

A Comparative Analysis of Story Representations for Interactive Narrative Systems

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Abstract

Interactive narrative is a blossoming field, with new systems and approaches being developed each year. However, despite this burgeoning array of designs, little work has been done in empirically evaluating and comparing them (Weyhrauch 1997; Nelson and Mateas 2005; Magerko 2007). Such a comparison is complicated by the fact that different systems are used to create different narratives; it is difficult to differentiate between the authored content and the system capabilities in an empirical setting. This paper proposes a comparative analysis approach to determining the strengths and weaknesses of interactive narrative systems. Such a comparison is a positive first step towards understanding and evaluating current and future interactive narrative systems.

Introduction

Research in the field of interactive narrative has increased dramatically in the past ten years. Many systems are beginning to emerge in this young field, offering new technologies to support and author interactive narrative experiences. Interactive narrative has been successfully applied to the training domain, where it is employed for trainee engagement, memory retention of content, and pedagogical effectiveness (Aylett 1999; Johnson, Marsella et al. 2004; Magerko, Wray et al. 2005; Riedl and Stern 2006).

Few of these approaches, however, have been individually evaluated (Weyhrauch 1997; Nelson and Mateas 2005; Magerko 2007), and none to date have been rigorously compared to other approaches. One of the difficulties in comparing interactive narrative approaches is the lack of a control for authored material; each system is created with its own story or set of stories in mind. When comparing systems with different stories, it is difficult to determine which differences are due to the authored content, and which are due to the architectures supporting that content.

A key aspect of an interactive narrative is the story representation used to encode the author's vision of the

possible narrative experiences, called a *story space* (Magerko 2007). How the system can make use of encoded content depends directly on the representation used to encode it. If a planning representation is used, for example, then the corresponding algorithms for managing the story experience would involve planning algorithms.

We can compare the expressivity of different representations used in interactive narrative systems to determine what types of stories a given architecture can support. Such a comparison would be useful in dealing with the variability found when trying to compare and contrast systems that are tied to different content. This paper makes an initial attempt to rigorously compare the different representational approaches that are used by current interactive narrative systems.

There are two methodologies for such a comparison. The first method is to implement the same story content, as closely as possible, using different representations. Different metrics could be assigned corresponding to what capabilities a representation affords, how long it takes to author similar content, and the impact each representation has on the end-user experience. A second method is to tackle a subset of these metrics, such as what capabilities a representation affords, and engage in a comparative analysis of the representations independent of their implementation in a particular narrative experience. I propose to use this lower-cost second method, specifically focusing on the affordance of interactive narrative system capabilities.

As the field has matured, the recognition of major system capabilities and their problems has crystallized. By identifying the key capabilities of current systems and then comparing and contrasting how well each representation supports each capability, we can arrive at a clear understanding of the strengths and weaknesses of the different representations. This understanding will not only aid in future system design decisions regarding choice of representation, but will provide insight into what current representations lack and how they may improve.

Capabilities of Interactive Narrative Systems

There is a plethora of components of narrative performance (e.g., character development, internal dialogue, focalization, diegesis, etc.) that could be used to compare representational approaches if the details of each of the story representations were known. What is available for comparison is the set of capabilities that each corresponding interactive narrative system is afforded by the representation.

The following are the major capabilities of the relevant systems to date. *Story mediation* is the execution of actions in the story world by a coordination agent called a *story director* or *drama manager*. Story mediation is used typically to address potential conflicts between player actions and authored story content, which is called a *boundary problem* (Magerko 2007). The director typically executes control of *autonomous synthetic characters*. *Content instantiation* is the ability of a narrative system to intelligently refine selected abstract plot content to fit a particular situation. *Prediction of player behavior* is used to preemptively avoid likely boundary problems (Magerko 2007). Systems may perform real-time *heuristic selection of plot content*, which adds structure to story content as the player executes actions and makes decisions. Systems may also perform *story generation*, taking inspiration from such approaches as TALE-SPIN (Meehan 1981) and MINSTREL (Turner 1994). Systems may also integrate *different performance modalities* for synthetic characters, such as discourse, body language, physical manipulation of the environment, etc.

Categorization and Comparison

The following sections present a categorization of interactive narrative representations that focus on high-level story descriptions. Approaches that focus solely on autonomous actors, such as (Cavazza, Charles et al. 2002; Cavazza 2005), or those that deal with narrative presentation, such as (El-Nasr 2004; Jhala 2007), are beyond the scope of this paper. This categorization of interactive narrative story representations provides us with an appropriate grouping for analytically comparing the different target representations without comparing each individual representation.

Planning languages

Both in fiction and film, narrative can be decomposed into the elements of *content* and *structure*. Structural representation can further be broken down into *temporal succession* and *causality* (Rimmon-Kenan 2002). Planning languages have the clearest mapping to this assertion of story structure being comprised of temporal and causal relationships. Partial-order plans have both temporal and causal constraints that directly represent these basic narrative structural building blocks. Story content is represented as planning operators. The constraints

between these operators (e.g., temporal and causal constraints) provide the non-linear story structure. The use of plans in narrative has progressed from the representation of only character goals (Meehan 1981) to a mixture of both authorial and character goals (Lebowitz 1985; Young, Riedl et al. 2004; Riedl and Stern 2006), which allows the authoring of stories that involve more than only character goals.

Planning languages support many of the capabilities described above. A system can easily recognize when *story mediation* is needed by observing when causal threats are created by player or synthetic character actions (Young, Riedl et al. 2004; Riedl and Stern 2006). A partial-order plan's structure also allows a search from a given story state to the end goal(s), allowing for a comparison of *predicted behavior*, which can be done with a plan recognition algorithm or others, to future content to identify potential future threats. It also follows that planning representations, which may include character goals as preconditions in planning operators, also facilitate the *direction of autonomous characters*.

Planning languages can also potentially support the instantiation of plot content, though this has only been shown in related hybrid approaches to date (Magerko, Wray et al. 2005). Story plans could conceivably be represented in a hierarchical fashion and that plan could potentially be decomposed into more refined plot concepts (e.g., representing story as acts, scenes, and beats). IDA, which is discussed in the next section, shows how the use of planning variables can be used to represent abstract author goals.

The heuristic selection executed in planning algorithms (Bonet and Geffner 2001) does not quite accomplish the *real-time selection* described in the previous section. An interactive narrative can heuristically select content based on the current actions of the user (Weyhrauch 1997; Mateas and Stern 2003; Magerko 2007). This is typically done in languages without an explicit representation of causality, only temporality. The main obstacles of using causal constraints for real-time heuristic selection is that a) a complete plan must be built beforehand, as opposed to being able to simply add plot elements to a set for consideration, and b) not all plot elements may be used in a constructed plan compared to being able to use that entire set.

The representation of *different interaction modalities* is not explicitly prohibited in a planning language, but there are no specific constructs to group and time a multi-model character performance. For this reason, the IN-TALE architecture uses the ABL language (discussed below) for the fine-grained representation of character performance (Riedl and Stern 2006). It is reasonable to posit that a planning language could be augmented to incorporate this information.

Modular languages

The term *modular language* refers to representations that make an explicit commitment to content (e.g., beats or plot

points) without a similar commitment to causality. Systems that use these representations take player actions as input to determine the most suitable event to occur next. The structure of these events may include timing constraints to ensure a logical progression of content without concern for causality. For example, an event that involves getting on an airplane should be constrained to occur after the events that would involve getting to the airport.

The strength of modular languages is their lack of commitment to explicit causality, which allows for *real-time heuristic selection* to be commonly done based on some metric of dramatic impact (e.g., following an Aristotelian arc). However, because of this lack of structure, comparing *predicted player behavior* against possible future boundary problems becomes a more expensive task, as essentially the entire set of events needs to be considered (e.g., the MOE director (Weyhrauch 1997) searches the space of all possible complete story linearizations). There is also no longer any means to logically infer conflicts; without an explicit representation of goals, it is difficult to determine when *story mediation* is necessary. Modular languages, such as ABL, (Mateas and Stern 2003) have been created in an effort to create a representation for synthetic characters that can perform in different audio-visual modalities (e.g., facial expressions, speech acts, and staging).

Content instantiation in modular systems has typically been examined only in systems that define content procedurally. Fairclough's OPIATE represents story as Proppian functions, which are instantiated and selected based on user actions (Fairclough 2004). Another system, DEFACITO, generates content based on author-defined rules of dramatic concepts (Sgorous 1999). These systems create or recognize story events according to this rule-based knowledge. While it is possible to author interactive narratives through procedural means, representing narrative concepts both accurately and with enough detail is an incredibly time-consuming human task (Bringsjord and Ferrucci 2000).

The use of declarative representations is less common. One modular system that uses declarative representations for content instantiation is the Interactive Drama Architecture (IDA). IDA is a modular approach to interactive narrative that represents story as an incomplete plan (i.e., planning operators with no causal links) (Magerko 2007). Content is selected heuristically based on user actions and then, if needed, instantiated to fit the current situation. Conditions contain *content variables*, constrained variables in story content that are left unfilled until run-time. IDA also includes a predictive model of player behavior as a key element of its story director.

Hybrid languages

Hybrid systems combine the less constrained approach of modular languages with the more causally-structured approach of planning representations. Hybrid systems should both allow for *control of synthetic characters* across

multiple performance modalities as well as provides for a high-level story representation that provides for *story mediation* and possibly *player prediction*.

The aforementioned IN-TALE / ABL combination of Riedl and Stern (Riedl and Stern 2006) is a good example of combining representations for this goal. IN-TALE provides a high-level planning language that incorporates directable synthetic characters defined in ABL.

The representation used in the Interactive Story Architecture for Training (ISAT) is another example of such a hybrid model (Magerko, Holt et al. 2006). ISAT represents plot as a two-layer construct. Story content at the top level corresponds to *plot points*, which are similar to planning operators with logical preconditions and effects. Plot points may be structured with timing and causal constraints. Plot points also encapsulate lower-level *events*. Events describe a small unit of performance, similar to the dramatic beats used in the ABL language (Mateas and Stern 2003). Events are a series of atomic actions that are temporally related (e.g., a squad turning a corner to fall into an ambush and taking a defensive position within a matter of seconds). The specific timing of these atomic actions depends on the user's actions. The selection of plot points then depends on a real-time heuristic selection, based on both pedagogical and dramatic relevance of content, or could be pre-constructed with a planning algorithm.

One goal of this paper is to critically identify the strengths of these different representations and better inform future hybrid approaches. The Interactive Storytelling Architecture for Training (ISAT) and IN-TALE / ABL both combine a mixture of planning and modular representations in an attempt to be more flexible representations. There are subtle differences between the two (e.g., ABL is a fully-developed agent control language with natural language parsing, which ISAT lacks), but are two main efforts in attempting to address all of the system capabilities highlighted in this comparison. The design idea of using more than one specific construct (e.g., plots point vs. events or plan operators vs. beats) seems to be a promising one that uses different elements to suit different representational needs. This provides for a fluid interplay between high-level story functions (e.g., *story mediation* and plausibly *player prediction*, given the use of planning formalisms) while fulfilling the lower-level representation goals (e.g., *different interaction modalities* and *control of synthetic characters*, as in the use). *Real-time heuristic selection* can be done at the character level, as in IN-TALE/ABL, or at the top-level, as in ISAT.

Discussion

This comparison highlights the strengths and weaknesses of the different representational approaches. Planning representations offer a complete story for prediction, are useful for director-based approaches, and are suitable for story generation. How planning languages would work well with content instantiation and representing multi-

model character performances is still not addressed in any system. Modular representations, on the other hand, prove ideal for real-time heuristic choice of content based on dramatic principles. Generative approaches, such as DEFACTO, can be viewed as modular approaches that are comprised of rule-based story content. That content is then used to create (or “instantiate”) new content in response to player choices. Hybrid approaches do offer more flexibility in terms of being non-committal to causality, allowing for the option of real-time heuristic selection at different representational levels. ISAT’s representation has the potential to offer similar benefits as the combination of IN-TALE / ABL (Riedl and Stern 2006), however it has yet to make a commitment to an explicit language for representing complex character performances, such as using processing dialogue or encoding body language. Both systems employ a split representation to handle different levels of story control (high-level plot versus lower-level events and character behaviors).

The comparative analysis executed here is a first step in providing more concrete evidence for comparing and contrasting approaches to interactive narrative. As this field matures, more metrics need to be developed to compare architectural approaches separate from the authored content. As these metrics mature, it will be much clearer what benefits each new approach will bring.

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