Social Gaming as an Experimental Platform

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ABSTRACT

In the past few years, there have been many examples showing the use of game environments as experimental platforms to advance science research. For some scientific research questions, specifically pertaining to social psychology, social believability and structure of the game environment and the characters inhabiting this environment is important. In the past year, we have started a collaborative project with psychology researchers utilizing game environments to investigate the relationship between non-verbal behaviors and trust. This study was motivated by psychological findings uncovering evidence suggesting that older adults appear to be less likely to differentiate trustworthy from untrustworthy nonverbal cues. In order to conduct such studies within a virtual environment, the environment needs to have virtual characters that are ***socially believable***, ***behaviorally consistent*** yet ***controllable***. This paper discusses a work in progress developing a novel gaming architecture composed of a set of semi-autonomous socially believable characters with different personalities, a scenario system, and a Wizard of Oz interface for psychologists to manipulate characters' behaviors. The paper discusses the current state of the art of the system and future directions of its use.

Categories and Subject Descriptors

H.5.Information interfaces and presentation (HCI). H.m. Miscellaneous.

General Terms

Design, Human Factors

Keywords

Believability, social narrative, game, virtual worlds

1. INTRODUCTION

Games and virtual environments have the potential to be used as experimental platforms geared towards investigating scientific questions with the goal of advancing science in many fields, including psychology, social science, cognitive science, and learning science, among others. This argument is not new; in fact several researchers have made similar arguments. For example, Blascovich et al. [6] have stated that immersive virtual environments can be used as a methodological tool for social psychology. Gratch et al. [10] discussed the use of virtual humans as a toolkit for cognitive science research. There are many examples of this approach showing its potential impact, including experimental work focusing on psychology [1, 2, 12, 15], learning and education [3, 28], and policy [5].

In the past year, we started to investigate the effect of nonverbal behaviors on trust. This study is motivated by early findings reporting both behavioral and neural evidence for age differences in response to trust cues in nonverbal behavior. Specifically, older adults appear to be less likely to differentiate trustworthy from untrustworthy nonverbal cues [7]. This evidence suggests that older adults are more susceptible to fraud. One problem with existing research on age differences and trust involves the reliance on judgments of faces; these faces may or may not display veridical cues regarding trustworthiness. That is, consensus exists about what faces appear trustworthy, but the actual validity of static facial cues in predicting actual behavior has been called into question [23]. Of course, in real life, judgments of trustworthiness involve assessments of a stream of behavior over time. The work by DeSteno et al. [8] has demonstrated that examination of dynamic sets of cues can predict trustworthy behavior.

To investigate this phenomenon, a controllable repeatable environment is required where many factors can be kept constant, and where specific nonverbal behaviors can be manipulated and repeated across subjects with minimum variability. This is hard to create in real life. While it is easy to get an actor to portray a character and ask them to make specific gestures, or convey specific nonverbal behaviors, the exact behaviors are hard to replicate across samples without much variations. Further, psychologists cannot ensure that the performance and the context are constant. Virtual environments provide a controllable environment with enough flexibility to enable the investigation of this topic.

However, technological development of this environment is not trivial. Specifically, the environment and the characters within it should be ***socially believable***, ***behaviorally consistent*** yet ***controllable***.

This paper discusses a work in progress addressing this issue. In particular, we will focus on discussing the virtual environment we have created for this experimental work. In particular, we are leveraging much of the research in interactive narrative and virtual agents (e.g., [14, 18, 22]) to develop a novel gaming architecture composed of a set of semi-autonomous socially believable characters with different personalities, affective states, and a Wizard of Oz interface for psychologists to manipulate characters' behaviors.

The contribution of this work is two fold (a) for science: an infrastructure for conducting controllable scientific experiments revolving around social, affective, and relational research questions, and (b) for virtual worlds and games research: an infrastructure for social and relational agents that can be puppeteered within virtual environments to develop new kinds of interactive narratives or social games.

2. RELATED WORK

This project involves work in three main related areas: (1) the use of games as experimental platforms, (2) the creation of socially appropriate virtual characters and environments, and (3) the use of Wizard of Oz for puppeteering. Below we discuss each.

2.1 Games as experimental platforms

Games as experimental platforms are starting to appear projecting utility and impact in many fields including cognitive science and learning science, to mention a few. While a review of this work is beyond the scope of this paper, we will briefly discuss some prominent examples.

Researchers at the Center of Games, Learning and Society at University of Wisconsin, Madison have been developing games for many years with the goal of investigating the fundamentals of learning in a socio-cultural environment [29]. There are many challenges in using such an approach, including developing engaging game learning environments, encoding learning objectives in game tasks, and appropriately assessing learning within game environments. However, the utility and impact of the approach outweigh the efforts needed to overcome these challenges.

For exploring social and psychological constructs, Blascovish et al. [6] advocate the use of virtual and game-like environments as an experimental playground to understand social and psychological constructs. Following this work, the Virtual Human Interaction Lab at Stanford explored many psychological constructs within virtual environments to further our understanding of social psychology and human behavior [1, 2, 3]. Additionally, the Institute of Creative Technologies (ICT) at University of Southern California developed virtual humans capable of interacting effectively with human participants through natural language and gesture [11, 13, 21]. They have recently started to use virtual environments inhabited with these virtual humans to investigate emotions, decision making, and other cognitive science constructs [10, 15].

A huge advantage of having an experiment setup in the virtual, rather than physical, space is that it allows collecting experimental data across many samples in a reliable and repeatable format, thus addressing questions of replicability, sampling, and reliability.

2.2 Virtual Social Situation Development

Creating socially believable virtual characters is an open problem. There has been several research work devoted to this problem. For example, the Oz project [4, 16, 23], developed in the 1990s, with the goal of creating virtual worlds inhabited with believable characters that users can interact with. This work resulted in many novel architectures and systems, including a novel believable agent architecture that embedded systems for computing and expressing attitudes and emotions. Agents in the Oz project had their own goals and used reactive planning to select behaviors at a given context based on their internal state, which included a model of attitudes and emotions.

Building on the Oz project, Mateas and Stern [14, 15] developed an interactive drama called *Façade*. Façade used a reactive planning based behavior language to select story units and behaviors to move an overarching plot along an escalating drama. Façade added a natural language component, where users communicate with characters through natural language. Additionally, Mateas and Stern [17] added a behavior language called ABL, which allows authors to encode realistic behaviors in Java-like syntax. The language extended the Oz project's *Hap* [15] by adding a multi-agent coordination system.

On another front, Seif El-Nasr [20, 21, 23] developed *Mirage* introducing a new architecture, building on the Oz project. Mirage emphasized the use of improvisation and acting theories for shaping character behaviors within a virtual scenario. *Prom Week* [20] extended previous work adding social goals. In particular, in Prom Week the user is required to solve character's social goals, such as helping a character become the prom king or dating another character. Each character has its own social relationships and status, which determine how the social exchanges will play out.

In addition, the virtual humans toolkit developed at ICT harnesses over fifteen years of research in developing virtual humans [27, 28, 29]. The goal of the virtual human project is to develop virtual characters with the ability to engage in natural language conversations with a user exhibiting naturalistic gestures and appropriate behaviors. Smartbody [31] is the underlying system within the virtual humans toolkit providing synchronization between speech, low-level animations and various routines for blending animations. Cerebella [16] further extends Smartbody automating parts of the process, such as listening behavior. The system takes as input the utterances, which can be a prerecorded audio clip of the character or live audio stream, and outputs suitable accompanying gestures to support the speech. The system has demonstrated high-quality human-like behavior when operating offline and is being developed for online performance.

While previous work did not address our specific problem, they signify a solid ground from which to build our current project. Specifically, we are integrating ABL with Smartbody in our system, which is discussed next.

3. SYSTEM

3.1 Goal

Our goal is to develop a virtual environment that embeds socially believable characters, which can be used to investigate social psychology constructs, such as trust, nonverbal behaviors, social affect, etc. To understand these constructs and investigate them in more detail, we developed a virtual environment infrastructure composed of virtual characters constructed as semi-autonomous agents that can be controlled by a Wizard of Oz interface (a psychologist behind the scene). The character architecture is developed to be semi-autonomous, and thus is able to carry out an interaction with a user and other characters if no direction is given but can also adapt when one is given through the Wizard of Oz interface. In order to investigate the social constructs discussed above, we needed ways to encode different personalities. For this infrastructure, we chose to start with warmth (high and low) and competence (high and low).

3.2 Architecture of the Agent's Behavior

The character's architecture, depicted in Figure 1, is composed of several systems and models. The architecture includes a computational model of personality along two dimensions: warmth and competence. Note that these dimensions are not orthogonal. The architecture also includes a model of affective state modulated over time, e.g., temperament, boredom, etc. We also included an event-based system for adjusting the affective states and a planning system that produces behaviors based on character's internal states: goals, affect and personality. We then use SmartBody to model behaviors and produce physical actions in terms of animations and audio utterances that are fed to the game engine for rending.

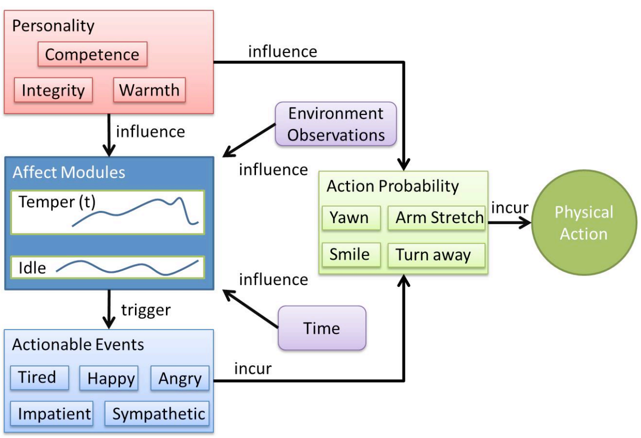

Figure 1. Architecture

Our planning architecture is inspired by the reactive planning system used in Façade [14, 15]; for more details the readers are referred to the original publication [16]. Briefly, ABL facilitates planning that takes into account the disruptive nature of the environment, such as when dealing with non-deterministic entities. Behaviors are encoded as *action plans* consisting of parallel and sequential goals, the successful execution of which determines the success of the encompassing behavior. While executing, as the environment changes dynamically, the *sensory* system perceives the world and updates its internal *working memory*, allowing real-time assessment of goal success status. If a goal in the plan fails or the current perceived context signals that the plan's execution condition is no longer valid, planning is restarted.

While powerful and allowing high expressivity, off-the-shelf ABL (the language and system powering Façade) does not instantly work for us. There is no notion of socially acceptable or personality-specific behavior. In particular, we want to vary a character's behavior according to her personality along two dimensions: warmth and competency. Besides, there is no defined mechanism to drive a character of hybrid control nature such as our agent character, one that can act autonomously on her own and be puppeteered at the same time. Our architecture is designed to build on top of ABL the ability to have personality-specific behavior while acting in a semi-autonomous manner.

We thus designed our agent's architecture to encode: (1) a model specifying a personality, (2) a computational model for encoding an internal affective state, and (3) a system that fluctuates temperament based on time and actions.

In our current system, the agent character's **personality** is defined as two continuous variables: competence and warmth. We chose these two variables because psychology literature often refers to them as the basic dimensions that when combined account largely for how people characterize and respond to others, especially when assessing their trustworthiness [9]. Thus, these attributes determine the overall mannerism of the character in terms of nonverbal behaviors: gesture, synchronization of gesture and speech, speed of gesture, gaze orientations, frequency of weight shifts (changing of the body posture), and the frequency and direction of gaze shifts. For example, a competent character would exhibit a very low frequency of weight shifting. An incompetent character would exhibit more gaze avoidance.

The liveliness of the character is driven by temperament and affective states (Figure 1). In our implementation, the "Idle" module progresses independent of the character's personality. This module dictates how frequently certain actions are executed, given no significant affect event, thereby characterizing the idling behavior nuances that most people have. For instance, an idle person who is not allowed to move freely has the tendency to shift her gaze or weight occasionally. The "Temper" module's progression on the other hand depends on each specific personality's attribute configuration. One heuristic we encoded is: a person with high competence and low warmth could be highly-tempered, i.e. "Temper" value increases at faster speed, becoming impatient more easily than one with high warmth. These heuristics are rules that can be adjusted through an authoring tool.

The affect module is currently a simple trigger that produces **actionable events** when a certain affective state is reached. For example, a Tired event is triggered when the Idle value exceeds a specific time value, thus moves the agent to a different affective state. These threshold values are currently set using video recordings of idle human subjects, as will be discussed later.

Each actionable event corresponds to a set of **probable primitive actions** that the character can do. Note that the personality also has influence on this set, characterizing the mannerism of the character in expressing her inner state. Finally, a **physical action** is sampled from this set to be sent to the animation engine. To complete the affect loop, some exhibited actions may influence the affective state variables.

We use Smartbody as the animation engine, receiving input from our extended version of ABL. Smartbody takes as input files or text in the Behavioral Markup Language (BML) format and turns them into time-synchronized character animations. A sample block of BML codes is shown in Table 1.

```
<speech ref="Start" id="sp1" type="application/ssml+xml">
        <mark name="T0" />OK,
        <mark name="T1" />
        <mark name="T2" />well,
        <mark name="T3" />
        <mark name="T4" />shall
```

```
            <mark name="T5" />
            <mark name="T6" />we
            <mark name="T7" />
            <mark name="T8" />start?
</speech>
<gaze target="Ted" sbm:joint-speed="0 120 120" start="0"/>
<gesture lexeme="SHRUG" speed = ".7" stroke="sp1:T8" />
<face au="1" side="both" start="sp1:T6" type="facs"/>
```

Table 1. Sample BML code that synchronizes a time-stamped pre-recorded speech with gaze, gestures and eye brow movements

Each action is described as a BML block that defines how a group of utterance and body movements should be played together. Smartbody facilitates both simple animation blending and more complicated gesture coarticulation, which swiftly connects sequences of gestures without losing the essence of each component gesture[1].

Suitable actions sent to Smartbody are computed by a group of ABL files, the structure of which is depicted in Table 2. Basically, the behavior of an agent is driven by three parallel goals: Executes speech actions and gestures in interaction or presentation periods, or expresses his/her internal affect state, triggered by actionable events (initial_tree). If the preconditions of these goals are satisfied, they will be executed. Although the goals are defined as parallel, we make sure that interaction and presentation's conditions do not ever overlap, while affect expression can happen any time.

```
sequential behavior manageInteraction() {
  with (persistent) subgoal interaction(); }

sequential behavior manageActionableEvent() {
  with (persistent) subgoal eventTriggered(); }

sequential behavior managePresentation() {
  with (persistent) subgoal nextPresentationParagraph(); }

sequential behavior interaction() {
  precondition {
   (InteractionWME mood::m sentence::snt start::start)
   (start == true)
  }
  act respond(mood, sentence);}

sequential behavior eventTriggered() {
  precondition {
   (ActionEventWME event::e)
   (e != None)
  }
  act execute(e);}

sequential behavior nextPresentationParagraph() {
  precondition {
   (PresentationWME paragraphLoc::loc start::start)
   (start == true)
  }
  act present(loc);}

initial_tree {
  with (priority 3) subgoal manageInteraction();
  with (priority 2) subgoal manageActionableEvent();
  with (priority 1) subgoal managePresentation();
}
```

Table 2. Sample ABL code that defines interaction and presentation periods. Note that while the system automatically determines the expression mannerism during presentation periods, the actor needs to furnish the mood and sentence to respond during the interaction periods.

3.3 Wizard of Oz Interface

For the experimental platform, we created two separate interfaces: one for the user and the other for the WOZ (henceforth referred to as the ***wizard***). Both the user and the wizard control their respective avatars in a simulated scenario.

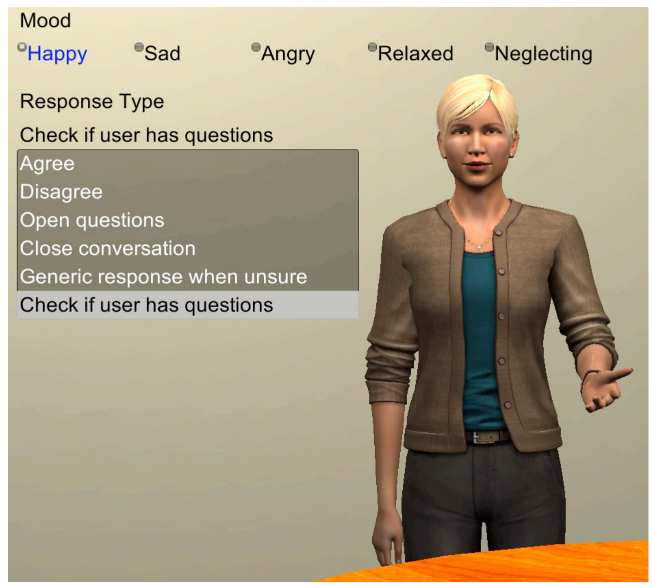

Figure 2. The Response menu in the Agent interface.

Each experimental scenario is comprised of interleaving speech and interaction periods. During the speech periods, the planning system takes control of the virtual character, selecting personality-matching sentences and accompanying gestures to deliver the speech. When the user interrupts or during the interaction portion, the control is negotiated between the wizard and the semi-autonomous system. Figure 2 depicts the interface that the wizard sees. In particular, he is able to puppeteer the avatar via a high-level menu of actions, in which he/she can select a response type and a mood to accompany the response speech. When the speech is played, the mood selection is fed into our planning system to generate primitive actions (posture/gestures/facial expressions) that are consistent with the character's personality and current

[1] http://smartbody.ict.usc.edu/HTML/SmartBodyManual.pdf

affective state. The wizard has the choice of navigating this menu using either keyboard/mouse or an Xbox gamepad.

While the wizard can only select pre-recorded speeches and accompanying mood, the user is allowed to communicate through a microphone system and control his/her avatar with a minimal set of basic gestures such as “Nod”, “Shake Head” and “Interrupt”. As such, we let the user press some predefined computer keys to execute corresponding gestures.

3.4 AI for social believability

In this project, we approach social believability by linking non-verbal behavior with a character’s personality. The idea is to invoke believability through persona-specific behavior and mannerisms. For instance, a character with a warm personality will exhibit a very different set of non-verbal behaviors (e.g., arms often open wide) than a character with a cold personality (arms usually crossed creating distance).

To make our characters as believable as possible we need to construct a set of gestures that will be highly indicative of each personality (high/low combination for competence and warmth). We developed a gesture set for each of the four personalities through several iterations where actors were filmed performing a pitch with a given personality. Each video was evaluated and the result used to improve the instructions given to the actors in the subsequent iteration. In the final iteration, the actors exhibited distinct difference in gesture selection and the display of specific gestures for each of the personality types. For example, in the case of a warm personality (high warmth) there was a higher frequency of smiles, open gestures and of facial expressions, in general, than for a cold personality. Additionally, actors performed more posture and gaze shifts for low than high competence. Another behavior observed for competence was the timing of gestures. Actors performing as competent had more appropriately timed gestures than those who performed with low incompetency. Incompetent characters had a slight delay when exhibiting gestures accompanying speech. These are only a few examples of the factors we found through coding videos of performances with actors exhibiting these personality variations.

The character’s behavior needs to be consistent throughout the experience. This is done through ensuring that the action selection system takes into account the character’s personality when choosing actions. For instance, the action “shake hand” in the context of “user responding well” and a warm and competent character personality will be mapped to right hand extended, body leaned forward and a smiling face. The same action for the same context but a cold personality will also map to right hand extended but with a stiff body and a straight face.

Determining heuristics for mapping gestures and behaviors to perceived personality traits (in terms of warmth and competence) is key to allowing the planning system to determine what low-level actions to carry out to maintain consistent personality for the character. In the context of our work, this will give the wizard the ability to select an action through an interface without having to maintain consistency in the character’s low level gestures and behaviors and how they are displayed, but instead have the system handle this mapping.

4. IMPLEMENTATION

4.1 Scenario

As discussed earlier, this project was motivated by early findings in psychology reporting evidence for age differences in response to trust cues in nonverbal behavior, specifically that older adults appear to be less likely to differentiate trustworthy from untrustworthy nonverbal cues [7]. Thus, our goal in this implementation is to specifically understand the relationship between trust and nonverbal behaviors. For this implementation, we developed a simple single-player game using the infrastructure discussed above. The user is given $10 at the beginning of this game, in virtual currency. He is told he can double it by choosing the right agent to invest with. The game starts with a backstory indicating that a user is about to meet four financial agents in a bank where they can choose to invest the virtual money they were given. The user starts at the entrance of the financial firm with pictures of four characters – the financial agents. As he enters the firm, he is taken to the elevator, where he has a choice of which floor to go to. Next to each floor number there is a picture of the agent occupying that floor. The user is given a choice to select who to visit first. Once that choice is made, the user is taken through the elevator to the virtual agent’s room. The agent will then pitch a financial plan with estimated return on investment. The user is free to interact with the agent through speech and gestures. They can interrupt them or do whatever they please. After the agent finishes his/her pitch, the user is asked if they have any questions. If not, they will then be transported to the next agent to visit. This process goes on until all four agents are visited. At the end of these visits, the user is then asked to select the agent they wish to invest with.

4.2 Current State

At this time, we are in the process of evaluating and tuning the system. For example, the set of heuristics that we developed to map mannerisms, gestural and gaze behaviors and their manipulation over time is still under construction and is being evaluated through a feedback and validation study. In particular, we have devised two techniques to allow us to iterate on the designs of these heuristics to get us to an acceptable state. First, we are iterating over the heuristics through feedback from a panel of experts composed of psychologists, directors, and virtual character experts. Second, we are planning a validation study through Mechanical Turk where we will ask subjects to rate videos of interactions with different character types as: high warmth and high competence, low warmth and high competence, high warmth and low competence, and low warmth and low competence. Through this experimental approach we hope to develop a set of heuristics that can allow us to procedurally manipulate character’s actions while sustaining their personality type along the dimensions of warmth and competence.

5. CONCLUSIONS

In this paper, we provided a brief overview on our effort in leveraging game technology to create an experimental platform for a psychology study around nonverbal behavior and trust. The paper presents a first step to develop an infrastructure for conducting controllable scientific experiment revolving around social, affective, and relational research questions. We believe this infrastructure will also have a transformative effect on interactive narratives and games as it can open new venues for interactive social interaction within virtual environments, perhaps a step towards more socially engaging interactions mediated through virtual worlds.

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