Demo Abstract: Integrating Sensor Presence into Virtual Worlds using Mobile Phones

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1. INTRODUCTION

Virtual world simulators represent one of the latest and most successful frontiers of online entertainment. Among them, Second Life [5] is the tenth most popular Internet-based virtual world [2] in terms of subscribers with over 500,000 active users. A client program called the Second Life Viewer allows it's users (called *residents*) to interact with each other through mobile *avatars*. Inside the game, residents can socialize and participate in individual and group activities. The appearance of an avatar has a wide range of physical attributes. She may be customized to produce a variety of forms. Avatars may be completely invented, without any relation to the physical aspect of the human user, or can be made to resemble the human whom they represent. However, in the current system, there is still a divide between the virtual world and the real one. Specifically, a user may be able to recreate her appearance but she can not automatically mirror/translate her current actions and movements in her real life to the virtual life of her avatar.

Our vision is to bridge the current divide between real worlds and virtual worlds, by having real world activities (e.g., sitting, walking, running, cooking) and other aspects of the human represented in real time in the virtual world [5]. Our aim is to go a step further than simply reproducing spaces (e.g., rooms, buildings, public spaces [6]) and the objects with which humans interact. We focus instead on the provision of the virtual representation of humans, their surroundings as sensed by the humans themselves, and interactions with the members of their social networks (e.g., fetched from external sources like Facebook [4]).

2. DESIGN

The ideal devices to build large-scale pervasive systems and people-centric applications [1] are mobile phones. The increasing availability and affordability of devices such as the Nokia N95, the Nokia 5500 and the Apple iPhone with embedded sensors indicate a promising future for large-scale mobile-phone-based sensing systems.

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Our current design sources sensor data collected from commercial off-the-shelf smart phones (e.g., Apple iPhone, Nokia 5500 Sport, Motorola PSI) equipped with embedded sensors, or via sensors packaged in external devices connected to the phone via Bluetooth. Activities inferred from a user's real world data are enacted by the user's avatar, either directly or translated via a user-defined mapping to a different action (e.g., jumping in the real world may map to flying in Second Life).

Many user-specified visualization policies for inferred activity may exist. For instance, some users might want to visualize their physical activities in the virtual world even if the recognition performance is poor. Other users may prefer to discard the information in this case. Alternatively, a default activity (e.g., standing) can be preset, which will be visualized if the system is not able to perform activity recognition with a sufficient accuracy. Other significant aspects in the design of the system include:

Scalability. Given the potentially high number of users, designing for scalability is important. To reduce the number of status updates flowing into the Second Life visualization, the status/activity of the virtual avatar is updated only when the inferred status/activity of the human user changes. This, in turn, is dependent on how often the activity classifier is executed. By leveraging historical activity traces, we propose to set the classifier execution frequency proportional to the degree of variability of the user's past behavior.

Intermittent Connectivity. Cell phones may experience intermittent connectivity due to limits in network coverage. Virtual avatars should be set to a meaningful state (e.g., a question mark appearing above the avatar) during these disconnected intervals, or when a certain time interval has elapsed without receiving any new update. Delay tolerant mechanisms can also be adopted to temporarily store user status locally on the phone in case of disconnection.

Privacy and Social Implications. Users should be able to disconnect from the virtual worlds at any time or be able to interrupt the sampling of their activities. The actual positions and the actions of users in the virtual world may be disclosed according to pre-configured user policies (e.g., only to one's listed buddies imported from other websites like Facebook [4]).

3. PROTOTYPE

Our prototype implementation is built as an extension to the CenceMe platform. CenceMe is a general personal sensing system that enables members of social networks to share their *sensing presence* with their buddies in a secure manner. We give a brief overview of the CenceMe platform in order

Figure 1: Second Life display of near-real-time inferred activities injected from CenceMe. Three states set by the CenceMe infrastructure are translated according to a user-defined mapping: sitting → yoga-floating (left), standing → standing (center), and running → flying (right)

to understand the architecture of the current implementation. For more detailed information on CenceMe see [7]. CenceMe is able to provide information about personal status of the users and their surroundings. Similarly, by mining the sensed data CenceMe can extract patterns and features of importance in a user's life routines, such as the current status in terms of activity (such as sitting, walking, meeting friends), mood (such as happy, sad), physical or logical location (such as at the gym, coffee shop, at work).

The bridging between CenceMe infrastructure and Second Life is based on the exploitation of virtual CenceMe objects that the Second Life avatar can wear or carry. The CenceMe object is implemented as a standard Second Life object that we program to communicate with the CenceMe infrastructure via XML encoded requests and responses exchanged via HTTP. Second Life CenceMe object behavior is written in LSL (Linden Script Language [5]). The interactions with the CenceMe infrastructure use the same CenceMe external application extension APIs as other application plug-ins (i.e., Facebook, Pidgin) that have been constructed (as described in [7]). Objects acquire new state by polling CenceMe infrastructure at a rate that can be set by users (within ranges defined by CenceMe administrators). The avatar can disconnect from CenceMe by taking off the object. The virtual object type dictates the nature of the integration.

We use a clothing metaphor to provide an intuitive way for people to configure and control the mapping of their actions. In Figure 1 we show a number of screenshots of an avatar that carries a CenceMe virtual object (in this case, a pager - see inset). This object alters the avatar animation to reflect the actual activity state of a human user carrying a cell phone that is running the CenceMe sensor application. In the figure, we show three states set by the CenceMe infrastructure and translated according to a user-defined mapping: sitting → yoga-floating (left), standing → standing (center), and running → flying (right). Details about the activity classifiers can be found in [7]. Alternative CenceMe clothing and accessories include significant places [7] t-shirts that display the logo graphic representing a location of significance in the user's life (i.e., the home, gym, pizzeria, etc.), and virtual mood rings that display the inferred emotional state of the human.

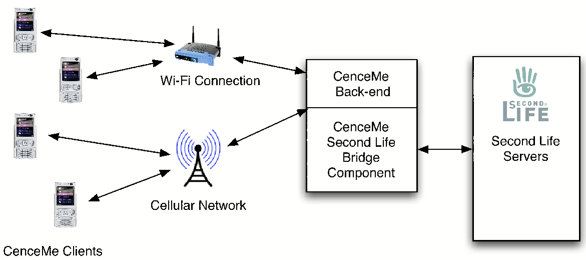

Figure 2: Architecture of the system bridging CenceMe and Second Life

We are augmenting our current implementation to: investigate controlling movement in the geographical space; define appropriate privacy policies; and develop mechanisms to address periods when the avatar becomes disconnected from the physical user, or when inferred user state accuracy falls below an acceptable bound.

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