Driving Interactive Drama Research through Building Complete systems

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Abstract
Interactive drama presents one of the most challenging applications of autonomous characters, requiring characters to simultaneously engage in moment-by-moment personality-rich physical behavior, exhibit conversational competencies, and participate in a dynamically developing story arc. One way to advance the field and continue to make exciting progress is to develop building blocks needed for creating these interactive experiences that are situated in a complete system. Our research goals presented in this paper are driven by this perspective of developing a complete interactive drama architecture. Specifically, we discuss the different research challenges that we are interested in pursuing at the different building blocks required to build a complete interactive drama. We also discuss the interactive drama domain we are developing and present our initial steps in handling the research challenges.

Introduction
In recent years, there has been a growing interest in creating story-based interactive systems where the player experiences a story from a first person perspective, interacts with autonomous, believable characters and, through her interaction, influences both the characters and the overall development of the story. These systems termed Interactive drama branches off into two major research themes, one centered around research issues in autonomous, believable characters, with rich models of personalities and emotions and second drama management components that incorporate the player actions into the ongoing narrative and provide a coherent, well-formed story structure to the whole interaction. Successful future research in believable agents requires deploying such agents in completed dramas, evaluating the effectiveness of the agents in creating a compelling player experience, and using the results of the evaluation to guide future research. Our approach to carrying out research in Interactive Drama (ID) and believable agents presented in this paper is inspired by this perspective and guides our initial steps in this direction.

Research in autonomous believable agents situated in ID systems have impact in other areas as well. Autonomous characters with conversational capabilities also termed Embodied Conversational Agents (ECA) have been employed in various applications including training people (Johnson & Rickel 2000), as real estate agents (Cassell et al. 1999), and as educating kids about historical characters (Corradini et al. 2005). One way to advance the field of believable agents and Interactive Drama is to develop and study complete agents in complex domains with the ultimate goal of drawing general lessons from the specific implementations. Furthermore successful research involving fully implemented solutions, algorithms and solutions can inspire new theory and vice versa. In this paper, we present our initial steps towards this objective through development of a complete ID experience. The inspiration behind our approach is the belief that it is important to develop and evaluate the technical approaches for believable characters in the context of a real interactive drama, not a toy domain.

One of our goals through this paper is to present the research challenges and our initial ideas on the different approaches we are pursuing for developing the different building blocks for creating a complete interactive drama experience. It is not intended to be a comprehensive list of research challenges that needs to be solved for creating a complete ID experience. Our ambition for the paper is to seek suggestions from colleagues who have been involved in similar research efforts and get suggestions on the approaches we want to undertake in different research areas.

To set the scene, we first present the significance of developing approaches in complete interactive systems followed by a discussion of different research challenges that we are pursuing. Next, we present the story domain in which we situate our research objectives and discuss our initial steps towards developing the different building blocks. We finally conclude with some future steps we plan to pursue.

Developing complete ID systems
The vision of carrying out research activities at the building blocks by developing complete systems has been emphasized by prominent AI researchers (Koller 2001; Stone 2007) as well. Peter Stone in his lecture on Computers and Thought Award at IJCAI-07 underscored the benefit of carrying out research activities at the individual bricks (individual components) and applications that require the practical unification of these various bricks within a complete
cathedral (complete agents). Koller in her 2001 computers
and Thought lecture presented a similar vision where she
emphasized the notion that in AI, as in many communities,
we have the tendency to divide a problem into well-defined
pieces, and make progress on each one. But as progress
is made, the problems tend to move away from each other
(Koller 2001). One way of approaching and combating this
issue of fragmented solutions is to create fully functional
agents in complex domains and build applications that re-
quire practical unification of the various individual topics
into a complete agent.

In Interactive drama and believable agents research, this
vision has been realized in Facade (Mateas & Stern 2003).
Our objective towards this vision is to understand and facil-
tate development of adaptive autonomous characters in the
context of advanced interactive systems. While there has
been a considerable amount of research in research issues in
individual pieces required to develop a complete interactive
drama experience, with the exception of Facade, there has
been little effort in incorporating all of them together into a
full fledged system. One of the hazards in not doing so is
that research in the individual problems might be deviating
too much from the real need in a real system. While devel-
oping a commercial-quality interactive drama is not one of
our research objectives, our goal is to have a realistic do-
main that provides a setup for us to develop viable represen-
tations and techniques and a platform for realistic evaluation
to guide future research.

Research Challenges

Some of the research challenges that we plan to undertake
through the development of a fully fledged 3D real-time in-
teractive story development are listed below:

- **Behavior Authoring support through behavior learn-
ing and runtime behavior modification** Hand crafted
behaviors are, ultimately, software code in a complex pro-
gramming language, prone to human errors. The behavior
events could be in the form of program bugs or not achiev-
ing the desired result. Another issue is that hand authoring
of behavior for believable character though allows design-
ers to craft expressive behavior for characters, but never-
thless leads to excessive authorial burden (Magerko & Laird 2003). Tools are needed to support story authors,
who are typically not artificial intelligence experts, to al-
low them to author behaviors in an easy way.

The initial behavior set for the game characters defined at
design time results in characters that are brittle to chang-
ing world dynamics as it is difficult to imagine all the
possible situation that the character would encounter in
the game. Moreover, the repetitive and predictable nature
of character behaviors can hamper the player experience.
The key problem then, is to develop a self adapting sys-
tem for these characters that is autonomously responsive
to new and unforeseen circumstances keeping the author-
specified personalities in mind.

- **Natural Language Generation**: Interactive domains in-
habited with believable characters provide rich opportu-
nities for Natural Language Generation (NLG). The style
of output text produced by the agents should be modified
based on the personality and the emotional state of the
character without adding a lot of authorial burden on the
author. The system should also be able to provide enough
generative abilities so as to undercut the cost of develop-
ing it.

- **Drama Management and Player Modeling**: There is
a growing interest in developing Drama Manager (DM)
components for story based games that gently guide the
player towards a story ending that exhibits a narrative
arc. The application of DM approaches in real large scale
games raises several research issues such as scalability,
long term story planning and player modeling issues. Fur-
ther Drama Management approaches require a “model”
that predicts the interestingness of story arcs, so that the
drama manager can plan which story arcs to pursue and
provide a better player experience.

To ground our discussion, next, we present the story do-
main in which we are pursuing our different research goals.

**Story Domain : Mystery Mansion**

The interactive drama we are developing is named Mystery
Mansion (MM). The story set up consists of six characters
and is set up in a British mansion at the beginning of the
20th century. The player controls one of the character and is
free to interact with the rest of the characters using natural
language and also move freely around the house and manip-
ulate some objects. In particular, the drama starts when two
of the characters decide to celebrate an engagement party,
and invite two friends to a dinner in their newly acquired
mansion. The remaining two characters are the butler of
the house and the father of the bride. Most of the charac-
ters have strong feelings (love or hate) for some of the other
characters, and as the story unfolds the player will discover
hidden relations between them. The player will take the role
of one out of three possible characters and will be able to act
freely in the mansion, with his actions strongly influencing
the development of the game.

The story consists of four big scenes: the cocktail party,
where all the characters arrive to the mansion and meet;
the dinner, where some initial discussions appear; the night,
where the characters go to sleep in the mansion and one (or
several) murders will happen; and finally the investigation,
where the survivors will try to investigate the murder. De-
pending on the player actions, each scene might happen in
several different ways; specially the third scene, where there
are about 10 possible different murders that can happen de-
pending on what the player does. The player himself might
get killed, or a combination of murders can happen. The in-
vestigation is an open ended scenario where the murderer may
or may not be discovered (the player himself might be im-
plicated in the murderer and he will have to cover himself).
Such a game will provide a perfect opportunity to combine
all the previously mentioned research goals into a real ap-
plication. In the remaining sections we provide a brief de-
scription of our initial steps towards the individual research
challenges we plan to pursue through the development of
Mystery Mansion.
**Behavior Authoring support**

Behavior authoring is the major bottleneck in interactive drama development. The standard approach for authoring autonomous characters is to hand-author behaviors or scripts that describe the character’s reaction in all possible circumstances within the game world. This approach of authoring characters presents several difficulties such as difficulty in planning for all possible scenarios a character might encounter and repetitive behavior harming the believability of the characters. One of the key issues, then, is the ability to construct or adapt behavior sets.

In this section we propose two complementary approaches to deal with such problem, namely: behavior learning from demonstrations and behavior modification.

**Behavior Learning from Demonstrations**

Story authors are typically non AI expert, and thus defining behaviors using a programming language is not an easy task for them. They have a clear idea in mind of the behavior they want particular characters in the game to exhibit, but the barrier is encoding those ideas into actual code. An approach to address that issue is programming by demonstration, where authors actually demonstrate the behavior a character must exhibit (by controlling that character manually) and the system learns from that demonstration.

In a previous approach, we have successfully developed a system capable of learning behaviors from demonstration in a real-time strategy (RTS) domain (Ontaño et al. 2007), specifically in the game of Wargus (an open source implementation of the classic Warcraft 2). We use a case-based approach, where each individual behavior that is learnt is stored as a **case**. In our approach, an expert plays a game of Wargus showing a particular strategy that he wants to teach to the system. The result of that game is an execution trace that the expert can annotate by pointing out which were the goals he was pursuing with the actions he was doing. The system can then analyze such annotated trace and infer behaviors to achieve the goals the expert has annotated. For each behavior that the expert has demonstrated, the system stores the particular game state in which it was executed. The combination of a goal, a behavior and a game state defines a **case**. Thus, the system can learn several different behaviors to achieve the same goal, and store in which situation each different behavior is better.

On execution time, when the system needs to achieve a particular goal (e.g. “destroy an enemy tower” in the Wargus domain), it will look for behaviors in its learned behavior library to destroy towers, and will select the one that is most appropriate by comparing the current game state with the game states stored with each behavior, i.e. the case retrieves the most appropriate case.

The described approach has been successfully validated in the context of real-time strategy games. Thus, the next research challenge is to apply it to interactive drama, where the behaviors involve verbal and gesture actions, in addition to the motion and physical actions already considered in the framework of RTS games.

**Behavior Modification**

Another approach to deal with the authoring consisting of modify behaviors on an ongoing basis through an analysis of the interactions of the characters with the player and with each other, relative to the primary rhetorical objectives of the game and the individual goals of the embedded characters, thereby relieving the author of writing behaviors for all possible circumstances.

In our previous approach, we have dealt with some of the research issues listed above (Zhang et al. 2007). To address these issues, we have developed an approach in which agents keep track of the status of their executing behaviors, infer from their execution trace what might be wrong, and perform appropriate revisions to their behaviors. We want to push our behavior adaptation approach further through the development of Mystery Mansion domain. We are developing an architecture called Automatic Behavior Adaptation architecture (ABA) to deal with the issue of dynamic behavior modification. The architecture has three main components, the character execution component A behavior Language (ABL) (Mateas & Stern 2002), the introspection component, and the behavior modification component.

The behavior execution component, based on the ABL behavior language, manages the behavior of the non player characters in the game. To do so, the game state is read through a series of sensors that update the working memory. The ABL runtime component selects which behaviors (from the behavior library) will be executed to pursue the current character goals as a function of the content of working memory, and tracks current goals and behaviors to determine if any should spontaneously succeed or fail because of changes in the world. ABL keeps track of the current active subgoals and behaviors in the Active Behavior Tree. The introspection component is one of the key modules in the architecture. Its goal is to monitor that the character behavior is satisfying the declarative behavioral constraints for each character, and to perform blame assignment if they are not. The behavior modification component job is to receive modification requests, and modify ABL behaviors to fix constraint violations detected by the introspection module. Once a behavior has been modified, it will be pushed back into the behavior execution component (the behavior library of an executing ABL agent).

**Drama Management**

Drama Management approaches have been shown to improve player satisfaction in the context of interactive games (Sharma et al. 2007b; 2007a). However, there are several challenges that have to be solved in order to incorporate drama management into complex games such as MM. Typically, drama managers use search based techniques to decide which are the best actions to select at any moment. However, in a big complex game, the amount of possible actions available is so large, that search based techniques cannot be directly applied. Moreover, previous drama management approaches do not take into account the timing problem, i.e. in addition to decide which actions the drama manager should take, also decide when to take them. An exception to that, is the work done in Façade (Mateas & Stern 2003), where they use beats to model timing. In a real-time game such as Façade or MM the timing problem is crucial, and should be taken into account. The research topics related to drama...
management that MM will allow us to develop are related to
a) Player preference and action modeling i.e modeling which
story arcs, drama manager interventions or other game ele-
ments a particular player might enjoy and further modeling
which actions each particular players are likely to execute
in any given situation, b) DM action selection and timing,
i.e. optimizing the search process and learn the best action
instead of searching for it and deciding the proper timing
for DM actions is as important as which actions to select to
achieve a good game dynamics and c) Proper story represen-
tation for a complex domain like MM.

In our previous approach (Sharma et al. 2007b) towards
drama management we have tackled the issues of player
preference modeling, story representation and DM action
selection. We want to move forward and start tackling the
research challenges mentioned above for MM.

Natural Language Generation

In general, there is a lack of reusability in NLG tools. In
our previous work (Strong et al. 2007), we decided to start
from scratch and build a system that is reusable across game
domains. Our initial system uses a set of author defined
templates that can be reused across different characters and
emotional states. We defined these templates as a set of sen-
tence structures that require words and phrases from a lex-
icon to complete the sentence. The words and phrases that
are used are dependent upon the parameters given by the out-
put from the emotion and game event tracking. We chose to
use templates for several different reasons. There is a con-
vincing argument by van Deemter et al. (van Deemter, Krah-
mery, & Theunez 2003) that there is no need to distinguish
between “template-based” natural language generation and
“real” natural language generation. At this point, both tech-
ologies have their advantages, and vary as widely within
their own class as between classes.

Our previous approach to deal with NLG issues (Strong et 
al. 2007) provides us a starting point in situating our work
in an interactive domain. However, as the domain is not
fully conversation centered, the opportunities to deal with is-
ues of a real time conversation-centered domain are limited.
Moving forward our work, we are extending the approach in
Mystery Mansion. As described above, the story of Mys-
tery Mansion is primarily divided into four scenes. We have
currently developed hierarchical templates for verbal output
generation for the first two scenes. The two scenes consist of
approximately 6000 (approx 400 lines) words of dialog. The
goal for creating hierarchical templates is to reuse different
templates across the different scenes and characters.

Conclusion

We share the perspective of various AI researchers (Koller
2001; Stone 2007) and prominent interactive drama re-
searchers (Mateas & Stern 2003) emphasizing the benefit
of developing applications that require the practical unifi-
cation of these various sub-components within a complete
system. In this paper, we have presented our initial ideas on
the research activities that we plan to undertake at the vari-
ous building blocks situated within a complete interactive
drama experience. As a future step, we are pursuing work in
each of the individual components forward.

Acknowledgement

The authors would like to thank Michael Mateas, author of
the ABL language and collaborator on the behavior modifi-
cation project, Peng Zang for behavior modification, Manu
Sharma for drama management work, and Christina Strong
for the NLG system.

References

Cassell, J.; Bickmore, T.; Billinghurst, M.; Campbell, L.;
Chang, K.; Vilhjalmsson, H.; and Yan, H. 1999. Embody-
ment in conversational interfaces: Rea. In Proceedings
of the SIGCHI conference on Human factors in computing
systems, 520–527.

Corradini, A.; Mehta, M.; Bernsen, N. O.; and Charfuelan,
M. 2005. Animating an interactive conversational char-
acter for an educational game system. In Proceedings
of Conference on Intelligent User Interfaces.

pedagogical agents: Face-to-face interaction in interactive
learning environments. International Journal of Artificial
Intelligence in Education.

IJCAI Computers and Thought Award talk.

drama architecture. In In Proceedings of TIDSE,
226–237.

for story-based believable agents. IEEE intelligent
systems and their applications 17(4):39–47.

in building a fully-realized interactive drama. In In Game
Developer’s Conference: Game Design Track.

Case-based planning and execution for real-time strategy
games. In Proc. of International Conference Case Based
Reasoning.

Player modeling evaluation for interactive fiction. In AIIDE
2007 Workshop on Optimizing Player Satisfaction.

Sharma, M.; Onaño, S.; Strong, C.; Mehta, M.; and Ram,
A. 2007b. Towards player preference modeling for drama
management in interactive stories. In FLAIRS 2007. AAAI.

Stone, P. 2007. Learning and multiagent reasoning for au-
tonomous agents. In IJCAI Computers and Thought Award.

Strong, C.; Mehta, M.; Mishra, K.; Jones, A.; and Ram,
A. 2007. Emotionally driven natural language generation
for personality rich characters in interactive games. In To

Real vs. template-based natural language generation:
a false opposition? Ass. for Computational Linguistics.

Zhang, P.; Mehta, M.; Mateas, M.; and Ram, A. 2007.
Towards runtime behavior adaptation for embodied char-
acters. In Proceedings of IJCAI.