Opportunities for Integration in Interactive Storytelling

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Abstract. While several Artificial Intelligence techniques have been applied fruitfully in the context of interactive storytelling, few projects todate have attempted to integrate many of them into a single, cohesive system. Meanwhile, the call for better integration across related research groups has intensified in recent years, with the goal of crafting new systems that benefit from the advancements of diverse lines of AI research. In this paper, we identify several key technologies in this area and propose a high-level approach that may facilitate their integration.

1 Introduction

We envision an interactive, simulated world in which multiple stories occur at the same time, and where the actions of one or more players can influence each story's progression by changing the state of the world. We view interactive storytelling (IS) as the combined tasks of creating such a world and maintaining it at run-time. Over the past three decades, a variety of artificial intelligence (AI) techniques have been applied to address specific challenges in this context. With a few exceptions, many of the projects that have been undertaken in this area have each derived primarily from a single line of prior IS research. At the same time, multiple ICIDS workshops have called for integration [9]. We seek to extend and integrate key technologies from several prior lines of research, toward creating a new AI system for interactive storytelling that benefits from their contributions. In this paper, we summarize our first steps toward this goal.

2 Background & Key Technologies

In the context of our work, a simulated world is an environment that transitions between states in response to actions, and actions are performed by agents therein. These agents are characters in stories that occur in the world, and they might be controlled by players. Each story consists of events that might occur in parallel, and each event consists of actions that might also occur in parallel.

We have identified several technologies that grant useful abilities to either story designers (those who create IS artifacts) or players (those who experience them). We describe these technologies and the abilities they afford in the remainder of this section; we propose a way to integrate them in Section 3.

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Hierarchical Story Planning (i): AI Planning has become a dominant technology for story generation in IS research [1, 4–8, 12], and hierarchical approaches to planning offer a way to simplify each planning problem through either manual or automatic decomposition [1, 12]. Such decompositions can also be partially specified by hand and then completed automatically [12].

Guiding Planning with Constraints (ii): By placing extra constraints on an AI planner that are then enforced during planning, designers can guide the planning process to avoid the generation of unwanted plans. These constraints can be used to assert that specific predicates should become true either sometime in the plan in general, or sometime before a specific other predicate [4, 8].

Role Passing with Constraints (iii): The ability to dynamically assign characters to designer-defined roles while an experience is underway (i.e., *role passing* [2]) gives more flexibility to an interactive storytelling system as it maintains the simulated world. Each definition of a role includes a set of constraints that must be satisfied by a character before it can "fill" that role (e.g., "the villain must be the character that most strongly opposes the player"). Role passing can also be extended to include roles for objects and locations in the world [10].

Narrative Mediation (iv): To handle potentially disruptive player actions in a plan-based interactive story, such actions can be detected as they occur and used to trigger plan repair; this process is known as *narrative mediation* [6]. To identify disruptive actions automatically, an *exemplar plan* (which defines how the story should proceed) must be provided as input to the mediation process.

Optimization-based Search (v): By treating the task of maintaining a simulated world as an optimization problem, designers can ensure that the AI system will adapt its behaviour as needed in pursuit of their goals [3, 5, 10, 11]. To allow the system to search for alternatives that are optimal, designers must provide an *evaluation function* that estimates the success of each option.

3 Proposed Approach

While previous systems have integrated different subsets of the technologies given in Section 2 (e.g., ii, iv, v [5]; i, ii, iv [8]; iii, v [10]), we propose that all five can be integrated using the approach that we sketch in this section. To save space, we focus on the challenge of integrating role passing (iii) with the technologies that focus on AI planning (i, ii, iv), since optimization-based search has already been integrated with technologies in both of these groups [5, 10]. More specifically, we aim to integrate two kinds of constraints: those that guide the planning process (tech. ii) and those that are used during role passing (tech. iii).

To begin, we envision an AI system where story content is represented at three levels of detail: actions, events, and stories. Each *action* defines a piece of content that can be performed directly by a character in the world (e.g., moving, manipulating objects, or expressing internal state) and is represented in the system as a planning operator. Each *event* defines a larger piece of story content (e.g., a bank robbery) and has a dual representation: as a partially-ordered plan of actions and as a planning operator. Each *story* defines an even

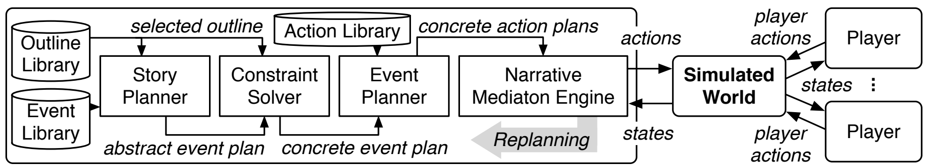

Fig. 1. Overview of our envisioned system and its interaction with a simulated world.

larger piece of content (e.g., a heroic journey); it is represented by a partially-ordered plan of events and an *outline*. An outline is a proto-story construct that specifies both planning constraints and role-passing constraints.

Figure 1 gives an overview of the system that we envision. The designer creates a library of outlines and two libraries of planning operators: one for events and one for actions. Given access to these libraries, the AI system would perform the following steps. First, it would use optimization-based search (tech. v) to select an outline from the library; this outline would constrain the impending planning and role passing processes. Next, it would use an AI planner ("Story Planner" in the figure) to generate a partial-order plan of events that respect the outline's planning constraints (tech. ii). To integrate role passing into this process, the planner must be able to reason over each outline's roles as first-class entities (e.g., allowing the event "Villain captures Hero at Lair" to be generated). We propose that this can be done by generating and solving *abstract planning problems* where the roles that are defined in the outline (e.g., "Villain", "Hero", and "Lair") exist as entities for the planner to use. To add sufficient variety to each problem's domain, an abstract world could be made by collecting all of the roles and preconditions that are defined across the library of outlines. These roles and their properties could then be used to solve each planning problem.

After finding a plan of (abstract) events for the selected outline, the system would use a constraint solver to assign entities from the simulated world to each of the outline's roles (tech. iii; e.g., "Villain:Nero", "Hero:Bond", "Lair:Volcano"), instantiating new suitable entities if the solver failed to find any solutions. Each role in the story's events would then be mapped to the entity that was found for it by the constraint solver, resulting in a plan of fully concrete events. Given this plan, the system would invoke its AI planner again (forming a two-level hierarchy of story planning; tech. i) to plan each event as a partial-order plan of actions ("Event Planner" in Figure 1). At run time, the partial-order plans in each story would be monitored by a narrative mediation engine (tech v.) to determine when each action therein was ready to occur. Ready actions would be sent to all involved characters for execution in the simulated world. To accommodate both disruptive player actions and conflicts between multiple simultaneous stories, the engine would re-plan using the mechanisms given above, along with optimization-based search (tech. v) whenever multiple plans were valid (like Ramirez & Bulitko [5]) or when multiple constraint solutions were found.

4 Conclusion & Future Work

We have proposed a high-level approach for integrating several key technologies from different lines of IS research, including hierarchical story planning, constraint-based planning, role passing, narrative mediation, and optimization-based search. Our work to implement it is now underway. Several broad challenges remain, such as finding useful evaluation functions to optimize, balancing long-term plan consistency with real-time flexibility, and developing a reliable way to evaluate our work. We particularly welcome discussions with the community with regard to these and related topics.

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