Intelligent Augmented Storytelling

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Abstract: *Interactive storytelling in virtual world provides a huge potential in learning and education. Alice Storytelling is a successful example. However Alice Storytelling lacks ability to support complex story, dynamic character as well as to handle the conflicts of author narrative and user interactions. This paper investigates Fuzzy Cognitive Map (FCM), for modeling virtual characters' behaviors, user's interaction in interactive storytelling. A reusable practical method and toolkit based on FCM to create Intelligent Augmented Storytelling using Alice is proposed. The experiment result shows the proposed methods are promising for intelligent augmented interactive storytelling.*
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1. Introduction

In recent years, Computer-Generated Virtual Worlds has popped into the headlines. As people's demand on computer entertainment are getting more sophisticated, the software tools to build virtual world and their underlying technologies must advance with the times as well. However, in most existing virtual world, virtual objects' lack of perception with their environment brings certain rigidness to them; and thus creates gap with attribution of the real world, where human beings and animals perceive things and react upon sensitive things.

Fuzzy cognitive maps (Kosko 85) are signed fuzzy digraphs which models the real world problem into a collection of concepts and their interactive causal relationships. Fuzzy cognitive map is a cognitive map or a "mental landscape" for knowledge representation and inference. It is one of the theories to help to bridge such gap and improve perception and automation to enrich virtual objects, thus FCM satisfies a pragmatic need for intelligence in virtual world.

2. Alice Storytelling

Alice is an innovative and unprecedented 3D programming environment that aims to transfer pure text programming into programming by creating an animation (Jose 2008). Alice has been successfully adopted by many middle school and high school teachers across America, and become their favorite educational software to teach "Introduction to Programming" course. Storytelling Alice, a spin-off of Alice, was created by Caitlin Kelleher (Kelleher 2005&2007) as her doctoral work at Carnegie Mellon University. Its purpose is to motivate students, especially female students to learn programming notation through creating their own 3D animated stories. Compared to Generic Alice, it includes a set of high-level social animation based on the survey they conducted and analysis of storyboards that students created and usability testing with target audience.

Overall, Storytelling Alice has a very interactive and user-friendly interface. Users can drag the tile of every graphical method from the object tree and place it on the script editor with desired sequence in order to construct a virtual story. However, there are many complex causal relationships that exist in real world's entities like human beings as well as in stories that simulates real world. Such causal influence in Storytelling Alice so far cannot be demonstrated, because all the virtual characters don't really have a "brain". Additionally environment variables always change in virtual stories; such uncertainty can be addressed to improve storytelling. Nevertheless in Storytelling Alice's, story scripts are all pre-fixed and thus characters wouldn't have different behaviors by perception of changes. Moreover, software users are now getting more and more "nitpick" about the virtual world environment. They want more innovation in visual quality, more excitement virtual world, more intelligent in characters; to sum up; they just want to see "more". Hence, it's a pragmatic need for Storytelling Alice to improve and attract users by bring in intelligent models and tools.

Hence, this paper introduces an Intelligent Augmented Storytelling Alice to enhance original application by embedding FCM theory and modeling tools to express certain types of interconnection and emotional behaviors reflected from causal changes.

3. Storytelling Fuzzy Cognitive Maps

FCM was first proposed by Bart Kosko (Kosko, 1985). FCMs are soft computing tools which combine elements of fuzzy logic and neural networks. They can be represented both in graphical view and in mathematical models. In terms of the graphical representation, a FCM is a causal graph which includes the following necessary components:

(a) Nodes: Each concept node indicates a characteristic of the system such as events, actions, and states.

(b) Edges: to represent the direct causal influence between concepts.

(c) Weights: to represent how much one node influence another.

(d) Activation events at different moment t. The stimulated events can bring changes to certain concepts, edges, or even the overall of FCM.

Beyond the graphical representation of FCM, there is a mathematical model, in which a FCM is a combined set of **(C, V, A, W, Ea, R)** [4].

- **C**= $\{C_1, C_2 \cdots C_n\}$ is an set of n concepts, which will be used to form the nodes of the FCM graph.
- **V=** $\{V_1,\ V_2, \ldots,\ V_n\}$ is a vector with size n for values of the set of concepts. Each value should also be bounded in a range.
- **A** $\in$ **C**×**C** is the set of edges A_{ji} to indicate causal relationship of $C_i \rightarrow C_j$, where i and j belongs to range [1, n].
- **W** is the weight associated with all the possible edges set **A,** If value of W_{ji} (weight on edge A_{ji}) is 0, C_i and C_j are not directly related; if W_{ji}>0 or W_{ji}<0, the causal relationship between C_i and C_j exists.

- **Ea** is the sequence of activation events occurs with time, which might or might not change the state of the FCM matrix.
- **R** is a recurrence relation.

During simulation, the value of each concept will be influenced by the set of edges pointed at it, with a function based on appropriate weights and its previous value. The new value V_i for C_i can be calculated by the following formula:

$$V_i^{new} = f(\sum_{j=1, j\neq i}^{n} \Delta V_j * W_{ji}) + A_i^{old}$$

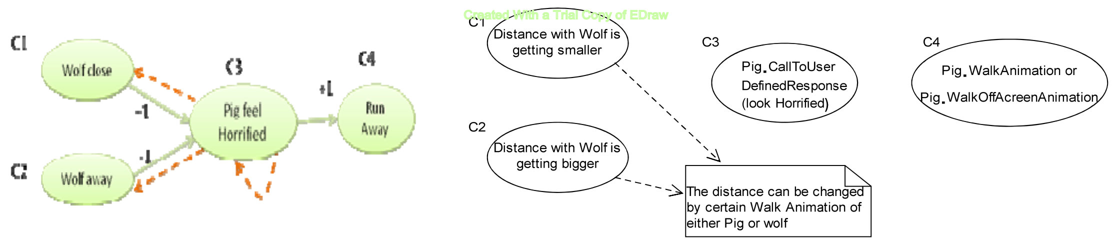
f is the "activation function", commonly used functions are threshold function, ramp function, linear function, and sigmoid function.

By putting FCM into virtual world (Dickerson 1994, Parenthoen, 2001) it can be used to model story characters, user avatars as well as dynamic scenes. The heart design of this FCM modeler is a java applet, which allows users to add, edit and remove concept nodes and edges and of course to view the overall FCM graph simply by mouse actions. One of the most important issues to be addressed is the mapping of concept properties and edges properties into Intelligent Augmented Storytelling Alice's created FCM structure. The idea that to construct FCM by allowing users to draw the FCM graph first, is a more convenient and more flexible approach. However, greater flexibility brings in more work to handle in the underlying programming design; as a result, this design needs more restriction and fault-tolerance capability. Also, the created concept and edges must be limited to meaningful ones in connection with the virtual stories. Take concept node for example, the name format of concept must be virtual object plus its characteristic in order to be mapped into virtual stories.

In design of Intelligent Augmented Storytelling Alice, the mapping is done by a predefined pool of the world's current existing characters and their states and action that might be a concern for users to model emotional behaviors. Another issue of concern is the association of event handling in the modeler's graph view area with virtual stories. And the original design involved a button panel to operate the state simulation and training process of FCM, which should be disabled because the simulation and activation of FCM should be done by Intelligent Augmented Storytelling Alice in this case.

4. Intelligent Augmented Storytelling Alice: Result and Discussion

Currently most research about FCM are all working for *one* single entity only, such as FCM for *one* political issue, FCMs for *one* particular control modeling system, FCMs for *one* Robotic experiment. Hence, for this paper, it's an unprecedented design to embed a FCM system that is able to create different FCMs for different virtual worlds which are produced in Storytelling Alice. Meanwhile, the embedding process of FCM system into development tool like Storytelling Alice can present certain challenges. The following figure demonstrates an example on how concepts can be mapped into virtual world behaviors and probably mapped into different ones.



(a) FCM components (b) Virtual world behaviors

Figure 1: Mapping of FCM components with virtual world behaviors

We now show the results and discuss their significance.

- The embedded FCM system does seamlessly connect to Storytelling Alice.
- The FCM editing tool (FCM modeler) is easily accessible for users via Storytelling Alice's platform.
- The representation of FCM components and its corresponding behaviors in virtual story are consistent and reasonably mapped, and certain error-handling routine are designed to avoid mismatch.
- When an Alice story is associated with a FCM with concept values vector **V** and weight matrix **W**, once the story starts its simulation running, its FCM will start running as well. **W** is considered to be fixed, and when one concept value is changed during simulation, in the same time unit the value of the rest connected concepts will be changed accordingly with the formula mentioned above.
- The activation output of FCM system, which are emotional behaviors can be clearly showed.
- We tested different activation functions as mentioned above. Result shows that the linear function generate the most concrete and meaningful output.

In order to implement and observe the performance of the Intelligent Augmented Storytelling Alice, let's have a simple case study. Its scenario is described as following: The virtual world has main character *littleRed*, *farmerPig*, and *BigBadWolf*, the details of plot are negligible for the time being. The virtual story has constructed an initial FCM graph as the figure shows. Take one concept value update for example to describe the causal relationships: When *farmerPig* escape away, it will reduce its own feeling of worried (negative: red color), cause *littleRed*'s feeling of relaxed increased (positive: blue color) and decrease *BigBadWolf's* happy factor.

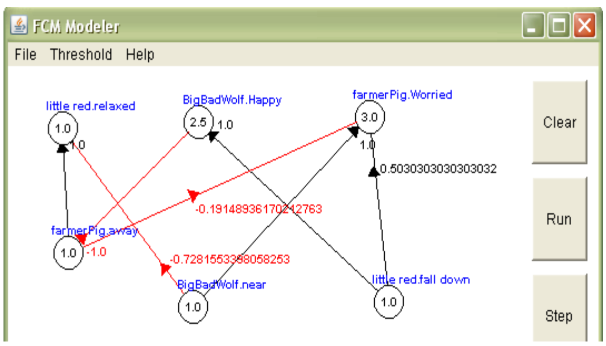


Figure 2: FCM graph and initial values

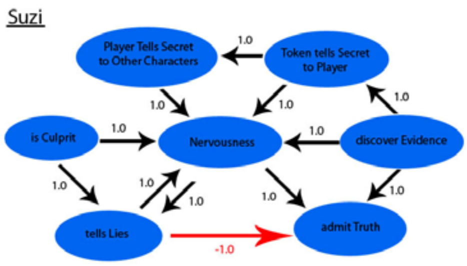


Figure 3: Fuzzy Cognitive Maps for mascot detection by the Scriptwriter Agent

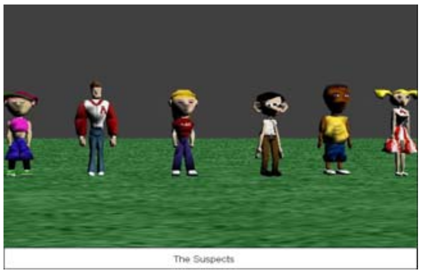


Figure 4: the 3D simulation scene of mascot mystery was created in storytelling Alice

Figure 3 & 4 show "Mascot Mystery in the School", the story is to find out suspect who steal the school's team mascot. According to the script and plot of the story, when the story is being played, the FCM's concept vector value will be updated accordingly and may generate different output behaviors.

5. Conclusions

This paper proposes a new intelligent modeling system based on FCM to extend Storytelling Alice to help virtual characters to perceive environment better and generate autonomic emotional behaviors. Our results indicate that this new system has successfully achieved its design objectives and we believe the ideas and development methodology described in the report can become a useful reference for future work on the subject. The proposed model and development system are not limited to Alice Storytelling; it can be plugged in various virtual world and storytelling systems. Experiments have also been done in Second Life, Active World and Torque Game engine. The experiments show that our proposed model and development toolkits are general and can be reused in various virtual world/storytelling/game engines for creating intelligent augmented storytelling/games.

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