Experience Management Using Storyline Adaptation Strategies

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Abstract. The central problem of creating interactive drama is structuring a media experience for participants such that a good story is presented while enabling a high degree of meaningful interactivity. This paper presents a new approach to interactive drama, where pre-authored storylines are made interactive by adapting them at run-time by applying strategies that react to unexpected user behavior. The approach, called *Experience Management*, relies heavily on the explication of a broad range of adaptation strategies and a means of selecting which strategy is most appropriate given a particular story context. We describe a formal approach to storyline representation to enable the selection of applicable strategies, and a strategy formalization that allows for storyline modification. Finally, we discuss the application of this approach in the context of a story-based training system for military leadership skills, and the direction for continuing research.

1 Dramatic Control

The central problem of creating interactive drama is structuring a media experience for participants such that a good story is presented while enabling a high degree of meaningful interactivity. The challenge has been one of striking a suitable balance between the control that participants have in shaping their own future in a simulated world and the control that must be exerted by the system to ensure that dramatic goals are also achieved. In searching for the right balance, widely different approaches have been proposed by researchers in this area. A fruitful family of approaches includes those that begin with fully simulated virtual worlds, but where the dynamic behavior of non-player characters is structured to achieve dramatic goals (e.g. [1], [2]). Other promising approaches can be characterized according to the amount of responsibility for dramatic control that they shift away from autonomous non-player characters to a central dramatic planning algorithm. For example, director agents can be employed to override the autonomous behavior of non-player characters and affect the way these behaviors are presented to the players to achieve dramatic goals (e.g. [3], [4]). Even

more centralized control is possible when the behavior of characters is placed entirely in the hands of a dramatic planner (e.g. [5]) that selects the most appropriate narrative beat given the current state of the fictional world and current position along a dramatic arc. In these approaches, moving toward more dramatic control moves the computational problem away from simulation and more toward maintaining a storyline in the face of user interaction.

In this paper, we explore an approach to interactive drama that pushes this tendency to its extreme, where simulation is abandoned entirely and where the sole computational problem is to maintain a storyline in the face of user interaction. The approach that we describe, called *Experience Management*, begins with a pre-authored, linear (or moderately branching) storyline in which the players assume an active role. Media is produced to tell the story in an immersive manner (e.g. as text, audio, or video clips), and formal descriptions of the expected player experience are authored, including expectations about the actions that the player will take as the storyline moves forward. When expectations about player behavior are wrong, a set of Storyline Adaptation Strategies are reactively used to modify the storyline as authored to accommodate the player behavior in a manner that keeps the storyline on track. This approach to interactive drama relies heavily on both the capacity to describe pre-authored dramatic experiences in a formal manner that can be algorithmically manipulated, and on the availability of a breadth of Storyline Adaptation Strategies that successfully maintain the player's sense of free will.

Section 2 of this paper details the Experience Management approach to interactive drama. Section 3 describes the formal language that is used to encode expectations about pre-authored dramatic experiences. Section 4 describes the specification of Storyline Adaptation Strategies and how they are used to modify formal representations of experiences in the face of unexpected user action. This approach has been implemented in the context of a military training application for staff officers in a brigade-level command center. The application, called the Advanced Leadership Training Simulation (ALTSIM), is described in section 5. Discussion of the relative merits of Experience Management over other approaches to dramatic control follows in section 6.

2 Experience Management

Among the first design approaches to interactive drama was one embodied in the Choose Your Own Adventure series published by Bantam Books [6]. In this early form of interactive fiction, storylines were presented as moderately branching tree structures. After reading a page of material, the reader would be asked to make a decision, and then asked to turn to a page corresponding to the branch of the story that represents the outcome of the decision. Even in this form, the problem of exponential growth was evident. Every decision that the reader made could potentially branch the story, and require a new outcome. Authors managed to include upwards of 40 unique endings by merging divergent storylines as the story progressed, and by keeping the number of well-developed storylines to a minimum. The level of choice enabled by

this format left much to be desired; a typical reading of the story would involve less than 10 decisions by a reader, and decision points rarely involved more than two options. To enable highly interactive dramatic experiences, a different approach must be taken.

Our approach of Experience Management begins with a linear or moderately branching story structure, typically with fewer branches than in the original Choose Your Own Adventure series. This structure encodes the *expected storyline*, and includes a reference to each of the actions that players are expected to take when presented with produced media that tells the story. In some cases, there is only one action that players are expected to take (encoded as a linear story sequence) and in other cases there may be multiple possible player actions that are anticipated (encoded as a branch point in a tree structure). For every point in the storyline, if the players do exactly what is expected of them, then the story moves forward and is told through produced media. If players do exactly what the authors of the experience expected of them for the full duration of the interaction, then the players have exercised their free will, their actions have led to events that are a part of an engaging narrative experience, and no computational dramatic management is necessary.

As an example, consider creating an interactive drama system from a simple short story written from the first person perspective and in the present tense, e.g. "As I'm walking through the neighborhood park, I'm surprised to see my friend Richard walking in the distance. I decide to follow Richard and see what he is up to. I see Richard heading for a café at the edge of the park. I see Richard enter the café. I look through the window and see that he is having lunch with my spouse. I enter the café and listen to their conversation. I overhear that they are planning a surprise party for my fortieth birthday. I am relieved and delighted."

For simplicity, imagine that the text of the story is the media that is presented to the player, but that it has been segmented into paragraphs at points where the narrator takes an action, or could have taken an action. These paragraphs could be presented one at a time to the player, along with an open-ended question: What do you do next? The player decides what to do (if anything) and composes a response back to the system, e.g. "I follow Richard to see what he is up to." In cases where the player responses matches exactly what the character did in the original storyline, the story moves forward and the next paragraph is presented, e.g. "I see that Richard is heading for the café in at the edge of the park."

Within this framework, the central computational problem is to accommodate unexpected player behavior. After all, the user could respond in a way that is outside the storyline, e.g. the user could decide to ignore the sight of their friend, and choose to walk back home instead. The effect is such that the pre-authored next paragraph would break the continuity of the narrative interaction. There are many creative ways, however, that the next paragraph could be rewritten to accommodate this deviant player action such that none of the remaining paragraphs need to change. The next paragraph could begin "As I walk back home, I notice the café at the edge of the park, and see that Richard is heading in this direction" or "As much as I try to ignore Richard and head back home, he seems to always be ahead of me, making his way toward the café at the edge of the park" or even "As I come around the corner and pass a magazine

stand, I see that there is a cover-story article praising wonderful food in the café at the other edge of this very park – just as my stomach begins to rumble from hunger."

In this simple case, the expected action is that the player will follow the story character to the café, and at least three methods for accommodating this single deviant action (heading home), are applicable. While it would be trivial to author a simple computational rule that would select and deploy one of these methods in the case that the player makes this action at this point in the story, the authoring of specific adaptations for every action that is possible at every point of the dramatic experience is intractable. Our approach to Experience Management works within this basic framework, but addresses the problem of intractability through the specification of generalized Storyline Adaptation Strategies that are algorithmically selected and applied in reaction to unexpected player behavior.

This functionality is best illustrated by considering the simplest approach to implementing the Experience Management system described above. Consider that a storyline could be represented as a set of moments where the user has the opportunity to take some action (one or more that is expected), and that between these actions there are media materials presented to the user to describe the state of the fictional world. This representation could be visualized as a one-dimensional vector:

moment 1	moment 2	moment 3	moment 4	moment 5	…	moment n

Likewise, the full set of possible actions that could be taken by participants using the system could also be represented as a one-dimensional vector. In the simple first person storyline described above, this list may include actions such as "follow Richard to see what he is up to", "walk back home" and "buy a magazine", etc. An example of such a vector might be as follows:

Follow character	Walk home	Buy magazine	…	Action n

If we add to this action vector the option of doing nothing at all, then we have a description of all of the potential actions that a user could possibly take at any moment in a dramatic interaction. The combination of these two vectors creates a matrix that couples every possible action that a user could take in the simulation with every expected action that a user is to take to move the story forward. Cells in this matrix can be filled in when the expected action is equal to the possible action, as follows:

	moment 1	moment 2	moment 3	moment 4	…	*moment n*
Nothing				▯		
Follow…	▯					
Walk…		▯				
Buy…			▯			
…						
Action n						▯

Given this representation, the job of the Experience Management system can be see as determining how the story can be changed if an unexpected action is taken at each of the storyline points (every empty cell). Given N possible actions and M moments in the story where an action can be taken, then the number of potential accommodating storyline changes that must be provided is simply N * M.

The simplest computational approach would be to hand-author a simple if-then rule to be executed when an unexpected action is taken at a given story moment. However, the feasibility of this approach quickly becomes intractable with storylines of any significant length and a rich set of possible actions. If there are 50 actions that the participants can take in a particular dramatic interaction and 50 moments in the story where these actions can be made, then there are 2500 places where some storyline adaptation may be required. From a development perspective, this approach is even less appealing, as it requires that this work be done over every time that there is a change in the set of potential actions, and every time that there is a change in the storyline.

The alternative approach that is taken in our approach of Experience Management is to automatically determine the adaptation to the storyline that is necessary, i.e. algorithmically filling in the cells of the table above. This level of automation allows for changes in the storyline and possible user actions without requiring the re-specification of accommodating storyline changes.

The key to automatically determining the accommodating storyline changes is to provide enough information to the Experience Management system about the storyline to make the appropriate choice among a broad range of possible adaptations. In our approach, this information is encoded into the representation of the storylines themselves. By replacing the simple ordered set of expected user actions (as shown above) with a rich representation of the experience that users have in the interaction, appropriate adaptation strategies can be identified without the aid of human intervention.

The remainder of this paper describes how expected storylines are formally described to inform the selection of adaptation strategies. Then the representation of the adaptation strategies themselves is discussed, along with a description of the algorithm of the Experience Management system that applies these strategies for a given story execution.

3 Story Representation

Despite extensive theoretical analysis of narrative form and function, few formal representational descriptors of storylines have been proposed, and fewer still have been used to encode narrative experiences of any significant length. In implemented computational interactive drama systems, the predominant approach is to describe storylines using the representational formalisms of AI planning systems (e.g. [1], [7]), typically as hierarchical or partially ordered operator sequences. The practical rationale for using operator formalisms is that they can be readily integrated with existing AI planning systems for use in character-based interactive drama, and they set down a blueprint for player action that can be easily monitored as the story moves forward.

In the framework of Experience Management that was laid out in the previous section, the purpose of functional story representation formalisms is twofold. First, as in previous systems, it serves as a blueprint for player action that can be monitored for the purpose of determining whether the player has taken the expected action, or has made some deviation. Second, the story representation itself is used as the basis for automatically selecting the most appropriate strategy for moving the experience back on the expected track when the deviant action is taken. While the first purpose is easily handled using an operator-based representation, the second requires information not only about what actions a character or player will take, but also information about the story world as experienced by the player. Our approach to Experience Management does not include world model representations for encoding this information (as no simulated virtual world is used), so this information must be explicitly encoded in the story representation itself.

The solution that we have used is to broaden the representation of storylines beyond expectations of user actions to include all of the expectations that storyline authors have about how the media affects the mental state of the player. That is, our representations of storyline encode the entire player mental experience, as expected by the storyline author. The insight here is that the design of a dramatic experience by a storyline author involves the creation of media that will have predictable effects on the mental state of the audience, including how the audience will imagine the entities in the fictional world. With this conception of storylines, many of the more cognitive aspects of audience reaction become first-class elements of a storyline description, including such things as when the audience notices an opportunity for themselves or other storyline characters, detects a threat to the success of their plans and goals, is reminded of events that have happened in the past, or foresees events that will happen in the future. In the production of contemporary non-interactive media such as television and film, expectations about the mental experience of the audience are often the explicit topic of conversation, particularly during the editing process. As filmmakers are neither professional psychologists nor computational cognitive modelers, we believe that these expectations are better described in terms of commonsense psychology than as processes in computational cognitive models of intelligence. Accordingly, the basis of our formal representations of the expectations of player experience consists of logical formalizations of commonsense psychology.

In our previous work [8][9], we identified 989 representational terms with broad conceptual coverage over the representational areas of commonsense psychology. For use in Experience Management, we recast this controlled vocabulary into a more formal structural form (first order predicate calculus) that allowed us to refer to the mental states and events of participants in a highly structured manner. Although a full description of the language is outside the scope of this paper, the following formalisms are intended to offer an impression of their form as used by the Experience Management system. Here, they are used to formalize the expected experience of the simple narrative in the previous section, where a player is expected to follow a character to a café to see what they are up to. Predicate calculus statements in this ordered list are grouped such that there is only one expected mental event expectation per group.

Comments, preceded by a semicolon, are ignored by the Experience Management system, but provided here to aid in readability.

(agent player) *;the player is an agent* (region reg1) *;there is a park* (event event1) *;there is an event* (recognize-location event1 reg1 player) *;the player thinks they are in the park*
(activity act1 *walking) *;there is an activity of going for a walk* (event event2) *;there is another event* (continue-activity-execution event2 act1 player) *;the player is going for a walk*
(agent person1) *;there is a person* (collaborative-relationship player person1) *;the person is the player's friend* (event event3) *;there is another event* (perceive-agent event3 person1 player) *;the player sees their friend*
(plan plan1) *;there is a plan* (event event4) *;there is an event* (continue-plan-execution event4 plan1 person1) *;the friend is executing the plan* (knowledge-goal goal1 plan1) *;there is a knowledge goal of knowing the plan* (add -goal event4 goal1 player) *;the player wants to know the friend's plan*
(plan plan2) *;there is another plan* (activity act2 *following) *;there is the activity of following someone* (subplan act2 plan2) *;the plan includes the activity of following someone* (event event5) *;there is another event* (successful-planning event5 plan2 goal1 player) *;a plan of following will work*
(event event6) ;there is another event (execute-plan event6 plan2 player) *;the player executes the plan to follow the friend*

Within the matrix format for the process of Experience Management described in the previous section, the formalisms of the "walk in the park" story listed above constitute a single moment in the overall storyline, and all six of these mental event representation groups would be the header for a single matrix column. Likewise, the expected player action (the last group of the six), would constitute one of the available player actions that are listed as row labels.

Using these formalisms for the story representation and for user actions, three critical lists can be maintained by the Experience Management system. First, the *Previous Storyline* is an ordered set of predicate calculus statements of the expected player experience from the beginning of the storyline up until (and including) the current point in the expected experience, formulated simply by concatenating all of the column headers up to and including the current one. Second, the *Future Storyline* describes the expectations of the experience that has yet to be delivered by the produced media, and is a list of all remaining column headers. Third, the *Player Evidence* is an ordered set of the behaviors that the player has taken at each previous story moment, constructed as a list of the appropriate row headers from the matrix. As discussed in the next section, it is these three lists that encode the information necessary for the Experience Management system to determine the applicability of any given Storyline Adaptation Strategy.

4 Storyline Adaptation Strategies

The task of Experience Management is to select storyline adaptations when unexpected user actions are evidenced, where these adaptations are appropriate given the current state of the story. To the Experience Management system, the current state of the story, as well as the evidenced user actions, are represented as three lists of ordered story representation statements (the Previous Storyline, the Future Storyline, and Player Evidence), where the Future Storyline may have multiple versions if branches in the storyline remain to be determined by user action.

The information that is provided in these three lists is rich enough to allow the Experience Management system to select contingencies (in the form of Storyline Adaptation Strategies) to be executed in the event that the user selects an unexpected action. For every sort of storyline adaptation that is imaginable, it is possible to specify the criteria by which the adaptation should be triggered as a set of conditions that must match over these three lists. In our approach, these trigger conditions are authored as partially specified story representation statements with component arguments that are variables.

For example, there are a number of Storyline Adaptation Strategies that may be applicable in the simple "walking in the park" storyline described above, each with a set of preconditions that must be met. For example, if it were important to the remaining storyline that the player knew that his friend was heading for the café at the edge of the park (to meet with the player's spouse), then there are a number of possible techniques for ensuring that this knowledge is obtained. Regardless of the technique, the preconditions may all be similar:

Trigger conditions:
  Previous Storyline:
    (continue-plan-execution ?e1 ?p1 ?a) *;Someone is executing a plan*
    (knowledge-goal ?g ?p1) *;There is a goal to know the plan*
    (add-goal ?e3 ?g player) *;It is the player's goal*
    (execute-plan ?e4 ?p2 player) *;The player does something at a time*
  Future Storyline:
    (achieve-goal ?e5 ?g ?p2 player) *;What the player did achieved the goal*
  Player Evidence:
    (execute-plan ?e4 ?p3 player) *;The player does something else at the time*

Given this formalization of the triggering conditions for a Story Adaptation Strategy, a simple pattern-matching algorithm can be used to determine whether any available strategies are applicable given the current state of the player experience, as encoded in the Previous Storyline, Future Storyline, and Player Evidence lists. For example, the above trigger conditions would match the "walking in the park" storyline if the user chose not to execute the plan to follow their friend (?g=goal1; ?p1=plan1; ?p2=plan2). In the algorithm that we have constructed for this Experience Management approach, this pattern matching algorithm is used to compare the trigger conditions for all strategies every time that any of the three lists are changed, due either to

the event of a user action or the advancement of the story state. In cases where multiple Storyline Adaptation Strategy trigger conditions match the current state of the player experience, a variety of techniques could be used to select a single one to employ. To date, we have relied on a fixed ordering of preference to choose among applicable strategies.

For any given adaptation strategy, there are two factors that must be considered in order to process the effects of applying the strategy to a particular story situation. First, there must be some specification of the *Media Effect*, which is the modification, insertion or deletion of media that would otherwise be presented to users to tell the story. Second, there must be some *Expectation Effect*, which modifies the expected storyline to revise the Previous Storyline representation as well as the Future Storyline representation lists.

To process the Media Effect, each strategy is paired with a specific procedure that is called in the event that the strategy is selected. In simple text-based interactive drama, this procedure may simply be used to swap the next message delivered to the user with a specified line. For example, the strategy described above, which triggers when a player does not do the thing necessary to uncover the plan of another person (e.g. chooses not to follow the friend to the café), may have a Media Effect that presents a new parameterized piece of text where this information about the plan is obtained in a different way (e.g. notice the friend entering a café on my way home).

> Media Effect: (New text message) "While I begin to (?p3), I happen to notice (?a), and it appears that they are engaged in (?p1)".

Expectation Effects are used to update the expected storyline (both Previous and Future) to reflect the change in the media that is presented to the player. Primarily, these effects are of two sorts. First, there is the invalidation of incorrect expectations in the Previous Storyline. When faced with player behavior that deviates from expected behavior, the Previous Storyline must minimally be modified such that the incorrect expectations are no longer valid, to prevent their matching against storyline adaptation strategies as the experience progresses. For example, if the player doesn't pursue the goal of finding out what his friend is up to, then we should not assume that this is a goal that he held in the first place. The mechanism that we use to invalidate expectations of player experience is to include a pattern for each invalid statement in a strategy's trigger conditions, and to indicate in the strategy representation that matching statements should be removed when the strategy is applied.

The second sort of Expectation Effects are those used to insert new expectation statements to describe the user experience as modified by the Media Effect. In the case where the player decides to execute some other plan instead of the one that was expected, but then achieves the knowledge of the other person's plan in some other way, then the strategy must append the Previous Storyline with an additional set of expectation formalisms that encode this experience in order to enable the coherent triggering of different Storyline Adaptation Strategies as the experience moves forward. For example, if we adapt the storyline by having the player notice the cover of a magazine praising a local café, then we would want to add the expectations that the player would

be incited by this new information to satisfy his hunger and go to the café. The mechanism that we use to insert new formalisms into the storylines is to mark certain patterns in the triggering conditions as insertion points for specified sets of statements to be inserted. These inserted statements may contain variables as well, which will be instantiated using the variable bindings identified when the strategy trigger conditions are met.

5 Application to U.S. Army Leadership Development

We have implemented this approach to Experience Management in the context of a story-based training application for brigade and battalion command staff officers in the U.S. Army. The Advanced Leadership Training Simulation (ALTSIM) uses stories to present trainees with a leadership crisis while performing duties in a deployed tactical operations center. The training goal of the application is to enable leaders to make clear decisions in situations in the face of high stress, where a complex mix of political, social, and military issues are involved. Rather than using text messages to tell the story and record player actions, ALTSIM presents users with a graphical user interface that mirrors the functionalities available to officers at a command post, where the storyline is presented using multimedia of high production value. To date, two prototype scenarios have been produced.

In the first, an inspection team under the command of the team of participants is at a weapons storage site in a fictional city. The inspection team discovers that weapons from the site are missing and that a hostile crowd is forming around them. As the inspection team radios for help, the members of the command staff must prepare and launch a rescue operation. Evidence begins to mount (via intelligence reports delivered through media) that the weapons were stolen by paramilitary troops who are motivating the hostile crowd and attempting to cause a major international incident. As additional paramilitary troops stream into the town, the command staff must overcome a series of obstacles in order to rescue the inspection team without incident or injury.

The process of implementing this approach of Experience Management within ALTSIM involved three difficult tasks. First, each of the actions that a player could select using the ALTSIM command and control interface needed to be paired with a corresponding formalization such that it could be encoded in the Player Evidence list. Second, the scenario that was authored for use in this training system needed to be fully encoded as formal representations of the expected experience of the player. Third, a collection of Storyline Adaptation Strategies needed to be identified and encoded using the formalisms of trigger conditions, media effects, and expectation effects. Only a few dozen Storyline Adaptation Strategies were identified in the course of implementing the two existing ALTSIM scenarios, but this level of breadth was sufficient to handle the types of interactions that occur within the restricted domain of our storylines. As an example from our first scenario, the command staff may feel that their best option is to send attack helicopters or other air assets directly to the weapons storage site, but this story direction would conflict with the dramatic (and pedagogical) goals involving civilians caught between opposing forces. The Storyline

Adaptation Strategy that we employ causes a thick fog to roll into the area when any air operations would conflict with an expected ground action.

6 Discussion

Although our research efforts to date have not progressed to the point of being able to conduct comparative evaluations of Experience Management to other forms of dramatic control, our efforts in implementing this approach within the ALTSIM project have offered some insights into the relative pros and cons of this research direction.

The first observation that we can make is that Experience Management does not reduce the amount of effort required to constructing engaging interactive drama, but merely shifts the type of labor that is required. By taking the Experience Management approach in the ALTSIM project, we have essentially shifted the technology hurdles from those of modeling and controlling complex behavior in simulated virtual world to those of knowledge representation (for encoding expected player experiences) and knowledge engineering (for encoding the interactive storytelling knowledge that is used to keep storylines on track). From the perspective of a storyline author, this shift can be somewhat liberating, as it no longer requires that the experience be constrained by what can currently be modeled in a virtual simulation environment. This is particularly important for authors of interactive experiences where simulation models are non-existent, e.g. the human elements relevant to leadership. On the other hand, the burden of labor falls on the shoulders of the knowledge engineers that are responsible for encoding these storylines in a formal manner and for authoring a broad set of Storyline Adaptation Strategies.

The second observation is the various labors involved in pursuing the Experience Management approach each have differing degrees of reusability each time a new interactive drama experience is authored. First, the ALTSIM command and control interface and corresponding action formalizations are reusable across all scenarios where players use this interface as their primary means of interacting with the fictional world, largely constraining its use to other sorts of military command staff officer training. Second, the formalizations of the scenarios themselves have almost no reusability, as a new encoding must be authored every time the media that presents the fictional world is modified. Third, the Storyline Adaptation Strategies are entirely reusable, as they encoded general-purpose methods for keeping a storyline (regardless of what it entails) on track in the face of expected player behavior. As more storylines are authored and new types of media interfaces are created, additional Storyline Adaptation Strategies will be necessary.

With these considerations in mind, the long-term success of Experience Management as an approach to dramatic control requires future research in two distinct areas. First, the non-reusable assets that are required, particularly the formal representations of storylines, need to be authorable by end user developers, likely to be story authors rather than knowledge engineers. We imagine that author tools that rely more heavily on natural language than formal vocabularies will be required. Second, the reusable assets, namely the collection of Storyline Adaptation Strategies, need to be authored

so that they are very widely applicable across scenarios and incrementally expanded to meet new adaptation demands as new scenarios are authored.

As these concerns are addressed, Experience Management will become an effective approach to dramatic control in interactive drama for instructional and entertainment applications.

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