A User-Centric Adaptive Story Architecture – Borrowing from Acting Theories

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ABSTRACT
Interactive virtual environments are becoming increasingly popular for their utility in education, virtual training, and entertainment. These applications often rely on a scenario that is revealed to the user as he/she interacts with synthetic objects and characters that inhabit virtual worlds. Current interactive narrative architectures used in the interactive entertainment industry often use decision trees, which are hard to author and modify. Some interactive entertainment productions are starting to use more generative techniques, such as plan-based or goal-based narrative. In this paper, I present an interactive narrative architecture that extends current research in interactive narrative by integrating a user modeling and user behavior analysis technique, which I argue facilities a more engaging and fulfilling experience. I have implemented the architecture within an interactive story called *Mirage*. The architecture resulted from an iterative design and development process involving a team that included film and theatre professionals. During this design and development process, I have experimented and evaluated different narrative techniques, which resulted in the proposed architecture.

Categories and Subject Descriptors
I.6. Simulation and modeling. J.5. Arts and Humanities, I.2. Artificial Intelligence,

General Terms
Design, Human Factors.

Keywords
Interactive Narrative, Virtual Story telling, Interactive Drama, Interactive Entertainment.

1. INTRODUCTION
Interactive virtual environments are important for their utility in virtual training, education, and entertainment. In this paper, I focus on elaborate interactive 3D virtual environments populated with embodied synthetic characters. Such environments are useful for many applications, including military training, social training, video games, and educational games.

While film and theatre designers have perfected the art of creating engaging visual experiences, interactive entertainment has yet to reach such success. Creating an engaging and dynamic interactive narrative is a very difficult task due to (1) the unpredictability of the environment, and (2) the need to satisfy story-based constraints, which include maintaining story coherence, maintaining a dramatic structure, while keeping the users curious, emotionally involved, and challenged. Current techniques within the game industry rely on decision trees, which, due to their exponential growth, are hard to author and modify. In addition, predicting users' behaviors is difficult. Thus, a decision tree-based interactive narrative design leads to very limiting and unfulfilling experiences, because they do not stimulate learning or thinking beyond the scripted paths. This drawback has hindered many interactive narrative applications, especially within the game industry. This is apparent by the gradual disappearance of adventure games, and the increase in the number of gamers who use cheats and walkthroughs.

There are several techniques developed by the game industry to stimulate anticipation, and emotional engagement, including atmospheric lighting and adaptive audio. These methods, however, are mostly scripted and triggered on certain events within the narrative. I argue that an interactive narrative architecture should include methods and constructs that allow dynamic manipulation of the story while ensuring dramatic structure, and keeping the users enticed, emotionally involved and challenged.

Some researchers focused on developing generative architectures for adaptive narrative. Mateas and Stern proposed a HAP-based architecture for interactive narrative [14, 15]. Young proposed a plan-based interactive narrative architecture, where plans are revised depending on users' actions [25]. Peter Weyhrauch proposed an interactive drama manager that uses game theory to select a story event given the current story state [24].

In this paper, I am proposing an interactive narrative architecture that extends current goal-based techniques by integrating a user modeling approach. In this paper, I propose to extend current research in goal-based interactive narrative by integrating user modeling and user behavior analysis as constructs that facilitate (a) better adaptation of the story using a character-based model of interaction, which, according to the evaluators, have promoted a novel method for game play within the realm of interactive stories, and (b) more adaptive characters who can dynamically improvise and select goals and arguments for their characters that better fit the user's intentions and goals.

I have implemented the architecture in an interactive story called *Mirage*. The architecture was a result of several iterations and experimentations of fusing current techniques for interactive narrative with acting and filmmaking principles.

In this paper, I will discuss this architecture. I will also discuss narrative representation and goal-based narrative design, since these constructs are important in understanding the architecture.

2. PREVIOUS RESEARCH

The need for a more suitable and adaptable method for interactive narrative architectures provides an incentive for many researchers to explore the utility of applying AI-based problem solving techniques to interactive narrative. In this section, I will describe a few attempts.

Some researchers developed character-centric interactive narrative architectures where the narrative emerges as a product of user's interaction with an environment populated with synthetic agents. Examples of these architectures include The Sims, Creatures, Catz, Dogz, and Woggles [13]. Researchers focusing on the character-centric approach usually focus on character development [2-4, 13, 19]. Since the narrative is not represented within the architecture, the utility of such architectures for authored interactive narrative[1] is unclear.

Mateas and Stern [14, 15] proposed a plot centric interactive narrative architecture, where story events are selected dynamically based on the history of events fired, character relationships, and authorial goals [14, 15]. They used a HAP-based (reactive planning) architecture, where a story engine selects a story event and character goals which are then distributed among agents who adopt behaviors and collaborate to solve the unified goals.

Young proposed an interactive narrative architecture that uses planning [25]. Young's approach relies on re-planning to accommodate user's behaviors. For example, if the user attempts to shoot an important character, then the system, recognizing that the character is important, will adopt a 'gun out of bullets' routine to prevent the user from killing the important character. This technique is problematic and may lead to user frustration, because it deliberately obstructs the user from his/her goal in order to keep him/her on the story track. In addition, many performance issues may arise due to the use of planning.

3. NARRATIVE STRUCTURE AND REPRESENTATION

Before I delve into the proposed interactive narrative architecture and its components, it is important to clearly describe the narrative structure and its representation. The interactive narrative architecture described here uses a representation that is adapted from acting and screenwriting theories [5, 17].

[1] Authored interactive narrative describes narratives where an author, a director, or a designer has a set of goals that he/she wants the trainee, player, or participant to achieve or reach.

3.1 Narrative Structure and Composition

An author composing a narrative first starts with a narrative objective, which is referred to as the controlling idea [17] or the argument of the play [1]. Once the narrative objective is set, writers compose a plot. A plot is a course of action required to achieve a narrative objective [5].

3.1.1 Plot Structure

Writers compose a plot using several structural constructs: scenes, beats, and character behaviors. The process of constructing a plot is similar to the process of constructing a plan, which I will refer to as the narrative plan, to achieve a narrative objective. A narrative plan is composed of scenes, scenes are composed of beats, and beats are composed of character behaviors. A scene is a narrative component that has a scenic goal. When a scenic goal is achieved the narrative advances towards achieving the narrative objective [5]. The term beat was first introduced by Stanislavski [21, 22] to define the smallest unit of action at the scene level that has its own complete shape. Like scenes, beats are composed of beat goals. When a beat goal is achieved the narrative advances towards achieving a scenic goal. Character behaviors[2] are methods that characters use to achieve their goals. When a character goal is achieved, similar to beat goals, it helps advance the narrative towards achieving beat goals. Hence, individual behaviors make up beats, beats make up scenes, and scenes form the overall plot that solves the narrative objective [5].

3.1.2 Narrative Constructs

The concepts discussed in the previous section are very important for understanding narrative structure. However, adhering to this structure does not necessarily provide an engaging or dramatic narrative. Continually increasing tension through a scene is important for drama and engagement. For virtual training environments or games, dynamic manipulation of the scenario to increase/decrease the challenge is important to stimulate engagement. Similarly, for interactive virtual environments, used in education, dynamically manipulating the scenario to adjust the difficulty of the projected lesson/task is important.

Therefore, using planning alone is not appropriate for entertainment, education, or training. Representation of character relationships, dramatic tension, character goals and objective and a model of user's goals and behaviors are very important. To manipulate the narrative to stimulate engagement, I am abstracting several narrative constructs. I define these narrative constructs as follows:

- Relationship values: relationships between characters.
- Difficulty level in a game or a lesson, or dramatic tension/conflict in a drama.
- Character objectives and immediate goals
- The object/character the user is attending to.
- Estimates user stereotype and confidence measure of the estimate

These narrative constructs can then be used as affordances for selecting or changing character, lighting, and camera behaviors.

[2] Theatre actors use the term tactics to denote character behaviors.

For example, a camera agent may position the camera differently depending on the relationships between the characters in the shot.

3.2 Narrative Representation

3.2.1 *Narrative Objective*

The narrative objective is represented as a goal, such as (show ?narrative-goal[3]).

3.2.2 *Scenes*

Scenes are represented using the following structure:

Scene Objective: (scene-goal ?sg), where ?sg is a list of states connected by ands or ors. When the statement ?sg is true the objective becomes true. For example:

(scene-goal (Told Electra Archemedis (story-of Electra))
where the scene's goal is to make Electra tell her story to Archemedis.

Scene Preconditions: list of conditions concerning the story state, user model, and user actions. If true they qualify the scene for being fired given that the story engine is looking for a scene that achieves the scenic goal listed by the scene.

Scene Posteffects: list of states that become true upon success.

Scene Effects: list of states that become true upon firing.

Scene subgoals: (sgoal ?z)

Where sgoal is
(sequence sgoal) | (parallel sgoal) | (beat-goal ?y)

3.2.3 *Beats*

Beats are represented using the following structure:

Beat Goal: (beat-goal ?bg), similar to scene goals

Beat Preconditions: list of conditions concerning the story state, user model, and user actions. If true they qualify the beat for being fired given that the story engine is looking for a beat that achieves the beat goal listed above.

Beat Posteffects: list of states that become true upon success

Beat Effects: list of states that become true upon firing

Beat subgoals: (agoal ?y)

where agoal is
(sequence agoal) | (parallel agoal) | (character-goal ?y) | (camera-goal ?c) | (lighting-goal ?x)

3.2.4 *Character behaviors*

Very similar to HAP [13], I are representing character behaviors as follows:

Behavior goal: (goal ?cg), similar to scene goals

Behavior Preconditions: list of conditions concerning the story state, user model, and user actions. If true they qualify the beat for being fired given that the story engine is looking for a beat that achieves the objective listed above.

Behavior Posteffects: list of states that become true upon success

Behavior Effects: list of states that become true upon firing

Behavior subgoals: (bgoal ?y)

where bgoal is
(sequence bgoal) | (parallel bgoal) | (action ?y) | (say ?c)

where *action* and *say* are terminal actions.

3.2.5 User behavior analysis and dynamic character improvisation

Justine Cassell has argued for the use of feedback and user modeling for conversational agents [6, 7]. Likewise, I argue for the use of such techniques for believable characters. By studying acting and observing actors improvise their roles, I concluded that current interactive narrative techniques do not advocate dynamic user monitoring or adapt behaviors according to dynamic user feedback. In contrast, actors continuously monitor each other within a scene looking for clues to evaluate their behaviors. They improvise by adjusting their behaviors to other actors' goals and behaviors.

Therefore, I advocate the use of: (1) a mechanism for using a user model to choose behaviors and (2) a mechanism for dynamic evaluation of success and/or failure of the behavior using an analysis of user's behavior. To evaluate failure or success of their behaviors, agents/characters will continuously monitor user's state and actions for signals. Thus, the interactive narrative representation is extended to include:

Failure condition:
e.g. (and (talking (character ?z))
(not (attending user (character ?z))))
Failure Tolerance: e.g. 90%

The failure condition example defined above identify when a character is talking, she/he will monitor the user to ensure his attention is directed towards him /her. The tolerance for violating this condition is high.

3.2.5 *Narrative Constructs*

The narrative constructs described above are represented as follows:

- Relationship values: is represented as love, hate, like, neutral with a number indicating intensity of the relationship, e.g. (love (character ?x) (character ?y) ?intensity)
- Difficulty level in a game or a lesson, Dramatic tension/conflict in a drama. This is represented as follows: (Tension ?intensity), where ?intensity is a number 0-100.
- User's attention: the object/character that user is attending to, represented as (Attending-to (user ?user) (object ?x)). This can be calculated using several methods depending on the devices used. In the prototype shown in the results section, I used mouse movement and clicks.
- Estimated user stereotype. This can be represented using different methods. I decided to use a character development model. Thus, the system forms a model of user's personality that fits a stereotype model described in 5-dimentional space,

[3] I am using the notation ?variable-name to denote variables, as used in [11].

describing five stereotypes: heroism, violence, self-interestedness, truth seeker, and cowardice.

3.3 Interactive Narrative Architecture

Following the narrative structure and representation described above, figure 1 shows the interactive narrative architecture. It includes a story engine for selecting scenic goals, beat goals, and character goals to achieve the overall narrative objective. In addition, the story engine includes rules for determining camera, lighting, and character goals to be accomplished given the beat. In this paper, I will not discuss these elements in detail, for more information on the camera and lighting systems, readers are referred to [9]. The story engine uses a user model which is continuously adapted given users' actions, characters' actions, and the story state. The director agent passes character-goals, camera-goals, and lighting-goals from the story engine to their perspective agents. It also ensures synchronization between camera, lighting, and character behaviors. Again, these issues will not be discussed in this paper for more information readers are referred to [9].

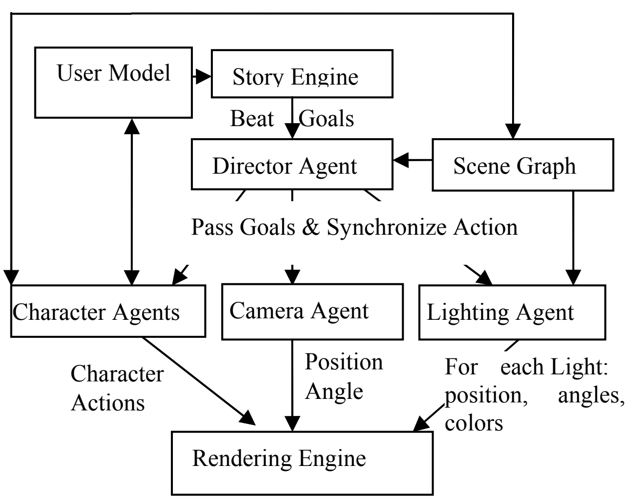

Figure 1. Interactive Narrative Architecture

Given the character goals, camera goals, and lighting goals, character, camera, and lighting agents select behaviors to achieve these goals. The camera and lighting agents use a scene graph, which represents the physical configuration of the scene to select positions, orientations, and, in case of lighting colors, that achieve the lighting and camera goals, maintain focus on the action, accommodate users' goals and actions, portray dramatic intensity, and show character relationship. Character agents construct behaviors to solve the character goals given by the director agent. They also continuously monitor the user evaluating their behaviors. The rendering engine renders the scene given the characters' actions, camera position and orientation, and lights' positions, angles, and colors. In the next sections, I will focus on the story engine, user model, and character agents. Lighting and camera agents are described in [9].

3.4 User Modeling

Games and other interactive media often use puzzle solving, navigation of space, or simple quests as an interactive model. Alternatively, I seek to explore an interactive method based on story and drama. I have spent a year experimenting with different techniques. I finally arrived at the conclusion of using interaction as a method for influencing user's character development within the story, which is the basic design principle of screenwriting [17]. To establish this model of interaction, I used a simple user modeling technique based on stereotypes.

User modeling was extensively explored in several areas of research, including web-based searches, Intelligent Tutoring Systems, and conversational agents [8, 16]. Many user models have been developed, including models fitting users into stereotypes [20, 23], inferring users' knowledge [8, 16], inferring users' cognitive model (e.g. learning styles and personality), estimating users' goal and plans [12], and modeling and inferring users' mood and emotions [18]. The models used to infer these characteristics differ depending on the concepts modeled; for example a simple questionnaire can suffice for collecting information on users' knowledge, but such techniques may not suffice for inferring users' cognitive model.

For interactive storytelling, a character-based approach to user modeling provides a better relationship between character development and plot development. Thus, I modeled user's personality according to the following vector of stereotypes:

<hero, violent, self-interested, coward, and truth-seeker>

Given a user action, the history of user actions, and the story state, a rule-based system is used to manipulate the user model to reflect the user's choice. The system uses very simple common sense rules, such as 'if user advances to attack unarmed characters then advance user on the violence scale'. The architecture includes a language that authors can use to write rules for more complicated inference involving behavioral patterns and character relationships.

The system calculates a confidence measure of the user model as a function of (i) the time it took the user to make a choice and (ii) the conformance to the estimated pattern given the predicted user personality, which was simply calculated as the max of the vector above.

This model was a very simple model. I wanted to first explore the utility of simple user modeling techniques in designing an engaging interactive narrative experience based on character development, as discussed by acting and screenwriting theories.

There are many improvements that I would like to explore in the future, including the use of plan recognition, stereotyped action patterns, using machine learning techniques to infer user's personality given action patterns and stereotypes.

3.5 Story Engine

The story engine keeps track of its current state including history of selected story beats, and character relationships. Given a number of authored story beats, the user model, and the story state, the story engine selects a story scene and then a beat for execution using a reactive planning algorithm [10].

As described by the representation, a beat is a collection of sequence and/or parallel beat subgoals or character, camera, or lighting goals. To get a sequence of simple goals (such as character-goals, lighting-goals, and camera-goals), the story engine includes an algorithm that iteratively loops selecting beats and breaks them into simpler beats, constructing a tree of beat-goals and simple-goals. Once a path is found with only simple goals, the story engine passes these simple goals to the director agent, who then relays them to appropriate agents. This deconstruction of goals to simpler goals is similar to the method described in [10, 11, 13].

Abstracting some elements that define the dramatic focus and dramatic intensity of the narrative is important for visual design. Thus, the story engine allows authors to write rules to identify shifts in dramatic tension through beat changes. These rules allow the story engine to identify the dramatic intensity of a specific moment, which is represented, as discussed above, as a number (0-100); an example is as follows:

if beat#2 is followed by beat #5
and Electra is using the threatening tactic on the user
then increase dramatic intensity by 10 increments.

These rules are extremely important, because they serve as catalysts for adapting the visual presentation to enhance and support the narrative.

3.6 Agent Architecture

Once a character-goal is given to the character agent, the agent uses a similar technique to beat deconstruction to deconstruct the character-goals into simple actions [13]. The agent breaks down the character goal into actions.

Actions are represented by an action, an adverb, and an actor; for example (Walk Electra slowly) is a behavior where the action is walk, the actor is Electra, and the manner in which an action is performed is slowly. Therefore, an action can be animated in different manners defined by the adverb. For example, 'take the sword' is an action that is defined as three animations 'take sword eagerly', 'take sword hesitantly', and 'take sword regretfully'.

One major difference between this architecture and the previous work, in addition to the use of user modeling, is in the agent's ability to dynamically adapt to the user's behaviors. Agents continuously monitor mouse movements, mouse clicks for clues to infer the direction of user's attention and user's goals and intentions. Given these inferred values, the agent will continuously adjust its success or failure rates until failure reaches the tolerance limit. If that occurs, the character will (1) declare the behavior a failure, (2) update the user model, and (3) choose another behavior to solve the character-goal. The algorithm can be summarized as follows:

1. Choose behavior plan given
   user stereotype,
   character goal,
   failed behaviors
2. each time tick
   2.1. monitor user action assessing current behavior
      2.1.1 if failure limit reached,
         2.1.1.1 fail behavior
         2.1.1.2 go to step 2.
      2.1.2. Update user model

4. RESULTS

The system was implemented within an interactive story called *Mirage*. Below I will discuss several scenes from *Mirage* showing the adaptability of agent's behaviors to user's goals. The architecture was a product of iterative design, where I focused on designing an engaging interactive model for interactive stories based on theatric and cinematic acting and screenwriting theories.

I experimented with several interactive narrative architectures, including HAP-based architecture [13], goal-based interactive narrative as addressed by Mataes and Stern [14, 15], and finally an integrated hybrid model of goal-based interactive narrative, user modeling, and user behavior analysis as feedback. The later model gave us a better design for the interactive story and achieved an overall better engagement value for the interactivity model, as discussed and critiqued by our collaborators.

As described above the plot varies in response to estimated user stereotype-based personality. To fully appreciate the interactive narrative system, readers need to interact with the system. Even a video of the system, will not suffice to show the dynamic nature of the interaction and improvisational ability of the characters. In order to show the variations in the plot, I will use screenshots and dialogue.

Figures 2 through 4 show several screenshots from *Mirage*. The figures show two characters: Electra and Archemedis. Archemedis is under the control of the user. Electra is an agent; she selects behaviors to achieve the character goals given to her by the director agent. The camera and lighting agents also play a role in choosing positions and orientations to show and support the narrative. In this scene, Electra is trying to convince the user to help her kill the king and queen. The figures 2 and 3 show two variations on the scene depending on user's model. In figure 2, the user model accumulated through user interaction indicated that the user is the violent type. As shown in the figure, the camera takes on a high-camera angle and Electra is perplexed by the user's behavior, but she is content that he is satisfying her goal by agreeing to kill the king and queen. On the other hand, figure 3 shows a different beat, where Electra, realizing that the user is the coward type as inferred by the history of his actions, reverts to violence to achieve her goal.

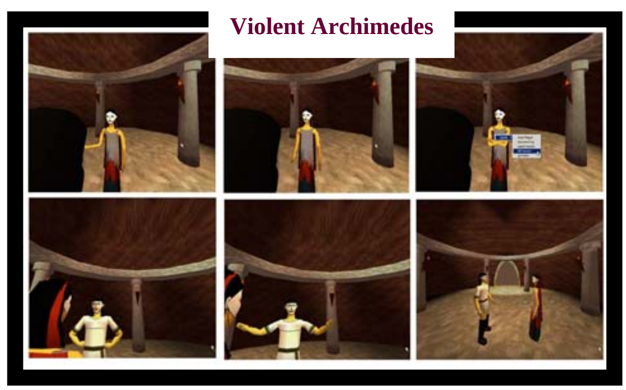

Figure 2. Showing outcome when user as violet type

Dialogue in figure 2:

ELECTRA

Archemedis, listen. I know this isn't what you thought you were coming here to do. But if you *did* come to find out who you really are, maybe this is your chance. It's the sort of thing that makes heroes. Are you going to run away from this, or face it? Decide quickly, they'll be here any minute.

<user made a choice here>

ARCHEMEDIS
Consider it taken care of.

ELECTRA
Seriously? You're gonna kill them?

ARCHEMEDIS
I mean, somebody has to show them a thing or two, right? And I'm somebody. I'm-- yeah, I'm sort of terrifying.

ELECTRA
Um--

ARCHEMEDIS
They won't know what hit them-- hey, do you have any honey?

ELECTRA
What?

ARCHEMEDIS
Yeah, I thought maybe we could tie them up and cover them in honey and feed them to some fire ants. Do you have any fire ants?

ELECTRA
This isn't some sort of trap?

ARCHEMEDIS
Trap? No! Wait! Trap! That's a great idea! Let's rig up one of those tiger pits! With the bamboo spikes at the bottom!

ELECTRA
Yeah! That sounds-- wait, what?

ARCHEMEDIS
This is gonna be great. Let's go! Let's go find them!

Dialogue in figure 3:

ELECTRA
Archemedis, listen. I know this isn't what you thought you were coming here to do. But if you *did* come to find out who you really are, maybe this is your chance. It's the sort of thing that makes heroes. Are you going to run away from this, or face it? Decide quickly, they'll be here any minute.

<user made a choice here>

ARCHEMEDIS
Listen, I don't want anything to do with any curse.

ELECTRA
But--

ARCHEMEDIS
I don't want to get the plague, I don't want to murder any royalty-- I just want to meet them. I want to find out who my real parents are. And who I am.

ELECTRA
I've already told you, she's a murdering whore and he's a tyrant with no right to the throne. As far as the real you goes--

ARCHEMEDIS
Yeah, I'd like to get a second opinion from somebody less crazy before I go on a killing spree. Besides, I'm sure if I explain the situation--

Electra pulls a SWORD.

ELECTRA
Let me explain the situation.

These simple figures do not show the use of the user model clearly. The figures may mislead the reader in thinking that different beats are selected according to the immediate user action. This, however, is not true. Users may choose the same immediate action and get different beats or Electra may use different behaviors depending on the user model, which is constructed using the history of user actions accumulated over the entire interactive narrative.

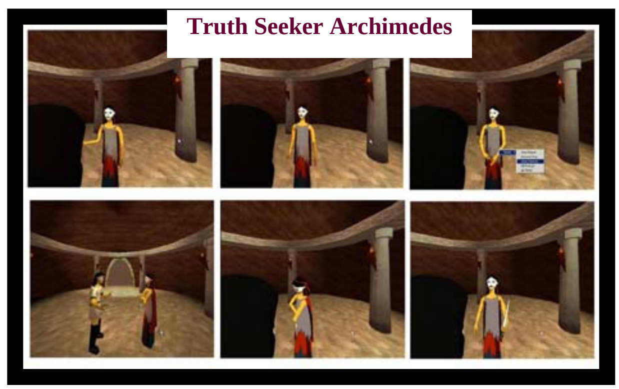

Figure 3. Showing outcome when user as coward type

As discussed above, characters adopt behaviors. They continuously monitor the user to identify agreement, conflict, and loss of attention or interest. Electra monitors the user in *Mirage* through mouse clicks, change in orientation, and action selection. In figure 4 she started using a behavior only to realize that the user has lost attention and is heading for the exit (shown in the third image within the figure). She then corrects the user model and chooses another tactic to get to her goal, as shown in the figure.

Dialogue in figure 4:

ELECTRA
Archemedis, listen. I know this isn't what you thought you were coming here to do. But if you *did* come to find out who you really are, maybe this is your chance. It's the sort of thing that makes hero – (interrupted)

<user made a choice to just leave>

Archemedis starts heading towards exit

<Electra fails her current behavior>

<She searches for a better argument (different behavior)>

<she re-plans>

<Electra's new plan includes:

1. stop user from leaving

2. use 'user has the plague' argument/behavior to get him to listen>

Electra blocks user from exiting

ELECTRA
So, what, you'll just carry the plague back to them? I'm sure they'll be happy to see you.

ARCHEMEDIS
What? No! I don't have the plague!

ELECTRA
I wouldn't be so sure, Archemedis. You don't look well. Are you feeling OK?

ARCHEMEDIS
Don't kid around--

ELECTRA
I'm not kidding. You've been exposed to it. If you're going to get sick, it will be in the next few hours. There's only one way to be sure you won't get the plague. You have to end the curse.

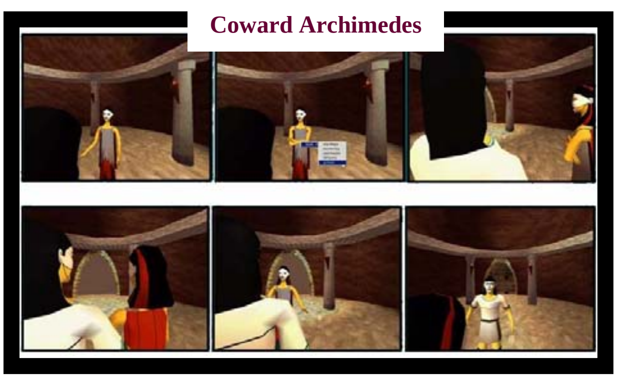

Figure 4. Showing dynamic change of tactic within the interactive story

5. CONCLUSIONS

I have presented an interactive narrative approach that adapts screenwriting and acting theories by integrating a user model formed by dynamically monitoring and modeling users' behaviors. The paper proposes an interactive narrative architecture that decomposes problem solving or plot generation among three levels: scenes, beats, and character behaviors. At each level, a reactive planning technique is used to generate a sequence of goals or behaviors that will achieve the narrative goals. The system uses user's actions and inferred stereotype-based personality to guide its decisions, thus forming a user centric approach to interactive narrative. At the character level, agents dynamically monitor user's behaviors for feedback to evaluate their behaviors. This architecture was implemented and tested within an interactive story called *Mirage*. Some screenshots of the story were discussed to show the dynamic adaptation of the narrative to user's actions given the user model, and thus forming a more engaging experience.

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