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ABSTRACT

Interactive storytelling attracts a lot of research interests among the interactive entertainments in recent years. Designing story plot for interactive storytelling is currently one of the most critical problems of interactive storytelling. Some traditional AI planning methods, such as Hierarchical Task Network, Heuristic Searching Method are widely used as the planning tool for the story plot design. This paper proposes a model called Fuzzy Cognitive Goal Net as the story plot planning tool for interactive storytelling, which combines the planning capability of Goal net and reasoning ability of Fuzzy Cognitive Maps. Compared to conventional methods, the proposed model shows a well-established temporal structure for story plot. It delegates the storytelling process to drama manager agent and sub drama manager agents. Dynamic storylines are prepared for the audiences' interactions. Fuzzy Cognitive Maps provide the drama manager agents strong reasoning capability with respect to story context and user interactions, which empowers the storytelling characteristics of context-awareness and user-awareness. An interactive storytelling engine has been built with the proposed model and knowledge base of interactive storytelling scenario. Based on the interactive storytelling engine, a prototype system, namely "illness investigation in Singapore River City", was implemented in the virtual environment, in which the story of illness investigation is presented in the dynamic context by responding to the user interactions and environment variables.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: AI Planning—*Goal Net*

General Terms

AI planning, plan execution, formation, generation, situated learning

Keywords

Goal Net, interactive storytelling, story planning, Fuzzy Cognitive Maps (FCMs)

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1. INTRODUCTION

Interactive storytelling is embedded within everyday human communication. It is the normal and acceptable form for people to share information and ideas. The term is defined by Chris Crawford, as a form of interactive entertainment in which a player plays the role of the protagonist in a dramatically rich environment[6]. Interactive storytelling is a mixture of story narrative and user interaction. Compared with conventional linear storytelling, interactive storytelling provides the audiences the capability to interact with the storyteller, so that dynamic and nonlinear storylines can be achieved. Thus, user awareness and context awareness are two main properties to be achieved in the interactive storytelling.

Story narrative requires to present the story scenario in a predefined way, but audiences expect to experience different or personalized story scenario through interactions. Therefore, there is tradeoff between the story narrative and user interaction. Determining the story plot with the balance between the narrative and interaction is really a challenge to the research of interactive storytelling. Currently there are some interactive storytelling engines created for such purpose. Marc Cavazza et al.[2] created an interactive storytelling engine with Hierarchical Task Network and Heuristic Planning Network. Hierarchical Task Network is one of most successful AI planning tool, which is also widely used as a plot design tool for interactive storytelling.

However, the current story plot planning tools have some drawbacks as they are not especially designed for the plot design of interactive storytelling. For example, the story plot created by Hierarchical Task Network is static. It specifies the way to decompose the complex tasks into smaller tasks, but the tasks do not have strong temporal causal relationships. The tool does not preserve the temporal structure required by story plot. Once conflicts are detected in the planning at user interactions, the plot needs to be partially replanned in order to solve the conflicts. It may give poor performance for the realtime plot design, especially when the context is very dynamic and the user interactions are very heavy. The tool cannot express complex relationships between the story scenes, such as independent scenes, synchronized scenes. Moreover, current plot planning tool does not guarantee the property of context-awareness and user-awareness, such that it does not make difference at the planning with respect to the user interactions and story context changes.

This paper proposes a model, namely Fuzzy Cognitive Goal Net, as a story plot planning tool for interactive storytelling. The model is composed of the story planning tool Goal Net as well as the context reasoning tool Fuzzy Cognitive Maps. Goal net provides a temporal and hierarchical structure, which is suitable to represent the temporal causal relationships among different scenes of story plot and the hierarchical structure to represent the complex story plot with different levels of abstractions. Different kinds of transitions of Goal Net fulfil requirements of different transitions for story presentation greatly from one scene to next scene. Moreover, Fuzzy Cognitive Maps provide stronger reasoning capabilities than rule-based reasoning at user interactions and context variables, by modelling the complex relationships among different factors and the decisions. Dynamic storylines are prepared by the drama manager, and the real time storyline experienced by the audience is based on the reasoning of the drama manager.

The paper is organized as follows. Section 2 gives a review over the related work about interactive storytelling, story planning tools and reasoning mechanisms. Section 3 introduces the rationale of our proposed model Fuzzy Cognitive Goal Net, its components, how it can be used to model the plot of interactive storytelling, and the interactive storytelling engine implemented based on the proposed model. In section 4, we illustrate a case study implemented based on our interactive storytelling engine over the virtual environment. Lastly, we conclude the paper and present our future plan.

2. RELATED WORK

Interactive storytelling, also known as interactive drama, interactive narrative, attracts a lot of interests in the recent years. According to Mateas (Oz Project)[13], there are three dimensions of research conducted over the interactive storytelling currently. The first dimension is local vs. global control of the drama manager over the story's spatio-temporal structure. In some local control examples, such as virtual pets, chatterbots and Multi-user worlds, local interactions give rise to "story", while Oz drama is proposed with a drama manager with global control for the whole plot. The second dimension is granularity of story control, i.e. levels of details of control for the story manager over the plot. Some system may control detailed events and behaviors, thus what a user can experience is fixed. In addition, the manager only decides some key scenes. It doesn't care the scenes in between. Therefore, it is possible that a story system can have multiple drama managers at different granularity of story. The third dimension is the story generation. The stories can be generated in a fixed manner (linear way), or with different approaches (branch way), or in a novel structure.

Currently, a lot of research is being conducted over interactive storytelling architectures for story generation and presentation. Magerko et al.[11] proposed an Interactive Drama Architecture(IDA) which employs a story director agent to manage the user' narrative activities. Young et al.[17] built an architecture called Mimesis for integrating plan-based behavior generation with interactive game environment. In contrast to the traditional plot-based storytelling, Marc Cavazza's group[2][5][3] focused on character-based interactive storytelling, in which each character has its own role and actions, and the characters have dynamic interactions between them with the guidelines from the storyline. In order to describe the complex goal of the character, the group uses the Hierarchical Task Network (HTN) to represent the goals or tasks for each character in the interactive storytelling. To improve the quality of real-time planning, anytime planning is proposed by Nick Hawes to replan in the complex environment in real-time.

Façade is currently one of the most successful interactive storytelling system[14]. In their system, a simple drama manager is implemented to plan the storyline based on a reaction formula of the scenes. The story builder assigns each scene an individual tension value that is applied to selection of the succeeding scene. Each succeeding scene should have more tension than previous one before climax, and then drama manager switches to scene with less tension. The VISTA project by Elizabeth F. et al.[8] creates an agent architecture to conduct virtual interactive storytelling.

Interactive storytelling adds the enjoyment of interactivity as well as the complexity, as the user interventions may cause the story scenario to change. Therefore, there are a lot of schemas used in the current interactive storytelling to prevent or restrict this kind of problems. For instance, the user can be a spectator in the virtual storytelling world, who is transparent to other roles in the games. Though they are allowed to move some objects in the virtual world to make the storytelling more dynamic, the whole story scenario will not be affected. In [9], virtual identities approach is used, such that, the user can experience the virtual worlds through the eyes of virtual identities, i.e. he/she can experience different views rather than a rigid one.

Moreover, interactive storytelling has been practiced in both the virtual environment and augmented environment. In augmented environment, researchers have developed StoryRooms[1], in which the children change their role from story participant to story authors. They are stimulated to direct their own stories and shared with their friends. Marc Cavazza et al.[4] also practiced the interactive storytelling in the mixed reality, such that a person is able to communicate with the virtual human, and finish the tasks in the story.

3. ELEMENTS OF INTERACTIVE STORYTELLING

According to the well-known courses of suspense of Aristotle (330 BC), the most important factor of a drama or story is the plot, which is composed of four phases along the time line: exposition, ascension, climax and conclusion. The four phases are causally related in the temporal relationships. The presentation of drama and story is shown linearly with a single serial of these key scenes at fixed time.

Interactive storytelling is composed of story narrative and user interaction. Different from the conventional storytelling, it presents the story non-linearly, such that dynamic storylines can be generated based on the user interactions. It

is expected that the storyline experienced by single user is a dynamic path which is different but close to the defined path.
The elements of a interactive storytelling system are:

Drama manager (DM): Drama manager is the storyteller, responsible for managing the story plot and presenting the story to the audiences. Every storytelling process involves at least one drama manger. As the storyline in interactive storytelling is dynamic, the drama manager in interactive storytelling dynamically present the storyline by selecting most appropriate or reasonable scene from many alternatives.

Event (E_i):An event in the plot planning means a scene in the story. A story is composed of the temporal-related acts. Each act is further decomposed to scenes. Thus, the storytelling can be seen as presentation of a temporal chain of the scenes. The event is the fundamental atom to build a story plot. The events are connected to each other with respect to the causal relationships.

Context Variable (V_i): In a dynamic storytelling, context variables are the state variables involved in the dynamic virtual environment, which might affect the decision of drama manager in selecting story paths, e.g., the time of event, the position of character, etc.

User Interaction (U_i): Users in an interactive storytelling are the audiences who listen to the story. User interaction is the way in which the audiences communicate with the drama manager. It is the most important factor in interactive storytelling. The user interaction can be done through different ways, for example, through conversation, or through virtual items. Through the interaction, users expect that the drama manager presents the storyline responsively to the interactions.

4. THE PROPOSED MODEL

In order to model the temporal structure of the story plot and the user interactions, we propose a model, namely Fuzzy Cognitive Goal Net, as the modelling tool for interactive storytelling. The model is made up of two parts: plot planning tool based on Goal Net and the context reasoning mechanism using Fuzzy Cognitive Maps (FCMs). Goal net is used as the story planning tool for the drama manager, and Fuzzy Cognitive Maps empower the drama manager ability to create dynamic path by reasoning user interactions and environment context.
The scene of a drama is regarded as a goal. The goals are loaded to the drama manager agents according to the temporal relationships of the scenes. For a complex scene in the presentation path, the goal of the agent can be decomposed to more specific small goals. Depending on the user interaction and the environment context, different consequent goals may be achieved after a certain goal. Fuzzy Cognitive Maps are used for the decision making or goal selection by analyzing the relationships among related concepts. The two modelling tools Goal Net and Fuzzy Cognitive Maps are illustrated in details in the following parts separately in terms of their functionalities in the interactive storytelling model.

4.1 Drama Manager Agent

In interactive storytelling, the drama manager, also known as director, acts the most important role, because it schedules the sequence of the scenes to be presented. Conventional storytelling involves one static drama manager as the sequence of the scenes is fixed. However, interactive storytelling involves user interactions as well as dynamic story context. These changes require the drama manager to be active, autonomous, such that dynamic storyline can be presented.
In the proposed model, the drama manager is implemented as an agent. An agent is an autonomous, goal-driven object, able to be reactive and proactive to the environment. The goal for drama manager agent is to present the story in a user-interacted manner. The goal of story narrative can be split into small goals of present scenes in the causal order.
In the case of complex story scenario, sub drama manager agents are created such that each of them can present its local story scenarios.

4.2 Plot Planning using Goal Net

The drama manager presents the story according to its plot for the story. The goal-modelling tool Goal Net is employed to design the plot for the drama manager.
Goal net is a tool for modelling multi-agent systems proposed by Shen[18]. It has been successfully used in the multi-agent system modelling in business forecasting and E-learning[16].

4.2.1 Structure of Goal Net

Goal net is a composite goal model which is composed of *states* and *transitions*. *States*, represented by circles, are used to represent the states that an agent needs to go through in order to achieve final goal. *Transitions*, represented by arcs and vertical bars, connect from the input state to the output state, specifying the relationship between the two states. Each transition is associated with a task list which defines the possible tasks that the agent needs to perform in order to transit from the input state to the output state. A Goal Net example is shown in Figure 1.
There are two kinds of states in Goal Net, *atomic states* and *composite states*. An *atomic state* is a primitive state which cannot be further divided, while a *composite state* can be split into states connected via transitions. Therefore, a complex goal can be recursively decomposed into sub-goals and sub goal nets. The hierarchical structure simplifies the goal oriented modelling process with different levels of abstraction. In Goal Net, there are four types of temporal

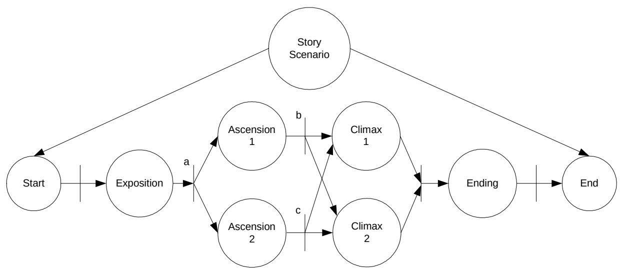

Figure 1: Goal Net with the Alternative Storylines

relations of goals represented by *transitions* connected the input states and output states: *sequence*, *choice*, *concurrency* and *synchronization*, which are shown in Figure 2. The transitions have the following meanings:

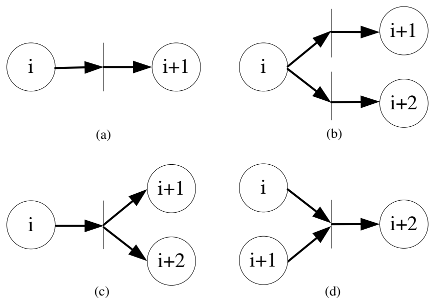

Figure 2: Goal Net Transitions: (a) Sequence (b) Concurrency (c) Choice (d) Synchronization

Sequence: A direct sequential causal relationship between input state i and output state $i+1$

Choice: A selective connection from input state i to possible output states $i+1$ and $i+2$, and only one output state can be selected based on selection criteria

Concurrency: Input state i at completing the tasks, all the output states $i+1$ and $i+2$ can be achieved simultaneously

Synchronization: A synchronization point from different input states i and $i+1$ to a single output state $i+2$, and the output state can only be achieved when all its input states are synchronized

In a Goal Net model, a state is represented as S_i, and the transition is represented as T_i.

4.2.2 *Plot Planning with Goal Net*

Goal Net is a very expressive and efficient tool to model the story plot for interactive storytelling.
The events are related in a temporal causal order in the storytelling. In the model, each scene/event E_i is represented as a goal/state, the causal relationships between event E_i and E_{i+1} is represented with the transaction T_i. The tasks for the agent whose goal transits from event E_i to E_{i+1} are represented as the task list at the transition T_i. As shown in Figure 1, a general storyline is encapsulated within Goal Net. Moreover, there might be multiple storylines in an interactive storytelling due to user interactions or context variable changes, the Goal Net shows different possible storylines with the relation of 'Choice'. Therefore, the drama manager has a combination of the ascension and climax to form the story in the process of storytelling. For example, the possible storylines include

```
Start->Exposition->Ascension1->Climax1->Ending->End
```

and

```
Start->Exposition->Ascension2->Climax2->Ending->End
```

The *states* of the goal net represent the story scenes. A complex scene is represented as a composite state, and a simple scene is represented as an atomic state. The composite state can be further divided into atomic states such that a complex scene is split into small scenes for a story narrative.
The *transitions* of goal net are adequate and capable to describe different relationships between story scenes in interactive storytelling. The *sequence* transition is used when two scenes has temporal causal relationships. The *concurrency* transition is used when two scenes are independent, such that the presentation order by the drama manager is not important. The *choice* transition is the most important to the user interaction and context variables change, as it might lead to different scene after the current scene. The *synchronization* transition is needed for the concurrent scenes, such that the next scene can be presented only after the concurrent scenes have been presented. Moreover, the combination of *transitions* allows to model complicated relationships among scenes, thus it is able to model a very complex storytelling.
The drama manager agent is responsible for presenting the story scenes from the Goal Net according to causal relationships among the scenes. If the story is quite complex, i.e. the Goal Net structure is complex, sub drama manager agents will take the responsibility for presenting the sub scenes, i.e. the sub Goal Nets.

4.2.3 *Comparing with Hierarchical Task Network*

Hierarchical Task Network (HTN) is an AI planning tool widely used in various planning problems, including plot design for interactive storytelling. Compared with HTN, Goal Net has several advantages:
Firstly, temporal information is one of the most important elements in interactive storytelling. The *states* of Goal Net have clearly temporal causal relationships, as the output state can be achieved only if the tasks at the transition are fulfilled. However, the tasks in the HTN don't have strictly temporal relationships.
Secondly, Goal Net is an agent model that supports both goal autonomy and behavior autonomy. In the short term, an agent is able to do a proper reasoning to select and execute an appropriate action in order to achieve the next goal; in the long term, the agent can do a proper reasoning to select the next best goal for achieving the final goal. In the proposed model, the states and actions are selected dynamically. Therefore, it provides the real-time planning for interactive storytelling with respect to user interaction and context change. However, for HTN planning, whenever conflicts are met, the HTN needs to be replanned. Even though it is partially replanned, it is still resource consuming, especially not suitable in real-time planning.
Thirdly, it is very easy to combine different reasoning methods at the transitions for selecting different storylines. Comparatively, HTN is lack of such reasoning mechanisms.

4.3 Context Reasoning Mechanism: Fuzzy Cognitive Maps

Dynamic storyline selection is achieved by goal/state selection in a Goal Net. And the reasoning mechanism provides the basis for the drama manager to make the selection.

Traditionally, rule-based reasoning technique is the most commonly used approach for agent reasoning, whereby the agents make the decisions based on the rules and input states. However, it is noted that rule-based reasoning is not powerful enough to model the situation in which there are complex relationships among the factors.

In the proposed model, we use the Fuzzy Cognitive Maps as the reasoning tool to provide Goal Net the property of user awareness and context awareness.

4.3.1 Structure of Fuzzy Cognitive Maps

Fuzzy Cognitive Maps (FCMs) is a kind of qualitative modelling tool proposed by Kosko [10]. It provides a simple and straightforward way to model the relationships among different factors. Currently, FCMs have been widely used for modelling causal relationships among different factors in different kinds of applications. In [12], the authors use FCMs to model the movements of the sheepdog and sheep. Bart and Dickerson[7] also illustrate using FCM to model the hunting process among sharks, dolphins and fishes. But until now, it has not been practiced in virtual storytelling.

FCMs include two elements: *concepts* and *causal relationships*. As shown in Figure 3, *concepts* are represented by circles, which represent the related causes and effects in the model. The *causal relationship* is represented by a directed arc, which has sign and weight. The '+' sign means 'positive causal relation', such that the increase of the starting concept value may cause the increase of the ending concept value. Conversely, the '-' sign means 'negative causal relation', such that the increase of starting concept value will cause the decrease of the ending concept value. The weights differentiate the important levels from the start concept to the certain end concept. To facilitate the analysis of the

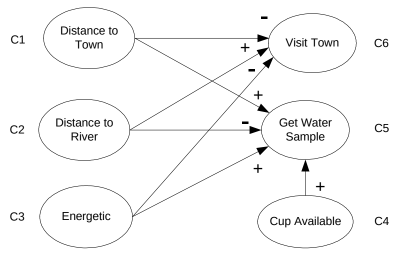

Figure 3: Sample Fuzzy Cognitive Map

FCMs, each concept is represented with a state value whose range is [0, 1] or [-1, 1], while the causal relation is represented as a weight, whose range is [-1, 1]. Suppose the value of the concept i is A_i, the new value updated with respect to relationships with other concepts can be computed as

$$A_i^{t+1} = f(\sum_{j=0}^{n} A_j^t \cdot w_{i,j}) \quad (1)$$

here, $f(\cdot)$ is the activation function.

4.3.2 Context Reasoning

In the proposed model, Fuzzy Cognitive Maps are used as the reasoning tool for goal selection as well as action selection. The user interaction, context variables as well as the decisions are encapsulated as concepts. The causal relationships among different concepts are determined according to the expert knowledge or a knowledge base. High weights are assigned to those more assertive causal relationships.

Figure 3 shows the relationships among several concepts. Among the concepts, "distance to town", "distance to river" and "energetic" are context variables; the concept "cup available" can be modified by the user interaction; and the concepts "visit town" and "get water sample" are decisions.

Suppose the initial state vector from concept C_1 to C_6 is given by

$$(0.8 \;\; 0.2 \;\; 0.4 \;\; 1.0 \;\; 0.0 \;\; 0.0)$$

And the weight matrix (row and column are both from concept C_1 to C_6) derived from expert knowledge can be computed as,

$$\begin{pmatrix} 0 & 0 & 0 & 0 & 0.5 & -0.5 \\ 0 & 0 & 0 & 0 & -0.5 & 0.5 \\ 0 & 0 & 0 & 0 & 0.4 & -0.2 \\ 0 & 0 & 0 & 0 & 0.6 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

The output state vector from concept C_1 to C_6 is

$$(0.8 \;\; 0.2 \;\; 0.4 \;\; 1.0 \;\; -0.38 \;\; 1.16)$$

It shows that, the value of C_6 is much higher than the value of C_5. Thus, "Get the water sample" is the final decision. It is shown that, the Fuzzy Cognitive Map does not have any loop. Once there is any loop of causal relationships among the concepts in it, the state vector might converge in several steps, and the final decision is made based on the final result.

Fuzzy Cognitive Map can be seen as a collection of the rules such that it not only concerns the relationships between the causes and effects, but also considers the relationships among the causes. Therefore, it provides a stronger reasoning ability than rule-based reasoning. It can be used to model complex relationships among different concepts.

4.4 Interactive Storytelling Engine

Based on the model of Fuzzy Cognitive Goal net, we designed an interactive storytelling engine for the storytelling planning (Figure 4). The framework is composed of an interactive storytelling engine and a visualization engine. The interactive storytelling engine has been designed and constructed. The story scenario is stored in the knowledge database, which includes both the story events and the relationships among related concepts. The drama manager is designed as collaborating agents. Java-based Multi-agent Development Environment (MADE)[18] is a platform for designing and implementing multi-agent systems. It provides great facilities to create agent environment and agents. In addition, fuzzy cognitive goal nets will be constructed and stored in the knowledge database. They will be assigned to the agents at runtime. Goals/scenes of fuzzy cognitive goal nets, which are selected on the desired storyline by an user, are loaded into the agents dynamically. For example, at the choice transition, story scenario can be decided using fuzzy cognitive maps, then the goals on the selected path are loaded. In this way, a story scenario is dynamically presented according to the user interaction at runtime.

The visualization engine adopts the commercial software ActiveWorld by ActiveWorlds Inc. The virtual environment was built with the Rendering Engine by Renderware.

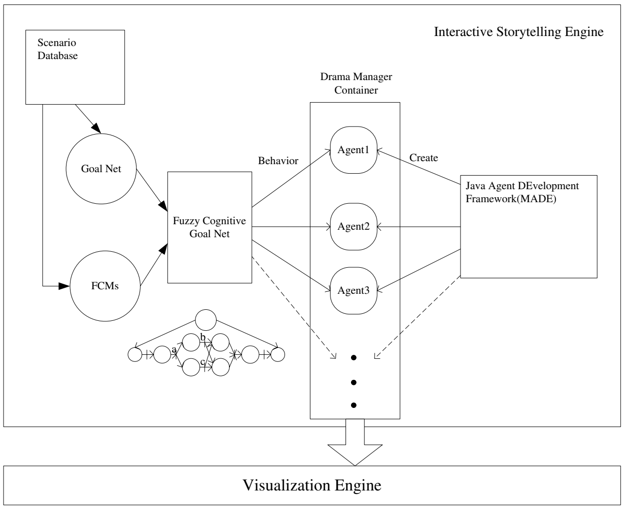

Figure 4: Interactive Storytelling Engine and Visualization Engine

The software provides the virtual world and also the virtual avatars for the story presentation. The system is constructed with server-client paradigm. Users can share the common virtual environment, which enables us to present interactive storytelling to multi-user simultaneously.

4.5 Advantages of Fuzzy Cognitive Goal Net

There are several advantages by using the model of Fuzzy Cognitive Goal Net as the planning tool for the drama manager. The first advantage is that, the events of a story are organized in the temporal manner expressively. High-level scene is decomposed to low-level scenes. The second advantage is that the tool has user-awareness and context-awareness features. Different user may experience different storytelling in the same story context, as the drama manager will select the story path partly based on the user interaction. Also, for a single user, the story path may be presented differently as the values of the context variables are different time by time. The third advantage is that the events of the selected path in the model are dynamically loaded into the engine. This improves the real-time performance of the engine.

5. CASE STUDY: "ILLNESS INVESTIGATION IN SINGAPORE RIVER CITY"

5.1 Story Scenario Design

A story scenario, namely " Illness Investigation in Singapore River City", was implemented using the interactive storytelling engine and visualization engine. The story is an educational program, targeting secondary students for the study of illnesses in normal life. Students are guided by the instructor agent to explore the virtual city and investigate the story. The story is presented to the students by the drama manager or sub drama managers in the process of investigation. By talking to different people (agents) at different places, or through collecting test samples in the city, the students need to conclude the thorough review over the unknown disease, including name of the disease, symptoms, precautions and so on.

The goal net for the story is shown in Figure 5. It is constructed based on the story scenario of the illness investigation, in which a student needs to explore the virtual world, communicate with the virtual avatars and finish the final test. The drama manager agents include instructor agent, doctor agent, villager agents and so on. Each agent presents the students its own story scenario, which corresponding to part of the goal net, under the coordination of the instructor agent.

Fuzzy Cognitive Maps (FCMs) are encapsulated at the *transition a* shown in Figure 5, which will reason about internal states of agents and the external states of the world as well as user interactions. The decision concepts in the FCMs will be used for the goal selection as well as action selection. This process ensures that the actions of agents are more reasonable and dynamic.

As shown in the goal net, four kinds of relations are implemented for specific scenarios:

Sequence: after "the student is assigned to get the water sample", then "the technician makes the laboratory test".

Choice: after "the student is assigned to get water sample", if "he/she is very young" or "he/she runs away from the dirty water", then "he/she requires to get help", otherwise, " he/she jumps into water to get sample".

Concurrency: after "the student understands the scenario", "he/she can go to hospital for symptoms of illness" or "he/she can go to health ministry for illness precautions".

Synchronization: Only after " the student explores all the places" and "the water sample is tested", "he/she can make the conclusion of the illness".

As shown from the goal net, with respect to the user interaction, different story path can be achieved. One story scenario could be

The student went to hospital, then he/she went to the Health of Ministry.

A second story scenario could be

The student went to the houses, where he/she caught ill, then he/she went to see the doctor.

Fuzzy Cognitive Map in Figure 3 shows the model for the goal selection between "visit town" and "get the water sample" in this test case. Depending on the real-time states, the quantitative values of the two decisions concepts are different. The goal with higher concept value will be loaded into the drama manger agent for next-step presentation.

Sample snapshots in real-time experiments are shown in Figure 6. As shown, the top left image shows that a student is talking to the doctor; the doctor is illustrating some information about illness symptoms. The top right image shows

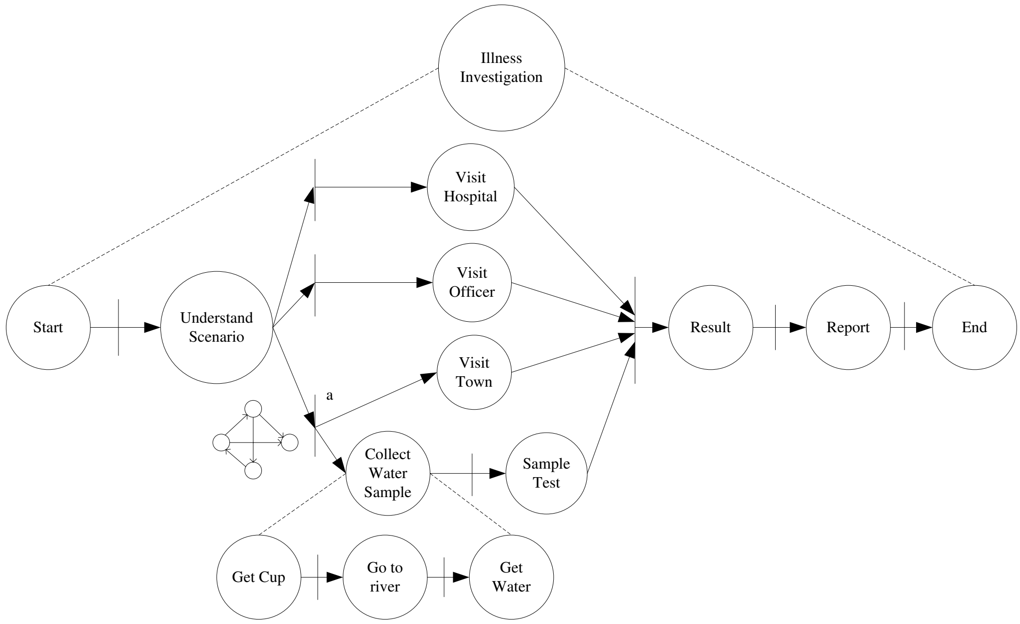

Figure 5: Fuzzy Cognitive Goal Net for Illness Investigation Scenario

that the patient 'Jane' is talking about her illness on the bed. In the bottom left image, the drama manager is showing us the street and normal scenes. it seems that the town is quite dirty. And the bottom right images shows that the water sample is being collected from the river and will be sent for the laboratory test. Based on the student's choice, he/she may ask the illness symptoms from the doctor and nurse as in the top left image, or go to watch the patient directly as in the top right image. This shows the freedom that the student can achieve with interactions to the virtual world.

5.2 Model Evaluation

The evaluation metric for user experience in the interactive storytelling is a subjective matter. Based on Murray[15], user experience for interactive storytelling can be evaluated in three categories:immersion, agency and transformation.

Immersion is the feeling of the user to be involved in the virtual environment, able to interact with the environment. With the proposed model, the drama manager agents plan the story scenario based on the user interactions, the user-awareness would immerse the user into the virtual storytelling with great experience.

Agency is the feeling that empowers the user to take actions in order to fulfil its intension. In our dynamic world, the user is able to make some actions (such as hiding the cup for getting water sample). The drama manager will determine different story path based on its cognition in real-time.

Transformation means the variety of the story presentation. Different user may experience different story path as the drama manger reasons about the user characteristics. For example, the drama manager may present some scaring events to one group of users, or allows them to do some dangerous tasks in the scenario. However, these are not available to the other group of users. Instead, alternative

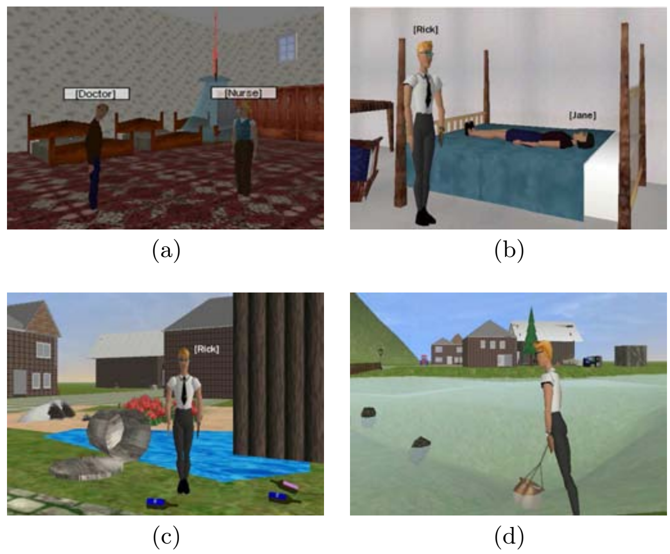

Figure 6: Snapshots for (a) talking to the doctor and nurse (b) talking to the patient (c) illustrating the dirty space (d) getting the water sample for laboratory test

scenarios will be provided.
As a conclusion, our model provides a more dynamic and user-awareness environment for the interactive storytelling, and the users would get much more attractive experiences in such dynamic environment.

6. CONCLUSIONS

In this paper, we propose Fuzzy Cognitive Goal Net as the plot planning tool for the interactive storytelling. Compared with conventional methods, such as Hierarchical Task Network, the drama manager has a global control for story plot. The story scenes are constructed with the temporal causal relationships. The model provides alternative storylines to handle user interactions and the context variable changes. Fuzzy Cognitive Map provides the strong reasoning ability required for selecting story scenes. Moreover, the real-time loading of the story scenes leads to the most responsive experience to the user. Based on the proposed planning model, we created an interactive storytelling engine for the ease of story generation.
Currently, the interactive storytelling is implemented in the virtual environment with the current engine. In the future, we expect to expand the interactive storytelling method in the augmented reality or mixed reality. Also, we expect to empower the reasoning ability of Fuzzy Cognitive Maps, so that the scene selection and action selection are more reasonable for extreme complex context in interactive storytelling.

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8. REFERENCES

[1] H. Alborzi, A. Druin, J. Montemayor, M. Platner, J. Porteous, L. Sherman, A. Boltman, G. Taxen, J. Best, J. Hammer, A. Kruskal, A. Lal, T. P. Schwenn, L. Sumida, R. Wagner, and J. Hendler. Designing storyrooms: Interactive storytelling spaces for children. In *Symposium on Designing Interactive Systems*, pages 95–104, 2000.

[2] F. M. S. Cavazza, M. Charles. Character-based interactive storytelling. *Intelligent Systems, IEEE [see also IEEE Intelligent Systems and Their Applications]*, 17(4):17–24, 2002.

[3] M. Cavazza, F. Charles, and S. J. Mead. Interacting with virtual characters in interactive storytelling. In *Proceedings of the first international joint conference on Autonomous agents and multiagent systems*, pages 318 – 325, Bologna, Italy, 2002.

[4] F. Charles, M. Cavazza, S. J. Mead, O. Martin, A. Nandi, and X. Marichal. Compelling experiences in mixed reality interactive storytelling. In *ACE '04: Proceedings of the 2004 ACM SIGCHI International Conference on Advances in computer entertainment technology*, pages 32–40, New York, NY, USA, 2004. ACM Press.

[5] S. C. M. Charles, F.; Mead. Character-driven story generation in interactive storytelling. In *Virtual Systems and Multimedia, 2001. Proceedings. Seventh International Conference on*, pages 609–615, Berkeley, CA, 2001.

[6] C. Crawford. *Chris Crawford on Interactive Storytelling*. New Riders., Berkeley, CA, US, 2005.

[7] J. A. Dickerson and B. Kosko. Virtual worlds as fuzzy cognitive maps. In B. Kosko, editor, *Fuzzy Engineering*. Prentice Hall, Englewood Cliffs, New Jersey, 1994.

[8] E. Figa and P. Tarau. The vista architecture: experiencing stories through virtual storytelling agents. *SIGGROUP Bull.*, 23(2):27–28, 2002.

[9] M. Greeff and V. Lalioti. Interactive cultural experiences using virtual identities. In *ICHIM (1)*, pages 455–465, 2001.

[10] B. Kosko. Fuzzy cognitive maps. *International Journal of Man Machine Studies*, 24:66–75, 1986.

[11] B. Magerko and J. Laird. Building an interactive drama architecture. In *First International Conference on Technologies for Interactive Digital Storytelling and Entertainment*, pages 226–237, Darmstadt, Germany, 2003.

[12] J. T. Marc Parenthoen, Patrick Reignier. Put fuzzy cognitive maps to work in virtual worlds. In *The 10th IEEE International Conference on Fuzzy Systems*, volume 1, page 38, Australia, 2001.

[13] M. Mateas. An oz-centric review of interactive drama and believable agents. In *AI Today: Recent Trends and Developments.*, volume 1600, pages 297–328.

[14] M. Mateas and A. Stern. Façade: An experiment in building a fully-realized interactive drama. In *Game Developers Conference, Game Design track*, San Jose, USA, 2003.

[15] J. Murray. Hamlet on the holodeck. *Cambridge, MA: MIT Press*, 1998.

[16] Z. Shen, C. Miao, X. Tao, and R. Gay. Goal oriented modeling for intelligent software agents. In *Intelligent Agent Technology, 2004. (IAT 2004). Proceedings. IEEE/WIC/ACM International Conference on*, pages 540–543, 2004. TY - CONF.

[17] R. M. Young, M. O. Riedl, M. Branly, A. Jhala, R. J. Martin, and C. J. Saretto. An architecture for integrating plan-based behavior generation with interactive game environments. *Journal of Game Development*, (1):51–70, 2004.

[18] S. Zhiqi. *GOAL-ORIENTED MODELING FOR INTELLIGENT AGENTS AND THEIR APPLICATIONS*. PhD thesis, Nanyang Technological University, 2003.