A New Cognition-based Chat System for Avatar Agents in Virtual Space

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Abstract

Short internet-based chat is typical of modern communication, especially for on-line game players. Improved chat tools are available to avatar agents in virtual space (e.g., Second Life) thanks to the fast-evolving 3D internet. The most common plain text chat is easy to use, but it is hard to understand who talks to whom. Advanced chat with 2D word balloons in 3D virtual space is difficult or unfamiliar, since it does not consider real world constraints. We propose a human-cognition based chat system for virtual avatars using geometric information. In our chat framework, if an agent (avatar) wants to talk with other people, then that agent should approach within an “audible distance” to read the text, as would be required in the real world to participate in a conversation. Additionally we propose a new model to manage the virtual chat social network over our cognition-based chatting system. Our experiment showed that the number of chat agents is saturated regardless of the number of chat agents, as occurs in real-world chat. Thus, the social-graph for chat agents is always of a manageable size in our cognition-based chat system.

CR Categories: I.3.7 [COMPUTER GRAPHICS]: Three-Dimensional Graphics and Realism—[Virtual reality]

Keywords: Virtual World, Chat, Communication, Cognitive View, Social Graph

1 Motivation

From an early stage, internet chat was supported in the form of text-based communication. We have recently witnessed advanced chat software that enables us to enjoy voice/image chat. Current chat software and component tools are rapidly evolving to adapt to the complicated and user-friendly environments demanded by users (personal agents) in 3D-based virtual worlds [Tansu Alpcan 2007]. Virtual world applications are now succeeding, due to rapid improvements in Information Technologies (ITs). For example ‘Second Life’ is a commercially successful model of virtual worlds. In such virtual spaces, chat is the most popular way to communicate among agents. The current chat environment in on-line games is simple, each avatar keeps its own chat text above the corresponding object (typically over its head) without considering other constraints. So we cannot express the human-cognitive view point in those chat systems.

In the current chatting systems, we can communicate with others without physical constraints to the talk space. This kind of “super-chat” ability is impossible in the real world. For example, in practice it is not easy for us to talk to a person who is more than 5 meters away. Such spatial restrictions are not considered in current chat systems. Therefore, we have to approach a group of agents if we wish to chat with them. There are other constraints in real world chat. For example, it is impossible to chat with more than 10 people simultaneously. Even though there may be more than 100 chat agents, we can only chat with at most 4-6 agents simultaneously. Without this real world consideration, the current chat system would have to keep chat history without interaction information. This would be burdensome where there are 1000 or more chat agents in a single virtual space. Our system applies such natural restrictions on nearby communications, as a distinct feature of our realistic chat environment. Our system is summarized simply by the motto - “if you want to chat to people, then you should go to them and talk.”

The main goal of our work is to provide more realistic virtual world chat. We would say that a distinct feature of real world chat is ‘Partial Chat’ that is quite different from ‘Complete Chat’. In ‘Complete Chat’, all participants can clearly listen (look) to the talk (word text) of other’s in a hall (virtual space). In the real world, I can hear only a few words from the chatter, if the object group is not nearby, and I can hear nothing of the conversation if the object group is more than 10 people distant to me (my avatar agent). We proposed a realistic chat system using 3D word balloons with ‘Partial Chat’ [Park et al. 2008b]. Here, we propose a more advanced cognition-based chat system and propose a new model to manage the social network among virtual avatars using our cognition-based chat system. It can be used to reconstruct the social-graph for agents in a virtual world.

2 Issues in Virtual Chat

Internet chat system changes are being promoted by fast evolving communication technologies. Initially Internet chatting services supported only plain text-based communication frameworks such as the ‘talk’ tool in a UNIX environment. Internet communication techniques have enabled us to chat in various multimedia environments through the addition of graphics or simple images. Currently, voice chatting and image-supported chatting are being used. These chatting systems are evolving to an acceptable user-friendly paradigm.

Text-based chat is the simplest way to communicate by sending plain text messages to people in the same chat room. These text-based chat systems are simple and convenient, as they can be used anywhere, anytime for ‘One-to-One Chat’ or ‘Group Chat’. However, in this simple method it is hard to reconstruct the social network among chat agents. Suppose that there are more than 10 chat agents in a single chat room. It is hard to distinguish the question and answer pairs among the chat texts appearing linearly in the temporal sequence. For example, agents $A_1$ and $A_2$ pose questions successively. Then, agent $A_3$ replies. In this case, we cannot tell if $A_3$ answered $A_1$ or $A_2$. This is an issue with text-based plain chat.

Some recent chat systems provide template image-based communication frameworks. ‘Comic Chat [Kurlander et al. 1996]’ is a styl-
ized system that automatically represents on-line communication in the form of comics. ‘Comic Chat’ provides numerous aspects of comic generation, including word balloons, characters, gestures and semantic panels using template images. It has several advantages over other graphical chat systems, including maintaining graphical history and various image presentation techniques. ‘Comic Chat’ provides three different balloon types, including speech balloon, thought balloon and whisper balloon. It provides several characters and their gestures to express user’s emotions. When a participant types dialogue, ‘Comic Chat’ determines the corresponding gesture and expression most appropriate the dialogue.

Figures 1(a)(b)(c) show snapshots of the most typical current chat systems. Current chat systems use a similar method to increase reality, but they invariably use word balloons and text messages without considering 3-dimensional spatial information. In communication systems that use only the invariable word balloons, sentences, called ‘Complete Chat’, are either totally visible or invisible. Since current chat systems display only ‘Complete Chat’ through the word balloons, they are unrealistic compared to the real world. Our system displays ‘Partial Chat’ that appears different depending upon the direction of view, analogous to keyword recognition in real world communication. Table 1 compares the features of different chat systems.

![Figure 1: Internet Chat System. (a) Text-based Chat(NATEON tool supporting Korean) with 8 chat agents. (b) A snapshot of 2-D Chat in ComicChat. (c) 2.5-D Chat in Second Life. All acting virtual agents are of 3D form, but their chat text appears on a 2D-based layer. All chat balloons are placed perpendicular to the viewer. (d) 3-D Chat (Our system). We can recognize the chat text within audible distance. In this model we perceive that some distant agents are chatting, but cannot clearly identify the text content due to the distance](image)

![Figure 2: Avatars A_a and A_b are chatting. The solid line segment denotes the width of word balloons W_a and W_b.](image)

**Table 1: Comparison of Internet Chat Systems**

<table>
<thead>
<tr>
<th>Cognitive View</th>
<th>Text Chat</th>
<th>2D Chat</th>
<th>2.5D Chat</th>
<th>3D Chat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expressing Emotion</td>
<td>Text</td>
<td>2D Avatar</td>
<td>3D Avatar</td>
<td>Balloon</td>
</tr>
<tr>
<td>History</td>
<td>Comic</td>
<td>Video</td>
<td>Graph</td>
<td></td>
</tr>
<tr>
<td>Reference</td>
<td>[Nate 2008]</td>
<td>[Kurlander. 1996]</td>
<td>[IMVU 2008]</td>
<td>Our System</td>
</tr>
</tbody>
</table>

**Definition 3.1** For two chat agents $A_a$ and $A_b$, we defined $VCB(Virtual Chat Bandwidth)$ to measure their communication capacity bandwidth.

$$VCB(A_a, A_b) = C_1 \cdot (\sin \theta_a \cdot \sin \theta_b)^{k1} \cdot (\text{dist}(A_a, A_b) + C_2)^{k2}$$

where $C_1$, $C_2$, $k_1$, and $k_2$ are control constants. [Park et al. 2008b]

This implies that the higher $VCB(A_a, A_b)$, the greater the extent to which two agents, $A_a$ chatting with $A_b$, are in clear and complete communication, and vice versa. This paper shows that $VCB$ does not increase proportionally to the number of chat agents, due to human cognitive limits. Previous chat systems mainly utilized artificial chat techniques, such as ‘One-to-One Chat’ and ‘Group Chat’ using ‘Complete Chat’ that were either completely visible or invis-

Conveying emotion is an important issue in virtual chat. One simple way of emotional talking is to send a predefined emoticon, widely used in plain chat. Some researchers have proposed improved emotion-base chat. The current 3D chat system lacks ways to express emotion. Our system is highly flexible in expressing chat mood. [Park et al. 2008a]

Keeping track of chat dialogue is crucial, since participants commonly interleave several tasks while chatting. However, most chat programs provide only textual history transcripts based on temporal sequence without an explicit relationship tag. Although ‘Comic Chat’ automatically represents on-line communication in the form of comics, most chat systems provide unstructured dialog sets.

3 Human-Cognition in Chat

In this section, we introduce our cognition-based chat system. As explained, the main object of this work is to simulate the real-world chat constraints in a human cognition model to form social interactions of a manageable size among chat agents. For a pair of two chat agents $A_a$ and $A_b$, we defined $VCB(Virtual Chat Bandwidth)$ to measure their communication capacity bandwidth.
ible. Instead, we simulated ‘Partial Talk’ utilizing 3-dimensional spatial relationships between agents.

Figure 3: (a) Agent C is connected to Group $G_1$ at time $i$. (b) C (cop) is watching A, B at time $i$, in partial talk. C cannot see A, B but recognizes that some agents are excitedly chatting. (c) B (green monster) is chatting with A. (d) A (black T-shirt) is chatting with B.

We assume that there is a virtual chat room consisting of three small subspaces. Nine virtual chat agents (denoted as A, B, ..., I) are strolling in the room. Group $G_1$ consists of agents A and B. Group $G_2$ consists of agents D, E, F. Group $G_3$ consists of agents G, H, and I. Chat agent C in the passageway gate is watching Groups $G_1$, $G_2$, and $G_3$. Although Group $G_3$ is invisible, users can recognize that some agents are chatting there. Figures 3, 4, and 5 show a topological view of the nine avatars and different views for each agent.

Current chat systems use word balloons and text messages without considering 3-dimensional spatial information. There are only sentences, called ‘Complete Chat’. Our system displays ‘Partial Chat’ that appears differently from the human-cognitive viewpoint.

4 Social Graph for Chat Avatars

The following sections consider two simulation chat models to explain our cognition-based chat system among virtual avatars. The system can be used to reconstruct the social-graph for agents in a virtual world. We provide some basic notation and definitions to explain the social models. In our system, when an avatar starts to chat (when an agent types dialogue text), the corresponding word balloon is created and placed above the agent. It is orthogonal to the viewing vector of the chat agent. That implies that each avatar always has his own word balloon above his head in the virtual space. Figure 6 shows $L_A$ and $L_B$, and the corresponding $BR(A, B)$, and three cases that could occur with two chat avatars.

For three avatar agents A, B, and C, if agent A cannot see the word balloon of B due to the word balloon of C, then we consider agents A and B are Invisible (Figure 6(c)). Now we define the chat visibility as follows:

Definition 4.1 Two agents, A and B, are represented in line segments $L_A$ and $L_B$, respectively from the topological view of chat

Figure 4: (a) Agent C is connected to Group $G_2$ at time $i+1$. (b) At time $i+1$ C is watching D, E, F in partial chat. (c) E (gray T-shirt) is chatting with D, F. (d) F (red T-shirt) is chatting with D, E.

Figure 5: (a) Agent C is looking at Group $G_3$ at time $i+2$. (b) At time $i+2$ C is looking G, H, I in partial chat. (c) G (black T-shirt) is chatting with H, I. (d) I (cop) is chatting with G, H.
virtual space. The boundary quadrangle for \(A\) and \(B\), \(BR(A, B)\), is defined as the minimal quadrangle enclosing \(L_A\) and \(L_B\).

**Definition 4.2** For two chat agents \(A\) and \(B\) in a virtual space, we say \(A\) is \(c_0\)-Strongly Visible to \(B\) (vice versa), if there are no agents in \(BR(A, B)\) and \(VCB(A, B) \geq c_0\). (Figure 6(a))

**Definition 4.3** For two chat agents \(A\) and \(B\) in a virtual space, we say \(A\) is \(c_0\)-Weakly Visible to \(B\) (vice versa), if there is at least one straight line connecting \(L_A\) to \(L_B\) in \(BR(A, B)\) and \(VCB(A, B) \geq c_0\). (Figure 6(b))

**Figure 6:** Three cases that could occur between two chat avatars \(A\) and \(B\). (a) Strongly Visible. (b) Weakly Visible. (c) Invisible.

This paper does not consider the Weakly Visible chat pair for the simple calculation, though partial chat is possible in this case. Now we want to compute the number of Strongly visible pairs of chat agents who are randomly placed in a radial-circle space and uniform-box space.

### 4.1 Social Chat Graph

We create a novel data structure, Chat Flow Graph (CFG), to manage the chat dialogue among multiple agents in virtual space. Table 2 shows the conversation in the ‘Dead Poets Society’ and Figures 7 and 8 show the resulting graphs from Table 2. This acyclic directed CFG is more flexible and superior to previous chat text that was only maintained in terms of temporal sequence without any information about question/answer pairing tags.

**Table 2:** Conversation in ‘Dead Poets Society’. We used the exact dialogue and time stamps from the movie.

<table>
<thead>
<tr>
<th>Time</th>
<th>Agent</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>A</td>
<td>“Sure, Cameron asked me, too. Anyone mind including him.”</td>
</tr>
<tr>
<td>15</td>
<td>B</td>
<td>“What’s his specialty, bootlicking?”</td>
</tr>
<tr>
<td>17</td>
<td>A</td>
<td>“He’s your roommate.”</td>
</tr>
<tr>
<td>18</td>
<td>B</td>
<td>“That’s not my fault.”</td>
</tr>
<tr>
<td>21</td>
<td>E</td>
<td>“I’m sorry. My name is Stephen Meeks.”</td>
</tr>
<tr>
<td>24</td>
<td>A</td>
<td>“This is Todd Anderson.”</td>
</tr>
<tr>
<td>33</td>
<td>E</td>
<td>“Oh, well. Welcome to Hell-Ton.”</td>
</tr>
<tr>
<td>35</td>
<td>B</td>
<td>“It’s every bit as tough as they say, unless you’re a genius like Meeks.”</td>
</tr>
<tr>
<td>37</td>
<td>E</td>
<td>“He flatters me. That’s why I help him with his Latin.”</td>
</tr>
<tr>
<td>38</td>
<td>B</td>
<td>“And English, and Trig.”</td>
</tr>
</tbody>
</table>

**Figure 7:** Chat Flow Graph. We set \(c_0 = 10\). This CFG enables agents to understand chat context.

**Figure 8:** Chat Flow Graph. We set \(c_0 = 20\).

### 4.2 Radial-Circle Model

First, we consider the radial-circle model to explain chat visibility among avatar agents enclosing a center. Suppose that one famous politician or actor is addressing his/her speech in a party, in which many people surround that person to listen closely. In the radial-circle model, all positions and viewing vectors of avatars are directed to the center. Figure 9 shows four examples of radial-circle models with different numbers of agents. We set the threshold parameter \(c_0 = 1.0\).

To avoid intersections between agents in the radial-circle model we placed each agent in the circles with different fixed radius. Table 3 shows the number of \(c_0\)-(Strong) visible edges and the corresponding \(VR_{c_0}(M)\), the visibility ratio of \(M\), a group of chat agents is fixed with the threshold value \(c_0\).

\[
VR_{c_0}(M) = \frac{\text{the number of strongly visible edges in } M}{\text{all possible edges in } M} = \frac{m(m + 1)}{2}
\]
Figure 9: Radial-Circle Model. We set the threshold parameter $c_0 = 1.0$. All avatar viewing vectors are fixed to the circle’s center. Lines denote strongly visible edges. Though the number of possibly-visible avatar pairs is $O(n^2)$, the number of visible (Strong and Weak) edges is $O(n)$, where $n$ is the number of chat agents. This means the chat bandwidth cannot be increased quadratically to the number of avatar agents. Table 3 explains details.

Table 3: Visibility Ratio From Figure 9.

<table>
<thead>
<tr>
<th>Avatar agents</th>
<th>Visible Edges</th>
<th>Visibility Ratio</th>
<th>Connected Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>9(a)</td>
<td>30</td>
<td>0.007</td>
<td>1</td>
</tr>
<tr>
<td>9(b)</td>
<td>60</td>
<td>0.010</td>
<td>11</td>
</tr>
<tr>
<td>9(c)</td>
<td>120</td>
<td>0.007</td>
<td>5</td>
</tr>
<tr>
<td>9(d)</td>
<td>240</td>
<td>0.006</td>
<td>22</td>
</tr>
</tbody>
</table>

As shown in Table 3, the higher the density of avatar agents, the lower the increment of the number of visible edges, including only strongly visible edges, and the visible ratio. Though the number of avatar agents is increased, the visibility of the chat bandwidth cannot be increased in proportion to the number of avatar agents. Finally, the number of visible edge becomes saturated.

4.3 Uniform-Box Model

We experiment with another chat group where there is no centric point. In this model, we assumed that each chat agent tries to talk with the adjacent agent to minimize the interference of neighboring agents. One typical example of this model is an icebreaking party in a big hall. In the uniform-box model, all avatars are in fixed positions. Each avatar can rotate around at his position to chat with other people. Edges between two avatar agents are determined through the visibility relationship. If two avatars are strongly visible, then they are connected. Figure 10 shows four examples of uniform-box models with different numbers of agents. We set the threshold parameter $c_0 = 1.0$.

Table 4: Visibility Ratio From Figure 10.

<table>
<thead>
<tr>
<th>Avatar agents</th>
<th>Visible Edges</th>
<th>Visibility Ratio</th>
<th>Connected Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>10(a)</td>
<td>30</td>
<td>0.045</td>
<td>7</td>
</tr>
<tr>
<td>10(b)</td>
<td>60</td>
<td>0.037</td>
<td>10</td>
</tr>
<tr>
<td>10(c)</td>
<td>120</td>
<td>0.033</td>
<td>3</td>
</tr>
<tr>
<td>10(d)</td>
<td>240</td>
<td>0.026</td>
<td>1</td>
</tr>
</tbody>
</table>

As shown in Table 4, as in the radial-circle model, the number of visible edges cannot be increased quadratically to the number of avatar agents. It too is saturated. This is similar to real-world chat. For example, many people chatting in a wide room cannot hear all conversations, since a human can only chat simultaneously to a maximum of three or four people, and there are spatial constraints among avatar agents.

5 Experiment

This section explains our experimental results. Figures 11 and 12 show $VR_{c_0}()$ curves with the radial-circle model and the uniform-box model, respectively by varying $c_0$ threshold constants. For each value of $c_0$, we conducted at least 50 different test cases to obtain an average.

This graph empirically shows that the relationship between the number of avatar agents and the number of visible edges. We tried to form an analytic model for $c_0$-Strong Visibility model using the curve fitting algorithm in Mathematica (version 5.2).
As shown in figures 11 and 12, we can find converging points. In chat agents, our curve fitting, we try to find the optimal constant $a$, $b$, and $c$ in $f(x) = ax^b + c$ that minimizes the least-square error. This experiment revealed that the number of strongly-visible chat pairs does not increase quadratically (saturate) in proportion to the number of chat agents.

As shown in figures 11 and 12, we can find converging points. In spare chat space, the number of visible edge is dependent on $c_0$, but in highly compact room, it is independent of $c_0$. In a fixed area of converging point is saturated regardless of $c_0$.

## 6 Conclusion and Future Work

Chat is the basic communication form for Internet users, especially for virtual space agents. The current 3D Internet chat tools are so complicated or insufficient to simulate real-world physical chat features, such as conveying mood. In this work, we exploited cognition-based chat techniques to support a natural chat environment that enables ‘Partial chat’. We created a social graph. Our experiment showed that this kind of restricted communication is reasonable to internet users, since this approach enables us to manage the social chat discourse in a highly structured form. Our experiment with two chat models (radial-circle and uniform-box model) showed that our social chat graph is efficient in managing virtual chat regardless of the number of chat agents. Our system (based on JAVA 3D) is being improved to allow more than 500 chat agents to chat simultaneously in a single virtual space.

## References


