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Building Active Conversation Environment for Edutainment

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Abstract

Generating composite human motion such as locomotion and gesture is important for interactive applications, such as interactive education and computer games. In interactive educational environments, characters do not merely stand in one position, they should be able to compose gestures and locomotion based on the discourse of the topic and related object locations in the scene. Thus in this paper, we propose a conversational locomotion model for virtual characters. We constructed a conversational locomotion network for a virtual environment. A multi-pass searching algorithm calculates the optimal walking path, which uses node activation from the story locations and conversation units. The character also locally adjusts its position so that it does not limit the referenced object from the player's sight. We have applied our technique to the education for the disaster prevention application, and demonstrated the composite motion of the character's locomotion and conversation thus strengthens the immersion and enhances the learning effect in the educational environment.

Keywords: conversational locomotion, conversational locomotion network, panorama

1. Introduction

In our daily life, humans perform many composite actions simultaneously. Walking and talking concurrently is one of the typical composite human actions. Composing locomotion and gestures is also important for applications such as interactive movies and games. In the interactive educational environment, characters do not simply stand in one position, and they should be able to compose gestures and locomotion based on the series of topic locations and surrounding objects.

The proper location and timing of the character is influenced by various contexts, such as the connection of scene locations and the current environment. The apparent size of objects and the detail of the explanation affect how much closer the character should move. Connection of the scene locations also affects the current position. When the character refers to particular objects during a conversation, and the objects are far from the character's current position, it is time consuming to make the character approach the object every time. However, when the referenced object is close to the next scene location, it is more reasonable that the character moves closer to that object.

In this paper, we propose a mechanism for fluid conversational locomotion for virtual characters. This is realized by calculating the optimal locomotion path, which is influenced by the conversation and the story location, and the characters then subsequently generate composite walking and conversation actions. The character also locally adjusts its position so as not to limit the referenced object from the player's sight. Figure 1 shows a typical example of conversational locomotion. In this scenario, the character first explains that the vending machine cannot be approached in the disaster zone. In the next scene, the player asks about the other specific objects that cannot be approached, and the character then moves closer to explain more about the background relating to the disaster.

Figure 1. Example of conversational locomotion in a disaster zone.

2. Synchronization of Conversation and Locomotion

2.1 Overview of the architecture

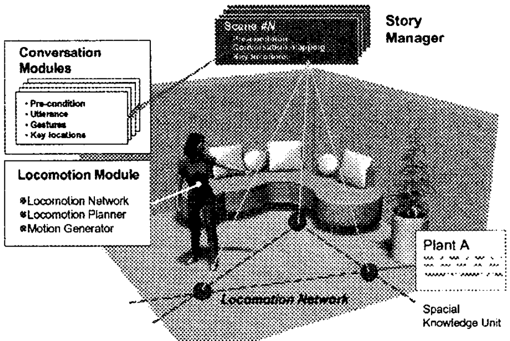


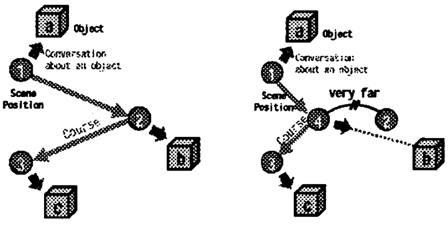
Fig. 2. Overview of the conversional locomotion architecture.

Figure 2 shows the conversational locomotion architecture. The system has a locomotion module, conversation modules, and a story manager. A story consists of a set of scene units and this controls the discourse of the conversation. A scene unit has a precondition, scene location, and links to a collection of possible conversation modules. Proper scene units are selected using the preconditions, such as a change in environment and the history of the player's verbal expressions. When a story unit is selected, the possible conversation units applied in the scenes are activated.

Conversation modules have preconditions, utterance, corresponding gestures and key locations. The locomotion module dynamically plans locomotion paths and generates walking motion patterns based on key locations.

2.2 Key location control

To compose locomotion and conversation, we need to decide the character's location and the timing of walking during the conversation. The locations of the characters are influenced by where the scenes are taking place and the content of the conversations. Figure 3 shows a typical example of locomotion planning during a conversation. Assuming that the character should move from node1 to node3, it is reasonable that the character stops at node4 if the referenced object is visible enough.



a) When location (2) is near   b) When location (2) is far

Figure 3. A concept of conversational locomotion using a simple example

Locomotion and conversation are composed by considering the following three types of location constraints:

1) Scene location: The scene location corresponds to where the actions and conversations are taking place. To begin a conversational scene, the character should be at a proper location.
2) Interpersonal location: The character changes relative locations from the other characters during conversation. For example, when the character begins to talk it needs to approach the other participants. When the character tries to explain something, visibility of the referenced object is also considered to decide interpersonal location.
3) Reference location: This is the relative location of the character and the referenced object.

These location constraints are used as key locations k_n in the conversational locomotion planning. The key location consists of a position in the floor coordinate system, and a standing duration t_k at a given key location. In most scenes, the proper standing position of the character has a degree of freedom. A key location has a several candidate positions with different activation values.

The standing duration of the key location can be dynamically changed by the key location control rules in the conversation units. For example, the initial standing duration can be used to decide how long the character can talk with the player at that particular position. When conversation with the player ends, the conversation units set the standing duration to zero that then causes the character to move onto the next scene location.

2.3 Conversational locomotion network

Activating the locomotion network using story locations and conversation units controls conversational locomotion. An optimal locomotion path is selected by calculating the optimal locomotion path with the maximum activation.

The locomotion node k represents a point on the floor coordinate systems (u_k, v_k). Characters can walk away from locomotion nodes for local position adjustment. The locomotion network $N_k = (G_k, length_k)$ consists of directed graph $G_k = (K, E)$, where the edges representing distance between the nodes are represented as $length_k(e)$. The initial locomotion network is constructed by sampling the possible standing locations. The candidate node positions are story locations and objects that have been referenced previously in conversation units. To increase the possible locations, we randomly sample the possible walking space.

Associating a key location at a proper clause in utterance controls timing of locomotion. For example, the reference location can be associated with clauses including the referenced object. There are several methods for associating the key location to a clause. When the numbers of conversational modules are limited manual association may be relatively easy. Even if the key location specification is predetermined, the actual character motion is dynamically changed depending on the story locations and the order of the conversations.

Timing of utterance is also synchronized to character locomotion. As illustrated in Figure 3b, the pre-condition of conversation units are used to pause and thereby wait until the character moves to the proper positions.

3. Conversational Locomotion Planning

Key locations are activated using scene locations and activation rules in the conversation modules. The locomotion path is dynamically selected by using a multi-pass searching algorithm that calculates the maximum activated path. When the conversation units change the status of activation the locomotion path is recalculated.

3.1 Multiple pass searching

Multiple key locations are set with a different activation value. By selecting N-best key locations, the possible locomotion segments between key locations are selected. The total activation along the locomotion segments is calculated. Locomotion segments between candidate key locations are obtained by employing the method of Dijkstra described previously [Dijkstra 1959]. As shown in Figure 4, we calculated candidate locomotion segments such as P_{00}- P_{01} and P_{00}- P_{02} ,to obtain the total activation value.

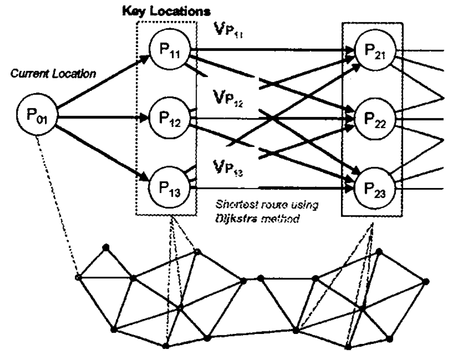
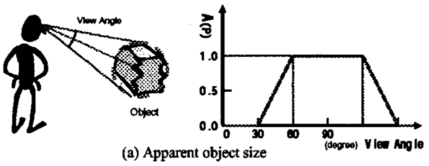


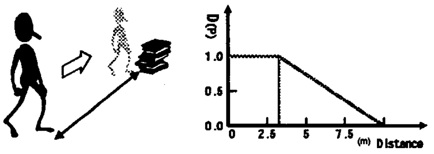
Figure. 4. Key location and multiple pass searching. N-best key location is selected to search the maximum activated pass.

3.2 Activation functions

In addition to the scene locations, we use the apparent object size and walking size to locally control locomotion. Figure 5 (a) and (b) shows the activation function used in this system.



(a) Apparent object size



(b) Distance from the object

Figure.5. Scene constraints and activation value. The apparent object size and distance form the object causes trade-off

1) Apparent object size: $A(P_{s,n})$

When the apparent size of the referenced object is small, the character should move closer until it becomes large enough to visualize easily. We determined the activation function as shown in Figure 5a. A sphere approximates the reference object, and the view angle from the player's eye position is calculated. Note that the approximated object size corresponds to the object area referred to in the conversation. When the character refers to a small area of a big object, the approximated object size is small. Orientation constraints are also integrated by forming activation distribution to a specific direction.

2) Walking distance: $D(P_{s,n}, P_{s+1,m})$

When the walking distance from the current location of the character is longer, the character tries to avoid this longer path. We determined the activation function as depicted in Figure 5b. The total activation values are calculated along locomotion segments.

$$V(P_{0,0}, P_{1,n_1}, \ldots, P_{s,n_s}) \\ = \sum_{t=1}^{s} \left\{ w(t) \cdot \left[\alpha A(P_{t,n_t}) + (1-\alpha) D(P_{t-1,n_{t-1}}, P_{t,n_t}) \right] \right\}$$

Where w(t) is a weighting value. w(t) is used to control the number of key locations that the character should consider.

Another type of activation function is easily integrated into this framework. For example, the access control of the character to a specific area can be represented. By setting the negative activation value to the specific locations, the character will avoid entering that place.

3.3 Local position adjustment

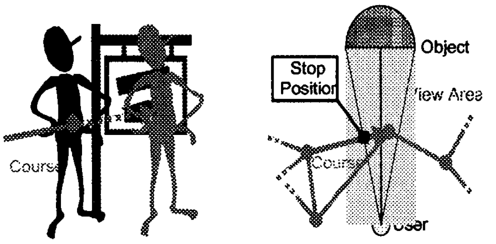


Figure.6. The local position adjustment using the player's relative position and the referenced object.

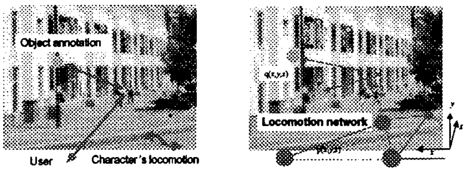
The character's position is locally adjusted so as not to obscure the player's sight of the referenced object. Figure 6 shows the concept of local position adjustment. As described in section 3.2, we approximate the reference area by using a sphere. The viewing area of the player is calculated from the 3D location of the player's eye and the reference object sphere. When the character approaches the object, it stops at the intersection of the view area and the edges of the locomotion network.

4. Panorama-Based Immersive Story Environment

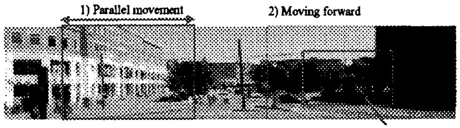
4.1 Introduction

As it is well known that constructing convincing photo-real 3D models is very time consuming, we first attempted to build a panorama-based immersive story environment to prove our theory. Virtual characters can walk and talk in a photo realistic environment by using a combination of locomotion network and object annotations. A model of the environment is approximated by the linked panorama images. The character and the player can thus move around in the photo-real scene.

4.2 The generation of node coordinates in 3D space



(a) Interaction between user (b) Locomotion network and object annotation



(c) Sight movement by user's locomotion

Figure.7. Interaction mechanism for panorama-based conversation environment.

To facilitate the character walking in the environment, we need a correspondence between the 2D panorama image and its 3D environment. We constructed the locomotion network to determine the walking area and calculate the appropriate walking path. Figure 7b shows an example of the locomotion network. Three-dimensional locations of scene objects are annotated so that the character can refer to these and point during conversations.

When the camera coordinates $\mathbf{P}_c = (x_c, y_c, z_c)$ and the 2D coordinates of the node in the panorama image are assumed to be $\mathbf{P}_n^{2D} = (x_n^{2D}, y_n^{2D})$, the 3D space where a virtual character exists $\mathbf{P}_p^{3D} = (x_p^{3D}, y_p^{3D}, z_p^{3D})$ is converted into the projection coordinates by

$$x_p^{3D} = x_c^{3D} \qquad (1)$$

$$y_p^{3D} = \frac{2C_y}{H} y_n^{2D} \qquad (2)$$

$$z_p^{3D} = f \qquad (3)$$

When a virtual character was displayed in the panorama image, it was necessary to convert the projection coordinates $\mathbf{P}_p^{3D}$ into the coordinates $\mathbf{P}_n^{3D}$ of 3D space to present the image that moves in the direction as depth changes.

The straight-line equation extracted from the camera coordinates $\mathbf{P}_c$ to projection coordinates $\mathbf{P}_p^{3D}$ is represented by:

$$y = \frac{y_p^{3D}}{f}(z - z_c) + y_c \qquad (4)$$

By employing the expression (4), when either the z or y value is determined, the other value is also determined. Then, the z value is set as a value proportional to height in the panorama coordinates by the use of the next expression.

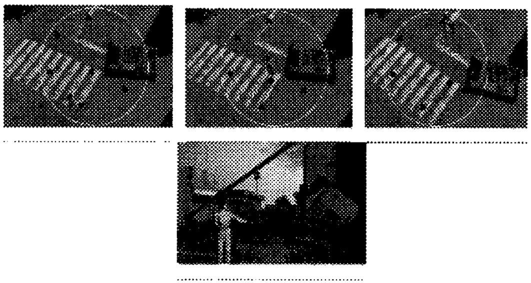
$$z_n^{3D} = \left(z_{\max}^{3D} - z_{\min}^{3D}\right)\frac{\left(y_n^{2D} + \frac{H}{2}\right)}{y_{\max}^{2D}} + z_{\min}^{3D} \qquad (5)$$

5. Experimental Results

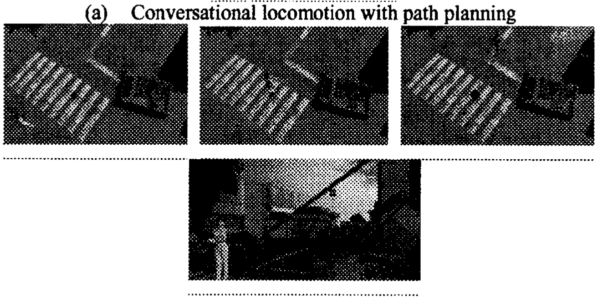
In this section we analyze the effectiveness of our technique and show an active conversation environment generated for education for disaster prevention using our approach, and the feeling of CG character's existence and the learning effect in a virtual environment were evaluated.

5.1 Composition of locomotion and conversation

Figure 8 shows the result of conversational locomotion. To synchronize locomotion and conversation, we need to determine location and timing of locomotion during conversation. Figure 8a shows a snapshot with locomotion planning, while Figure 8b illustrates a snapshot without locomotion planning. We can see that the characters try to select a closer position to explain relevant details.



(a) Conversational locomotion with path planning



(b) Conversational locomotion without path planning

Figure 8. Snapshots from a conversational locomotion sequence, illustrating the concept of locomotion planning.

5.2 Locomotion conversation based on panorama picture

A panorama of images surrounding a church (Figure 9) was constructed to confirm the effectiveness of the technique. In this panorama image, the technique mentioned previously was applied, and a virtual character moved in the panorama space while simultaneously talking with the player. Thus a movie where a virtual character acted as a guide of the building was generated very effectively (Figure10).

Figure.9. Panorama image of church

Figure.10. Snapshots from virtual trip sequences

5.3 Evaluation

What learning effect and interest could be given to the player through the conversational locomotion that we proposed in this paper was evaluated. The evaluation was executed by the investigating of questionnaire, and the previous disaster contents were used for the experiment.

In the evaluation experiment, we investigated some items such that the feeling of CG character's existence, the learning effect, and the interest from the players, and many participants had given a good evaluation.

As a result, we can say that the feeling of immersion and the character's existence have enhanced, the interest of player's learning has increased by conversational locomotion from the CG character.

6. Conclusion

In this paper, we have proposed a conversational locomotion model for virtual characters. By calculating the optimal locomotion path influenced by conversation and topic locations, the characters generate composite walking and conversation actions. The character also locally adjusts the position considering the visibility of relevant objects from the player. We have validated our model, and produced a highly accurate interactive animation sequence using conversational locomotion that will provide significant improvements to current interactive educational applications.

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