Concept

Stories are partially ordered spaces of events. Stories evolve over time during game playing when new events are entering the story space and new relations of time dependence are becoming known.

This is a crucial point for understanding what it means to experience a story when playing a digital game. In sophisticated games, it may happen that there are events recognized by the one player, but overlooked by another. Those players, necessarily, experience different stories even when performing completely identical sequences of actions.

According to Andrew Stern's dream [7] cited above in section II, it is an attractive goal to design a game G in such a way that the space of all potential game plays $\Pi(G)$ allows for the unfolding of substantially varying game playing experiences $\pi_1, \pi_2 \in \Pi(G)$ when different humans play the game or when the same human plays repeatedly.

Playing π_1 or π_2 or any other sequence of actions possible according to the game mechanics of G, certain actions introduce events or–at least–may be seen as introducing events. This does not necessarily provide events in a chronological order w.r.t. time in the virtual world.

Here is an illustration. In a criminal story, you–your avatar–may talk to some virtual character who tells you about a murder that happened sometime earlier in the virtual game time of the virtual world. From the one perspective, there are two events: the talk and the murder. From the other perspective, if you are not interested in recording and investigating events such as talks, you may confine yourself to the consideration of just one event: the murder. It is an obviously interesting and often very important question to decide what shall be seen as an event and taken into account and what not. However, this fundamental question is not further discussed here. Instead, we focus the issue of time. In the present example, the murder is an event that took place in the past. The event has to be inserted into the totality of events recognized so far. It might easily happen that it is not completely clear how this new event relates to several others which have entered the story space earlier. Formally speaking, the story space becomes only partially ordered.

In other words, although game playing is seen as being linear (represented by the formal language terminology [19] underlying M, M^*, and $\Pi(G)$), the story does not evolve linearly because events come up in an unordered manner.

In fact, the way in which (knowledge about) events come(s) up is an issue of dramaturgy [17].

In digital games in which Andrew Stern's dream (see above) comes true, varying sequences $\pi_1, \pi_2 \in \Pi(G)$ lead to the unfolding of substantially varying story spaces.

For better understanding what it means and how it may happen that different players experience different stories, it is advisible to abandon the so far rather wordy introduction of the present section and to continue with a more formalized and, thus, clear conceptualization.

A story space is a structure that evolves over time. For simplicity, one may assume that it is initially empty. This is clearly an oversimplification, because many games welcome the player with an interesting background story like, for instance, Prince of Persia: The Sands of Time, the background story is nicely interweaved with the story which unfolds when playing the game.

At every point m in time, the individually experienced story space is abstracted as a set of events E_m and a partial ordering $\preceq_m$ of these events. The story space is $\mathcal{E}_m = [E_m, \preceq_m]$. Initially, $\mathcal{E}_0 = \emptyset$ and, consequently $\preceq_0 = \emptyset$. With proceeding game play, the story space evolves: $\mathcal{E}_m$, $\mathcal{E}_{m+1}$, and so on.

In the most simple cases such as typical jump 'n' run games in which the player is collecting coins, gemstones or other objects, the linear occurrences of activities in some $\pi \in \Pi(G)$ may be seen as lineraly emerging events.

There are a few fundamental properties of the evolving sequence $\{[E_n, \preceq_n]\}_{n=0,1,2,\ldots}$ of story spaces.

a) Monotonicity: For all indices n, it holds $\mathcal{E}_n \subseteq \mathcal{E}_{n+1}$.

b) Linearity: For all indices n and for all new events $e \in \mathcal{E}_{n+1} \setminus \mathcal{E}_n$ it holds $e' \prec e$ for every $e' \in \mathcal{E}_n$.

The formalization of the story space concept allows for this rather lucid formulation of fundamental properties. At a first glance, it seems that one might take properties such as monotonicity for granted in interactive storytelling.

In contrast, a few ambitiously designed games such as, for instance, Shadow of Destiny demonstrate that the abandonment of monotonicity may be one of the key dramturgical ideas of a fascinating game.

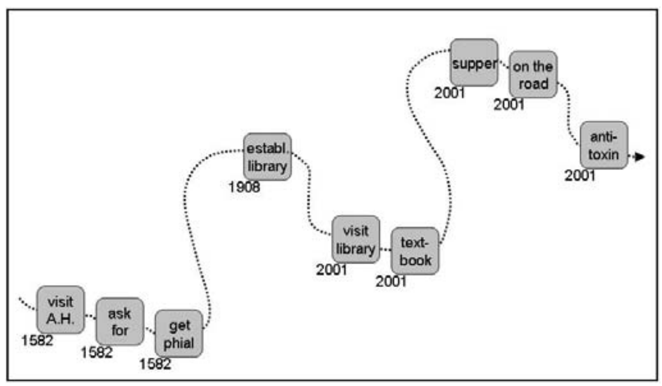

Fig. 4. A Linear Part of a Highly Complex Story Space

Figure 4 depicts a particularly small and simple part of the story space of the game Shadow of Destiny, which grows during game play in a very intricate way (see [12] for a detailled discussion).

Let us name the story space from which the excerpt above has been taken shortly by $\mathcal{E}_n$. At an earlier stage $\mathcal{E}_m$, i.e. $m < n$, there was an event of the player's sudden death following the "on the road" event shown in the right upper corner. If the player succeeds in taking some antitoxin, the evolution of the story space incorporates this as a new event and the event of sudden death disappers: $\mathcal{E}_m \not\subseteq \mathcal{E}_n$

Dramaturgical design deals–very abstractly speaking–with the arrangement of game playing activities which allow for an appealing evolution of story spaces.

V. THE JOSTLE & GORGE CASE

The present author's earlier game JOSTLE [22] is taken as a basis to investigate issues of dramaturgical design and to demonstrate that the author's approach works in practice.

The author's practical goal was to develop a digital game

- which is particularly simple such that experiments with children are not complicated by the problem of understanding the game rules,
- which allows for a sufficiently short game play such that experimentation may lead to sufficiently comprehensive statistics,
- which offers alternatives of rather different behaviors ranging from a friendly and cooperative, even altruistic behavior to a freeloader, and
- which provides a framework in which one may ask how a player's behavior–regardless of being human or not–can be visibly experienced, hypothesized and, perhaps, even identified just by observation.

One of the game's purposes was to illustrate game intelligence. Children have been introduced to the game and have been enabled to control the NPC intelligence. In such a way, AI may be demystified and children may enjoy the power of being in control of complex IT processes–a step towards media and technology competence.

The process of dramaturgical design proceeds as follows.

1) Think about what effects or affects you are aiming for.
2) Design the general ideas of a digital game in which the effects you are interested in might possibly show.
3) Choose terms to formalize sequences of game play.
4) Determine sequences of interaction, i.e. game play, likely to support the envisaged goal.
5) Develop some qualitative game idea possible allowing for those sequences.
6) Design a related game mechanics such that the target sequences of interaction you are focussing occur when playing the game.

In terms of the formalisms sketched above, 3) means the choice of some descriptional alphabet M. Every sequence according to 4) may be understood as some $\pi' \in M^*$ for the game G still under development. If 6) succeeds, every π' may appear when humans engage in playing the game, i.e. $(\exists \pi_1, \pi_2 \in M^*) \pi_1 \pi' \pi_2 \in \Pi(G)$.

Under a completely formal perspective, the problem of dramaturgical game design may be abstracted as follows: (a) Choose some alphabet M. (b) Determine a set of target strings $\Phi \subset M^*$. (c) Design some digital game G such that the game mechanics implies the validity of the game property $(\forall \pi' \in \Phi)(\exists \pi_1, \pi_2 \in M^*) \pi_1 \pi' \pi_2 \in \Pi(G)$.

It is very likely that this logical approach is not of any help for the creative task of designing a new digital game. But the logical perspective allows for asking questions that might otherwise never be asked. It serves, so to speak, as a magnifying glass. Even those traditionally asked questions may be asked now with more precision and, sometimes, turn out to have several variants that have been overlooked before. Here is an example.

Imagine any game design process that successfully proceeds as circumscribed above and some terminology has been chosen such that $(\forall \pi' \in \Phi)(\exists \pi_1, \pi_2 \in M^*)\ \pi_1 \pi' \pi_2 \in \Pi(G)$ holds and, thus, shows the success of dramaturgical design.

What about the following alternative game properties:

$(\exists \pi' \in \Phi)(\forall \pi \in \Pi(G))(\exists \pi_1, \pi_2 \in M^*)\ \pi = \pi_1 \pi' \pi_2$

$(\forall \pi' \in \Phi)(\forall \pi \in \Pi(G))(\exists \pi_1, \pi_2 \in M^*)\ \pi = \pi_1 \pi' \pi_2$

The second condition is clearly stronger than the first one, and both are not equivalent to the original one. The last formula means that each of the abstracted game experiences occurs in every completed game play. Do we really want this? And if not, what else?

There are even more truly reasonable alternatives; readers are invited to find their own variants.

What really meets the designers aims of implementing ideas of dramaturgy that are abstractly represented by the collection of formulas in Φ ...?

In the present section, we suspend the logical discussion for a while and continue, instead, with real game design issues. When finished, we may return and apply the logical reasoning approach once more.

In the present case study–as said above–the author's game JOSTLE [22] is taken as a basis. In its original version, the game has been implemented in a large number of variants. One of them occurs in some framework by Swen Gaudl developed for a variety of TURING test experiments [23].

Let us focus on the third item of the goal specification above saying that we are going to extend the game JOSTLE towards a more flexible and exciting game in which the game mechanics offer new challenges. Subsequently there will be surveyed some game design extending JOSTLE towards a game in which different personalities of players show–even when the player is an NPC, i.e. just a computer program.

The following enumeration of practical application steps refers to the author's process model of dramaturgical design introduced in the first column of this section.

1) Players shall be forced to decide between friendly and aggressive behaviors. The behavior of NPCs shall be quite easy to identify such that human players may naturally experience different characters and respond accordingly. We want them–roughly speaking–to love or hate their NPC playmates.

For the purpose of research and experimentation, the design should be as simple as possible.

2) The key idea is that of a “gorge” interrupting a game track. Players cannot pass a gorge unless another player willing to take sacrifices has been stepped into the gorge before.

There are a few secondary refinements. 2.1) Before every gorge, there is a distinguished area to form so-called roped parties. 2.2) Only players of a roped party may step down into the gorge. 2.3) Only players of a roped party are allowed to cross a gorge. 2.4) When crossing the gorge, it depends on the crossing player whether the player in the gorge is rescued or left behind.

3) Characteristic actions are "entering a roped party" ([erp], for short), "stepping into a gorge" [sig], "not crossing a gorge" (although this would have been possible with rescuing the player from the gorge) [ncg], "not stepping into a gorge" (although this would have been possible) [nsg], "crossing a gorge and rescuing the player from the gorge" [cgr], "crossing a gorge and leaving the player in the gorge behind" [cgl], e.g.

Actions will be explained once more when being used in game design below.

4) [erp][sig] whenever possible looks quite altruistic whereas [erp][ncg][ncg][cgl] seems to be a typical freeloader's behavior.

Those activity patterns nicely characterize different styles of game play and behavior. It is a task of the game mechanics to make those things to happen in real game play.

5) Every player is controlling several characters (4 turned out to be an appropriate figure). The game proceeds in turns. A player roles a dice and chooses one of her characters to be moved forward as many steps as the dice shows.

Through the simple idea of seeing the result of roling the dice first and, then, deciding which character to activate, the player has some freedom of choice between friendly and aggressive behavior.

6) The game has been implemented within the author's lectures on digital games by more than 20 teams of students. A recent implementation by the author's colleagues Christian Woelfert and Sandy Stehr is shown by means of figure 5.

Figure 5 shows two gorges on parallel tracks. The backmost gorge has been entered by one of the players. As a result, the other one in the roped party is now able to cross the gorge. At the front gorge, three players are queueing, but nobody took yet sacrifices and stepped into the gorge.

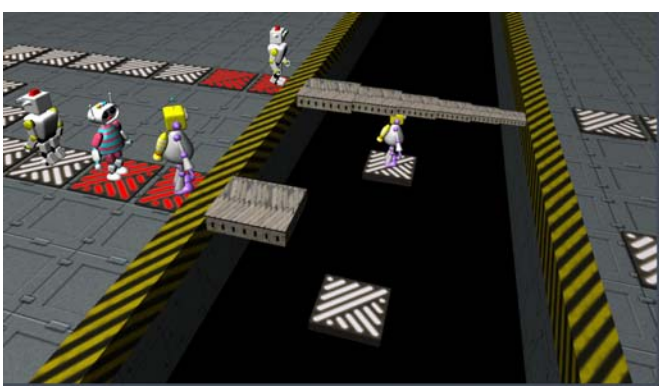

Fig. 5. Conflicts at a Gorge in GORGE © [game design: Klaus P. Jantke; implementation: Christian Woelfert; 3D graphics & animation: Sandy Stehr]

In the screenshot of figure 5, we don't see the dice rolls that took place. Maybe, the second one in the queue have had already several opportunities to step into the gorge, but did not do so. Maybe she is just waiting for another one to step into the gorge, then, to cross the gorge as soon as possible.

Designing the new game according to the expectations and requirements of allowing for the experience of substantially different behaviors needs a specification of crucial alternatives and conflicts.

This means behavioral planning. According to [2], a plan is represented as a hierarchically structured directed graph. From the perspective of dramaturgical design, a plan is a storyboard and a storyboard is a plan. The varying level of granularity in storyboarding are reflected by the different layers of the hierachical graph [8].

The following excerpts of a storyboard on different levels of granularity are not correct, because they reflect only a single player's alternatives of action and do not even mentioned the actual player. However, for a short discussion of the essentials, this presentation is appropriate.

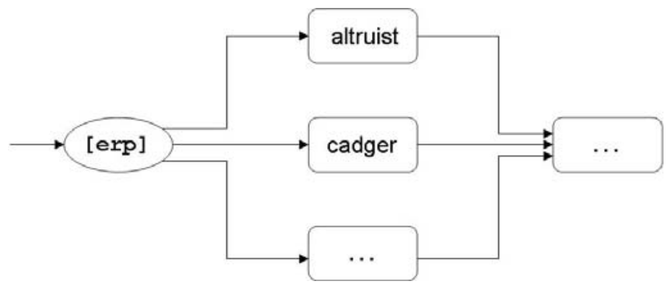

Fig. 6. Excerpt from a Simplified Storyboard Containing Episodes of Alternative Behavior for a Player who has just Entered some Roped Party

In these three figures, the elliptic nodes of the storyboard graph (according to Jantke & Knauf [8])–a hierarchically structured plan (according to Arnold [2])–denote scenes, i.e. elementary building blocks of the storyboard. The larger boxes denote episodes which may be decomposed into sub-storyborads, i.e. sub-plans.

The dramaturgical design on display in figure 6 means that after entering a roped party it is up to the player which template of behavior (s)he selects.

The branching of paths as can be seen after the [erp] scene mean alternatives and indicate possible branches in the story experience.

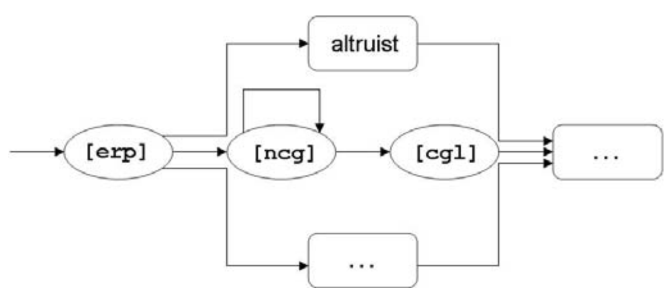

Fig. 7. Expansion of an Episode into a Sub-Graph of Two Scenes

The episode concept is recursive. Episodes may have sub-episodes which may have sub-episodes and so on.

The episode of a cadger's behavior is broken down into a simple, but cyclic graph of two scenes only.

The episode of altruistic behavior has been expanded into two different alternatives–either stepping down into the gorge or rescuing another player from the gorge.

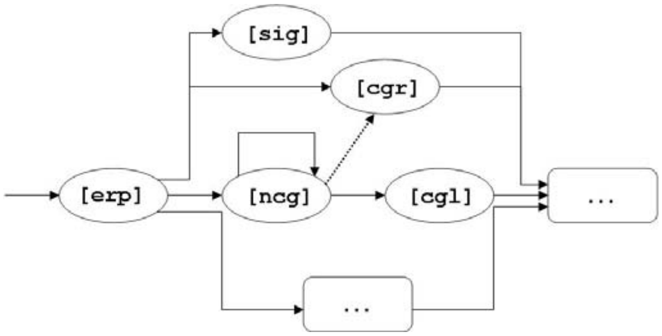

Fig. 8. Storyboard Expansion Including an Incorrect Extension

The dotted line in figure 8 contradicts the hierarchical structuring of storyboards. Indeed, acceptance of this line would allow for implementations which are disturbing the dramaturgical design which focusses conflicts between those players who have, so to speak, a clear personality profile. In our dramaturgy of NPC behavior in GORGE, a cadger is never giving up and turning into a cooperative guy.

The structural investigation of behavioral planning or storyboarding is bringing us back to the logical perspective. The string $[\texttt{ncg}]^n[\texttt{cgl}]$ (for any $n > 1$) is such a $\pi' \in \Phi$ as discussed above describing a freeloader's behavior.

Fig. 9. GORGE © has been played in a Girls' Day workshop at IDMT; the GORGE workshop has been hold by Denise Lengyel and Swen Gaudl.

The Fraunhofer IDMT in Ilmenau, Germany, is annually arranging a public event named Girls' Day which addresses young girls to demonstrate to them the attractiveness of science and engineering studies. Such a Girls' Day comprises general information sessions, some guided tours through the interesting labs with technical installations and several workshops in parallel. Although a systematic evaluation of the workshop about GORGE on April 23, 2009, goes beyond the limits of this paper, a short summary may be given.

A dozen girls participated in the workshop and received a first introduction into Artificial Intelligence. They have been able to adjust different characteristics of NPCs in GORGE. All girls reported that they experienced, to some extent, the humanness of the NPCs who showed attitudes such as altruism or selfishness. Dramaturgical design did succeed.

VI. DICHOTOMY OF STORYBOARDING & PLANNING

To relate dramaturgical design and storyboarding may appear natural to most readers. But what does it buy us to see dramaturgical design from the AI planning perspective?

Indeed, there might be not so many convincing arguments as long as we stick with deductive planning.

But the author advocated from the early beginning of the present discourse to engage with the inductive plan generation approach by Arnold [2].

The peculiarity of inductive plan generation–in contrast to deductive planning–is the absence of any concept such as executability. In conventional deductive planning, one may (logically!) prove the executability of a plan being generated. In contrast, in dynamic environments conditions may change during plan execution such that after a certain number of actions have been performed, it turns out that the remaining part of the plan is infeasible.

In those cases, the revision of plans becomes inevitable. Plans are, so to speak, hypothetical.

This perfectly fits the situation in digital games where a player's actions interfere with other players' behavior, even if they are only NPCs, i.e. non-human.

In the field of inductive plan generation, there have been developed involved architectures and algorithms for coping with the dynamics of application areas. We confine ourselves to only a few remarks about the planning architectures on display in figure 10.

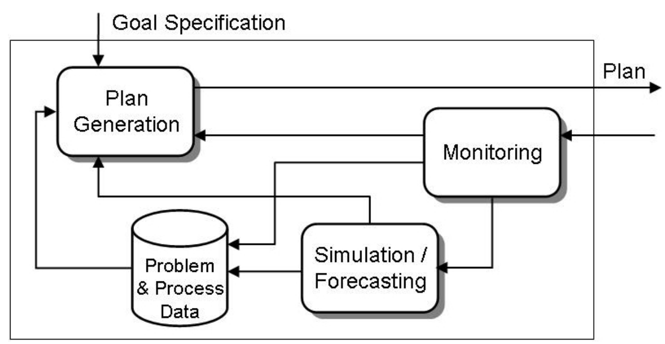

Fig. 10. An Architecture for Inductive Plan Generation seen as a Guideline for Approaches to Dramaturgical Design and Storyboarding Agent Behavior

If you are not sure whether or not your plan–say an agressive NPCs behavior, e.g.–will succeed, you need to monitor what happens when part of the plan is executed. Incoming data may be utilized to forecast what might come next. Based on the previously generated plan, on data from the outside reality, and on forecasting, early plan revision may help to avoid crashes. Plans are just hypotheses.

Future dramaturgical design will take benefit from the inductive perspective at anticipated behavior. The dynamics of advanced digital games that are able to tell a variety of stories will lead to more dynamic variation of planned behaviors.

Nowadays, storyboarding is mostly conventional. In the future, advanced storyboarding will become inductive plan generation introducing more dynamics into the story spaces.

VII. Summary & Conclusions

The stage is set for AI planning-like dramaturgical design of digital games that bear the potentials of storytelling.

"It is not only for lack of trying that a good vocabulary for describing game experiences does not exist. It is downright hard to describe video games and experience of playing them." [24] The present research aimes at a little contribution to a terminology for digital games research with a particular emphasis on storytelling games and on dramaturgical design. Those digital games that do not tell a story are out of scope (see [12] for a discussion of why TETRIS and PACMAN als well as most of sports game are not seen as storytelling).

Part of the author's more comprehensive research and development programme is to exploit a suitable combination of dynamic plan generation à la Arnold [2] and storyboarding à la Jantke/Knauf [8] for purposeful design of digital games. Conflicts and alternatives of choice shall be planned in advance, and the dramaturgical design itself shall be made subject to investigations such as automated property checks.

There is hope that based on sufficiently formal concepts as in [25], one will come up with insights into the mechanisms of game playing dramaturgy explaining not only fun [20], but frustration, frightening, and so on in the form of patterns beyond the current state of affair [21].

Placement & Acknowledgements

The author gratefully acknowledges four critical reviews of his submission. He tried to reflect as many of the reviewers' suggestions as possible in the above part of the paper. Two remarks of the reviewers shall be considered more explicitly.

About the author's model of time, there is the remark that "one could also have games (and these exist) where the timing of actions is crucial (e.g. most sport games)", and another remark proposes to relate the author's approach "to open game play".

Apparently, there has been lost sight of the focus of the present investigation expressed by the paper's title phrase of *Dramaturgical Design of the Narrative in Digital Games*. In dozens of current sport games, there is no narrative at all. In the author's opinion, most sport games serve a purpose other than storytelling. And pressuring players with shortages of time rarely contributes directly to an exciting game story. Where the pressure of time is crucial to storytelling, indeed, more refined models of time might become relevant to subsequent research extending the author's present foundation.

Another acknowledgement goes to Oksana Arnold [2]. Her seminal work on dynamic plan generation is irreplacable.

The development of the author's storyboarding approach (see [8], for the roots) has been considerably influenced by the cooperation with Rainer Knauf who ultimately took the lead in the continuation of technology development and applications in largely varying fields.

Last but not least, Swen Gaudl directly contributed to the completion of the present final version of this paper.

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