Interactive Narrative: A Novel Application of Artificial Intelligence for Computer Games

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Abstract

Game Artificial Intelligence (Game AI) is a subdiscipline of Artificial Intelligence (AI) and Machine Learning (ML) that explores the ways in which AI and ML can augment player experiences in computer games. Storytelling is an integral part of many modern computer games; within games stories create context, motivate the player, and move the action forward. Interactive Narrative is the use of AI to create and manage stories within games, creating the perception that the player is a character in a dynamically unfolding and responsive story. This paper introduces Game AI and focuses on the open research problems of Interactive Narrative.

Artificial Intelligence in Computer Games[1]

Artificial Intelligence in Computer Games (Game AI) refers to algorithmic techniques to augment the player's experience in computer and video games. The goal of Game AI as a discipline is to produce the illusion of intelligence in the behavior of Non-Player Characters (NPCs—the opponents, companions, and other entities in the virtual game world) in the virtual world of the computer game. Almost all modern computer games utilize some form of artificial intelligence, making games the largest class of commercial product through with public regularly comes into contact with artificial intelligence.

The most common forms of Game AI in modern computers are those that select animations for NPCs and allow the NPCs to navigate through the virtual environment without failure (i.e., pathfinding). It is not always the case that a commercial computer game product requires sophisticated or cutting-edge artificial intelligence techniques. Modern computer games typically devote a majority of processor time to graphics. Even when processor time is available, modern computer games do not necessarily *require* sophisticated algorithms; the illusion of intelligence can often be accomplished quickly with clever design specifications, finite state machines, and rules. Game AI as practiced in industry thus encompasses a larger class of algorithms, data representations, hacks, and workarounds used to convey this illusion of intelligence.

Laird and van Lent (2001) put forth an argument for AI in computer games as an academic pursuit. They specifically argued that those pursuing complete, "human-level" AI systems should use computer games as testbeds for research endeavors. This opened computer games up to a wide range of academic research goals under the Game AI umbrella:

- **"Human-Level" AI.** The development of artificial intelligence algorithms and architectures that can act in computer game worlds equivalently to humans. Laird and van Lent (2001) argued that computer games have many of the properties of the real world without the overt complexity of the real world and thus could act as a non-trivial stepping stone toward improved AI performance.
- **Better games.** The improvement of algorithms that operate under the real-time constraints of modern computer games and on game-specific computer architectures. A primary concern is to improve NPC pathfinding and real-time NPC decision-making to better utilize the unique requirements and operating environments of computer games. Examples include improved or specialized pathfinding on game console architectures, pathfinding for many hundreds of entities, pathfinding with dynamic terrain, and reactive behavior planning.
- **Supporting Game Development Practices.** The development of techniques that automate portions of the game development process. There are three ways in which AI can automate game development. First, an intelligent system can perform part of the game development during development time such as generating and placing trees (cf., *SpeedTree*) in the large virtual worlds found in many modern game genres. Second, an intelligent system can automate the testing of computer games, which is typically a human-intensive process. Third, an intelligent system can procedurally generate computer game content such as levels, weapons, enemies, and quests (Yannakakis 2012).
- **New Experiences.** The development of new artificial intelligence approaches to entertaining humans in real-time virtual worlds outside of the confines of the typical operating environments. Progress is made by bringing to bear AI algorithms that have not yet been considered in a commer-

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[1]This paper was invited as a "What's Hot" paper to the AAAI'12 Sub-Area Spotlights track.

Figure 1: Screenshots from Interactive Narrative systems (Mateas and Stern 2003; Riedl et al. 2008; Magerko 2005; Thue et al. 2011; McCoy et al. 2010; Cavazza, Charles, and Mead 2002).

cial game product, exploring the use of algorithms that currently require too many computational resources, or discovering new algorithms that autonomously create an manage player experiences. Examples include: sophisticated NPC behaviors including natural language processing, emotion, and personality; agents that learn from humans; and interactive narratives.

The AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE) was created in 2005 to support the growing community of AI researchers interested in computer game technologies and also to act as a bridge between academic researchers and industry practitioners. The conference grew out of a series of AAAI Symposia and workshops starting in 1999.

Interactive Narrative

Interactive Narrative is a form of digital entertainment in which users create or influence a dramatic storyline through actions, either by assuming the role of a character in a fictional virtual world or by issuing commands to an autonomous NPC. Story is a significant component of most modern computers. In computer games, the storyline (a) provides a contextual against which the actions, tasks, and characters make sense, (b) motivates the player to perform actions, and (c) creates transitions between various task and activities. However, storylines in most commercial computer games cannot be created or significantly influenced by the player. If the storyline in a commercial game can be influenced by the player it is because a small number of choice points—called *story branches*—have been hard-coded into the game. Branching is rare in commercial games as the amount of game content that must be authored at design-time theoretically grows exponentially with the number of branches (Bruckman 1990).

Artificial intelligence can help realize Interactive Narrative as a form of interactive digital entertainment by autonomously engaging in the creation or selection of story content based on the player's actions or preferences (see Figure 1). AI approaches to interactive narrative generally fall into one of two classes. *Emergent narrative systems* are simulations constructed from autonomous lifelike character agents (Aylett 1999; Cavazza, Charles, and Mead 2002; Brenner 2010). *Drama management systems*, the use an intelligent, omniscient agent—called a *drama manager*—that monitors the game world and intervenes to drive the story forward according to a model plot progression and player preferences (Bates 1992; Kelso, Weyhrauch, and Bates 1993; Weyhrauch 1997). Typically the drama manager drives a story forward by directing NPCs in how to respond to the player actions or to proactively engage the player in activities. Thus, Interactive Narrative is also the pursuit of creating the illusion of life.

What makes Interactive Narrative a challenging problem is the necessity to balance *authorial intent* and *player agency* in the context of storytelling. On one hand, a human designer—called the *human author*—may have very specific criteria with regard to the player's experience in the fictional virtual world. For example, the human author may require the player's experience to be structured according to principles of dramatic arc, and/or contain specific events; not any story experience will suffice. On the other hand, the player should perceive herself as having agency—of being being able to act freely in the virtual world to pursue her own interests and goals. By exerting agency in the virtual world, the player influences the story in ways that may or may not be desirable with regard to authorial intent.

Interactive Narrative makes a regular appearance at the AIIDE conference with several papers published on the topic every year. Further, there are a number of academic research venues devoted to the topic, including the AAAI Workshop series on Intelligent Narrative Technologies (INT) and the International Conference on Interactive Digital Storytelling (ICIDS).

Open Problems in Interactive Narrative

Storytelling in games has historically been the purview of the human designer. Interactive Narrative as a form of interactive digital entertainment in which some—or all—of the responsibility for managing the player's narrative experience in the hands of an intelligent, autonomous system. It is not yet well-understood how to instill computational systems with *narrative intelligence*, the ability to represent and reason about stories. Consequently, there are number of open research questions pertaining to how to make computational systems reason about narrative and manage players' interactive experiences in virtual worlds. The following is a non-exhaustive list of open research questions pertaining to Interactive Narrative and some of the current approaches that are being pursued.

Story knowledge representation

How does the drama manager know what a "good" player experience should be? The drama manager is a surrogate for the human author. One way to ensure that the drama manager preserves authorial intent under all conditions—no matter what the player does—is to have an explicit representation of the space of all acceptable solutions. The simplest representation for the story space is a *branching story*, such as those found in Choose-Your-Own-Adventure novels. Authoring a branching story is intractable for any sufficiently complicated story space and thus other intermediate representations have been proposed such as the *plot graph* (Weyhrauch 1997), which defines a set of possible events that can occur in the story and necessary temporal necessity relations between events. Algorithms are necessary to reason over the knowledge representation to bring about the human author's intent and still provide the player with agency.

Real Time Adaptation

A drama manager must respond to the player's actions in a way that neither diminishes the player's perceived agency nor violates authorial intent (Magerko 2005). Drama managers must search for the best future story experience for the player based on the player's actions, preferences, and current story world state. Typically, this process is modeled as a form of search. *Façade* (Mateas and Stern 2003) and *Prom Week* (McCoy et al. 2010) use reactive planners, requiring extensive plan libraries. Drama managers based on the plot graph formalism must search for possible expansions of the space of possible stories and use heuristics to select future story trajectories that push the player toward more favorable experiences according to some set of criteria (Weyhrauch 1997; Nelson and Mateas 2005; Roberts et al. 2006; Sharma et al. 2010). It is often the case that players become aware that their experiences are being managed. One way to reduce the intrusiveness of the drama manager is to real time adaptation algorithms with models of psychology in order to reason about the most effective means of shaping the player's experience (Roberts, Narayanan, and Isbell 2009).

Story generation

A more general solution to Interactive Narrative is to instill the drama manager with the ability to automatically generate novel branches. This trades the problem of authoring branching stories and plot graphs with the problem of generating novel stories. Story generation has been a topic of investigation for over 30 years, using a variety of AI techniques including (a) planning (Meehan 1976; Lebowitz 1987; Porteous and Cavazza 2009; Riedl and Young 2010; Li and Riedl 2010; Ware and Young 2011) and (b) case-based and analogical reasoning (Turner 1994; Pérez y Pérez and Sharples 2001; Gervás et al. 2005; Ontanón and Zhu 2010). As part of an interactive storytelling system, the story generator must run in real time. This can be accomplished with real-time planning (Barber and Kudenko 2007; Cesar, Vidal, and Nareyek 2011) when the space of possible stories is relatively well-constrained, or by precomputing a library of story branches (Young et al. 2004; Riedl et al. 2008) to be selected in response to player actions. Story generation is an open research problem. Thus there is a trade-off between the degree of story generation performed and the size of pre-authored knowledge structures required to effectively manage players' narrative experiences.

Authoring

AI systems require knowledge. Regardless of whether the drama manager is manipulating plot graphs or constructing novel story branches using a story generator, some amount of knowledge must be authored by the human author. In the former case, the plot graph must be authored. In the latter case, other more fine-grained knowledge structures must be authored such as planning operator libraries or case libraries. The open research challenge is to make the specification of artificial intelligence constructs for Interactive Narrative systems accessible to a wide range of non-experts who wish to design and deploy interactive stories. There has been some work on authoring tools for interactive stories (Cash and Young 2009; Skorupski and Mateas 2009). An interactive system is bound the micro-world defined by its authored knowledge structures—it can only generate/select what is knows—and future approaches to Interactive Narrative may automatically learn the necessary knowledge from the Internet (Li et al. 2012).

Believable Character Agents

A *believable character* is a character in an Interactive Narrative that does not act in a way that breaks the player's suspension of disbelief. There are a number of factors that make a character believable including appearance, animation, personality, emotion, desires, and intentions (Loyall 1997). In emergent narrative systems, believability is achieved through autonomous, virtual humans (Swartout et al. 2006). In drama management systems, believability is a combination of drama manager directions to NPCs and autonomously selected character behaviors. How to create believable characters in Interactive Narratives is still an open question. However, some have started looking to improvisational theatre as a model for how believable characters can make real time autonomous decisions (Magerko et al. 2009).

Player Modeling

Up to now, we have made the assumption that the drama manager is a surrogate for the human author by representing his or her authorial intentions in the face of player autonomy. A drama manager may also act as a surrogate for the player, by modeling and predicting player preferences for different story experiences. While player modeling is becoming more common in Game AI (Smith et al. 2011; Yannakakis 2012), it is not yet well understood how to model player preferences over interactive story experiences. Thue et al. (2007; 2011) and Yu and Riedl (2012) have taken early steps to learn the user's play style and select pre-scripted story branches based on the model.

Interactive Narrative for Serious Games

Computer games are most commonly associated with entertainment. A small but growing faction of researchers are considering the applications of computer game technology to "serious" application such as education, training, advertising, and argumentation. Interactive Narrative also has its serious applications. In the last few years, Interactive Narrative has been applied to science, technology, engineering, and mathematics (STEM) education (Rowe et al. 2011) and military training (Magerko et al. 2005; Riedl et al. 2008; Hodhod, Cairns, and Kudenko 2011; Zook et al. 2012). Interactive Narrative for education and training acts to guide a player through a series of pedagogical objectives, similar to the operations of an Intelligent Tutoring System (VanLehn 2006) that can dynamically change the problem the learning is working on to facilitate the educational experience.

Conclusions

Interactive Narrative is a novel expression of many of the goals of Game AI—the autonomous management of player experience through NPCs. Bringing Interactive Narrative to the point where it can be deployed as a form of digital entertainment as pervasively as other types of modern computer games requires many open research problems to be solved. By solving these open research problems, Game AI researchers are tackling fundamental problems of human-level AI as well as forging new paths toward the use of artificial intelligence to entertain, educate, and train humans. The future of Interactive Narrative will see Game AI systems that are capable of computationally expressing creativity beyond the original parameters of the human author, capable of computationally reasoning about aesthetics, and learning to act in the best interests of the player to dynamically create optimally engaging experiences.

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