Notes on the Use of Plan Structures in the Creation of Interactive Plot

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Models of Narrative for Interactive Systems

An interactive system defines a virtual space, whether the system's interface provides access to the inhospitable planet of Stroggos or the Microsoft Windows desktop. Users of both these systems interact with a *place*, one created by a computer and in which users and computational agents carry out their individual and collective activities. The intuitive and often-discussed benefit of a well-designed interface metaphor is that it allows users to carry over conventions from their "real" experience when performing tasks within the interface world.

Another key and often unarticulated value of an interface arises from the interface's mimetic quality. While mimesis is often discussed by narrative theorists as a contrast to diegesis, distinguishing the concepts of showing versus telling (Aristotle), my emphasis here is to distinguish between an artifact that is intended to be an imitation of something, but is *not* really that thing and an artifact that is intended to be mistaken *as that thing.* An example of the former case would be a film of a fictional account of the D-Day landing on the beaches of Normandy. An example of the later might be a virtual reality system displaying photo-realistic graphical images of a physical space. D-Day stories like *The Longest Day* and *Saving Private Ryan* are, in some ways, imitations, and so are more mimetic than VR systems whose design is intended to "...produce synthetic images visually and measurably indistinguishable from real world images." (Greenberg 1999)(pg. 45).

The interface to a virtual space presents an abstracted, artificial representation of a world and the activities within it; it is the mimetic character of the space, together with our understanding that we are interacting with a mimetic artificat, that allows us as users to bring to bear all our knowledge of narrative understanding during our interaction (Brannigan 1992). When a user enters into a such a virtual space, it is as if a narrative contract is established between the user and the system's authors. [1] The contract establishes the expectation that the system will obey certain narrative conventions. In this way, the contract is beneficial to both designer and user. It facilitates the user's comprehension by licensing interpretation of experience within the system's interface in ways that would not otherwise be open. It provides the designer with useful constrains on the system's performance, delivering a ready-made vocabulary from which the designer constructs the events that occur in the virtual world. In many ways, this narrative contract functions similarly to Grice's Cooperative Principle (Grice 1957).

It is the interactive character of the interface that contributes most strongly to the creation of a sense of narrative in its use (Reeves & Nass 1996), and the mediated nature of this interaction provides the hook needed to integrate intelligent systems into narrative-based computer programs. From the graphical rendering of the world to the execution of the simplest of user actions, all aspects of a user's activity with interactive system are controlled (or at least, they're *controllable*). Some system designs may chose to abdicate control to the user or pass over much of the mediation that might take place. For interactive systems, mediation provides the fulcrum on which to leverage the power of a computational model of narrative.

In this extended abstract I describe a particular approach to the computational modeling of plot as described by narrative theorists. This model extends techniques from recent approaches to AI planning (Young, Pollack, & Moore 1994) — particularly the combined representation of the causal and hierarchical structure of plans and the methods by which the plans are constructed — to capture key features of narrative structure. Below, I provide two short discussions with examples of how these models of plans and planning can be used to create interactive, plot-based narrative experiences. First, I sketch briefly how a plan-based representation can be used to share control of plot flow between a user and an interactive system. Then I discuss a technique for modeling the suspense experienced by a user while experiencing an unfolding plot.

[1] See a compelling and much more extensive discussion by Kendal Walton on the role of mimesis and its relationship to make-believe (Walton 1990).

Reasoning About Actions in Plots and Plans

Adopting a model of plot

In our work in the Liquid Narrative research group at North Carolina State University, we are developing computational models of the narrative structure described by narrative theorists such as Bal (1997), Rimmon-Keenan (1983), Ryan (1991) and others. While particular frameworks for representing narrative vary from individual to individual, in many models, narrative structure is characterized hierarchically. At the lowest level is the *fabula*, consisting of the agents that populate a story world, along with the actions that these agents perform and the causal and temporal relationships between them. The next level, that of the *story*, consists of a subset of the events in the *fabula* to be conveyed to the reader, with a particular ordering imposed on this subset indicating the order of the telling. The final level is the level of the *text*, in which the story elements are realized in a particular medium (e.g text, film) for communication to the reader.

A model of plot as plan

Agents, actions and their causal relationships are not new to Artificial Intelligence. These notions are the stuff that makes up most representational schemes in planning research. The idea that plans might be put to use to represent plot is also not new (Schank & Abelson 1977). However, the planning representations that have previously been used to represent plot have roughly been based on early, *ad hoc* models of plans (Sacerdoti 1977). As a result, aspects of narrative in these systems reflected the representational limitations of the underlying plan structure.

Our work employs recent models of plans and planning from AI to represent the hierarchical and causal nature of narratives identified by narrative theorists. Specifically, we are using a model of planning that differs from others previously used in narrative contexts in at least two ways. First, the plan representation that we employ contains a rich, formal representation of the causal structure of a plan. Each causal dependency between goal, precondition and effect in the plan is carefully delineated during plan construction. Second, the plan construction process we use is one of search through the space of all possible plans rather than the incremental construction of a single plan. Consequently, the system can characterize a plan relative to the broader context in which it occurs. As I describe below, both of these features can be used to create and maintain narrative structure in an interactive system.

An AI Architecture for an Interactive Narrative System

In the type of interactive narrative system we envision, a user performs activities within a virtual space, either singly or with other users and/or computational agents. The application may be explicitly story-oriented or not, but in either case interaction within the environment is structured as a narrative. To achieve this type of interaction, the system uses the following components:

- A declarative representation for action within the environment. This may appear in annotations to virtual worlds suggested by Doyle and Hayes-Roth (1998), specifically targeted at the representational level required to piece together plot using plan-based techniques described in (B).
- A program that can use this representation to create, modify and maintain narrative-structured plans for interaction with the environment. The plans represent the activities of users, system-controlled agents and the environment itself.

  This program consists of two parts: an AI planning algorithm and an execution monitoring component. The planning algorithm forms plans for user and system interaction that contain such interesting and compelling narrative structure as rising action, balanced conflict between protagonist and antagonist, suspense and foreshadowing. The execution monitor detects user activities that deviate from the planned narrative and decides how to respond. The response might take the form of re-planning the narrative by modifying the unexperienced portions of the narrative plan, or it might take the form of system intervention in the virtual world by preventing the user's deviation from the current plan structure.
- A theory capable of characterizing plans based on their narrative aspects. This theory informs the program in (B) above, guiding the construction of plans whose local and global structure are mapped into the narrative structures of conflict, suspense, etc.

In the following two examples, I suggest ways that plan representations can be used 1) to detect and respond appropriately to a user's deviation from a given plot line and 2) to characterize plans in terms of their narrative features.

Exploiting Plan Structure to Share Control in Narrative Environments

For the designer of a narrative-oriented system that allows substantive user interaction, the greatest design challenge revolves around the distribution of control between the system and its users. If a design removes all control from the user, the resulting system is reduced to conventional narrative forms such as literature or film. If a design provides the user with complete control, the narrative coherence of a user's interaction is limited by her own knowledge and abilities.

Most interactive narrative-based systems have taken a middle ground, specifying at design-time sets of actions from which the user can choose at a fixed set of points through a narrative. The resulting collection of narrative paths is structured so that each path provides the user with an interesting narrative experience. This approach, of course, limits the number and type of stories that can be told.

Our approach is to provide a mechanism by which narrative plans are generated at execution time, in response to user preferences and other contextual factors (e.g., other users' unfolding narratives within the same virtual space). The plans we use contain a rich causal structure; all causal relationships between steps in the plans are specifically marked by data structures called causal links. To ensure that the plans are functionally correct, these links are originally added to a plan at construction time. We put them to use at execution time; in our system, when a user attempts to performs an action, the declarative representation of that action is checked against the causal links present in the plan. If the successful completion of the user's action poses a threat to any of the causal links, an exception is raised.

Exceptions are dealt with in one of two ways. The most straightforward is via intervention. Because all of a user's actions in the environment are mediated, it is the system itself that determines whether an action succeeds or fails. Typically, the success or failure of an action within a virtual environment is determined by software that approximates the rules of the underlying story world (e.g., firing a railgun directly at a Strogg Enforcer results in the Strogg's timely death). However, when a user's action would violate one of the narrative plan's constraints, the system can intervene, causing the action to fail. In the Strogg example, this might be achieved by surrepticiously substituting an alternate action for execution, one in which the "natural" outcome is consistent with the existing plan's constraints. A railgun misfiring, for instance, or a shot that misses its mark by a hair's width, preserve the apparent consistency of the user's interaction while also maintaining the Enforcer's presence in the storyworld.

The second response to an exception is to adjust the narrative structure of the plan to accommodate the new activity of the user. The resolution of the conflict caused by the exception may involve only minor restructuring of the plan, for instance, selecting a different but compatible location for an event when the user takes an unexpected turn down a new path. Alternatively, this may involve more substantive changes to the plan, for instance, should a user stumble upon the key to a mystery early in a narrative or unintentionally destroy a device required to rescue a narrative's central character.

There are, of course, many open research questions. One involves deciding between the two categories of response. If a system is constantly altering the narrative plan in response to user activities, interaction may reduce to one in which no narrative coherence exists. Alternatively, if user actions are constantly failing, the user's illusion of control disappears and the immersive natural of the virtual world recedes. Similarly, knowing when and how to intervene or how to restructure a narrative plan are two central issues that are, as yet, unresolved.

Creating and Manipulating Suspense

Recent work in cognitive psychology (Ohler & Nieding 1983; Gerrig & Bernardo 1994; Comisky & Bryant 1982) has considered the role of narrative structure in the creation and maintenance of suspense in film and literature. Gerrig and Bernardo (1994) suggest that people who read fiction act as problem-solvers, continuously looking for solutions to the plot-based dilemmas faced by the characters in a story world. This work indicates that a reader's suspense is greater when fewer solutions to the hero's current problem can be found by the viewer. We are currently developing a cognitive model of a user's plot-based reasoning that can be used to structure a user's interaction to increase or decrease her feeling of suspense at specific points in the interaction (Young 1999).

Our cognitive model employs the model of *planning as search* defined by Kambhampati *et al* (1995). In this approach, finding a solution to a planning problem involves search through a space of plans, represented as a directed graph. Nodes in this space represent (possibly partial) plans. Arcs from one node to another indicate that the second node is a refinement of the first, that is, that the plan represented by the second node is an incrementally more complete version of the plan at the first node. The root node of the graph contains the empty plan and the leaf nodes of the graph contain solution plans (i.e., complete plans that solve the planning problem).

By characterizing the space of plans that a user might consider when solving problems faced by a protagonist at a given point in a plot, the model can make predictions about the amount of suspense a user will experience at that point. The greater the number of solution plans at the leaves of the graph, the less suspense the user is likely to experience. More interestingly, the model can also be used to suggest ways to increase or decrease suspense by manipulating the knowledge held by the user about the state of the story world and the actions available within it. We are currently implementing these ideas and plan to evaluate the validity of the approach empirically.

The Role of Narrative in Our Research

In the work we are performing, narrative plays two central roles. The first is as the central target application. Aspects of narrative play a key role in learning, communication, social interaction, our arts and recreation. In our work, we seek to understand human interaction in these contexts and apply this understanding to the structure of human-computer interaction designed to exploit our common orientation towards narrative.

Narrative, and more specifically narrative theory, plays a second role as the source for formal models that can be adopted to characterize interaction in the contexts listed above. By adopting a cross-disciplinary approach, we gain access to the body of work on narrative that dates back to Aristotle. Further, we provide collaborators in narrative theory with computational tools for modeling narrative interactions that have previously been unavailable to them and in return they provide critical feedback and analysis of our efforts that prove essential in refining our models.

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