Title: *GretAR - Virtual Agent's Spatial Behaviors in Augmented Reality Environments*

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Abstract: The GretAR project aims at developing an environment/framework to study the interaction between humans and virtual agents in Augmented Reality (AR). The research will be focused on the spatial nonverbal behaviors, the sense of presence, the proxemics behavior and other social behaviors in AR environments.

2. Project objective:

The two main objectives of this project are as follows:

(1) Build a framework that integrates a Virtual Agent (VA) with an Augment Reality (AR) environment.

(2) This framework will be used to conduct experimental studies to investigate the social behaviors and the sense of presence of virtual agents in AR.

To achieve the main objectives of this project we propose a scenario in which spatial relations between the agent, human participants and other real objects are exploited. The scenario is based on allowing the participant to interact with the VA to help find hidden objects in a closed room. The agent is then able to move and assist the participants in where to look-for within the room. In such a simple interaction scenario various spatial relations may occur between the participant and the VA, such as the variation in distance between the agent and the user and their orientation. Also, several nonverbal behaviors that refer to the position and location of the objects in the space can be further investigated.

The described scenario allows us to investigate research questions regarding the role of VA in AR-based application. We can fully exploit the advantages of AR i.e. the relation with the real space and the sense of presence. The same scenario can be also easily realized with different media such as virtual reality or physical robots which allows one to compare them.

The project will be mostly based on existing software and hardware: the Greta virtual agent developed by Telecom Paristech (*Niewiadomski et al., 2009*) and ARToolKit (*Wagner et al., 2006*) created at the HITLab NZ. The *Greta agent* is able to use verbal and nonverbal channels to communicate its intentions. The control of the agent is realized using the standard XML-based language (e.g. BML, http://www.*mindmakers*.org/projects/*BML*). *ARToolKit* is a software library for building Augmented Reality applications. During the project several modules will be developed: Planner for Deictic Behaviors, Lexicon of nonverbal behaviors, Dialogue Manager, Path Planning Module, Detector of

user position and orientation. We also plan to work on visual and auditory representation of VA in AR.

In more details, during the eNTERFACE 2011 project, we will create a high level commands language to control the agent's behavior. Such a language will be used in a Wizard-of-Oz interface allowing a human participant to control the agent's behaviors. Examples of commands are "*indicate object X*" or "*approach object Y*" that will be combined with a verbal content. The **Planner of Nonverbal Spatial Behaviors** will generate a sequence of BML commands that expresses the agent's intention. The Planner will use other two modules that will also be created during the summer school. The first one - **User Position Detector** - will serve to detect in real-time the position and orientation of the user. The second - **Path Planning Module** - will maintain the topographic information about the room and the position of the objects. During the project a **Lexicon** of the nonverbal behaviors will be created from the literature (e.g. Hall, 1963; Clark 2003) and/or the annotation of a corpus. Regarding the verbal content, a WoZ, or a **Dialogue Manager** will be used.

We also plan to work on audio\visual presentation of the VA in AR. At the moment Greta agent is not able to walk naturally. Thus, regarding the visual presentation a **Model of Walking** should be developed. Finally, **Auditory Model for Spatial Impression** should be also added as the position and orientation of the agent changes during the interaction.

The second part of the project will focus on the analysis of the user's reactions towards VA in AR. Firstly we plan to analyze if the user's reactions in AR are consistent with the proxemics theory of Hall (1966). For this purpose we aim at measuring the physiological reactions of the user as a response for invading the user personal space by the agent during the experiment. From literature (e.g. *Llobera et al., 2010)* the arousal measured through skin conductance rises in such situations. Thus, measurement and interpretation of physiological data are indispensable to check if the human reactions for VA in AR are similar to reactions in real world.

We also want to check if different social behavioral strategies of the agent may influence these user reactions (e.g. if the personal distance may be reduced). Finally we also plan to compare the impact of AR based environment with different media that can be used in the same task such as voice/text only, virtual reality etc.

Our project requires a high interdisciplinary collaboration from different fields. We expect contribution from many different domains such as computer graphics, sound modeling, linguistics and human sciences. Constructing a framework and an environment to support virtual agents in AR will allow the project participants to conduct further research with different scenarios after the eNTERFACE 2011 workshop is concluded.

3. State of art:

The virtual agent technology was integrated in augmented reality in location-awareness scenario by Schmeil and Broll (2007). In that scenario the user, walking outdoor, is informed about the several facilities by the virtual agent. The system is composed of ARToolKit integrated with GPS unit.

The impact of virtual environment was often analyzed. The proxemics behaviors in a virtual immersive reality environment were studied by several researchers including Bailenson et al. (2003) and Llobera et al. (2010). In Llobera et al. (2010), the effect of approaching virtual objects and characters on the user arousal was observed in immersive virtual reality environment. Kastanis and Slater (2011) proposed a virtual reality based scenario in which the virtual agents learn to maintain the right personal distance. However, to our knowledge similar studies are not conducted with virtual agent in augmented reality environments.

The concept of proxemics was also used to create a multimodal interface by Ballendat et al. (2010). In their system the position of the user and its orientation towards a LCD screen influence the content presented on the screen.

4. Detailed technical description:

a. Technical description

Our project is organized in a modular structure and contains several main tasks. Some of them are necessary while other will be developed depending on the interest and capabilities of the project participants.

The following describe the main tasks of the proposed project:

- *Nonverbal behavior planner:* at the moment the Greta agent is driven using BML commands. Each command describes a specific behavior e.g. pointing gesture or, a turn. One of the purposes of this project will be to introduce the Planner for Nonverbal Spatial Behaviors of the agent such as *to move* or *to indicate an object*. Then these intentions will be realized by a set of BML commands. A planning should consider the location of the objects, position and orientation of the user. We also plan to allow the agent to indicate for objects in different ways.
- *Lexicon of nonverbal behaviors*. The agent may indicate objects in many different ways. In the basic scenario we will use the existing literature on nonverbal behaviors to define gestures and other nonverbal behaviors used to indicate an object. Depending on the interest of participants this work may be extended by creation and annotation of a corpus of nonverbal spatial behaviors.
- *Path planning module, orientation in space and location-awareness*: using the predefined static map of the environment the agent will be able to plan and perform autonomously nonverbal behaviors. In the first version we expect that the position of the objects will be

static (can be prescribed) and only the position of the agent and human may change. The possible extension may include the dynamic objects detection for example using RFID tags.

- *Dialogue manager*: In the basic scenario we plan to use wizard-of-Oz or a simple prescript dialogue manager.
- *Proxemics evaluation:* To measure the impact of the AR we propose experiments inspired by proxemics theory (Hall, 1966). Firstly, to analyze objectively the impact of the agent in AR we will use the physiological data. According to the theory of proxemics the reaction for invading the personal space is the arousal rise (see Llobera et al. 2010). We will try to verify if this occurs also in AR. Such effect can also be compared though different media (e.g. VA displayed on LCD screen). Another factor that can be looked at is the human orientation towards the AR agent during the interaction.

  We will also investigate if some other social behaviors (e.g. facial expressions) of the agent may influence the social distance.
- *The animation*: Implement a walking animation.

Depending on the project participants' interest and skills the following additional modules would be developed, for instance:

- *Auditory model for spatial impression*: while the position and distance between the AR agent and the user changes during the interaction the agent utterances should be modified to express these spatial relations.

***b. Resources needed: facility, equipm*ent, software, staff etc.**

Facility: a big (empty) room for experiments, for certain scenarios a big LCD display/projector and audio system would be necessary.

Other equipment: we will bring our laptops, micros and cameras, augmented reality hardware and portable physiological measurement.

Each participant is expected to bring his/her own laptop.

c. Project management

The project is lead by Radoslaw Niewiadomski and Mohammad Obaid. It is also supervised by Catherine Pelachaud, research director at CNRS/Telecom-ParisTech.

5. Minimum work plan:

WP1. Creation of the Lexicon and Behavior Planner for the VA

WP2. Spatial Information Inference and Path Planning Module

WP3. Dialogue Management

WP4. Experiments on Proxemics, presence and social behavior

The additional workpackages will be developed depending on the skills and interests of particular participants:
WP5. Animation in Virtual/Augmented Reality
WP6. Auditory model for spatial impression

6. Benefits of the research: expected outcomes of the project

One of the main benefits of this project is the creation of integrated VA with an AR-environment for location-awareness scenarios. It may be used in several experiments concerning different domains from linguistics and humanistic sciences to vision recognition algorithms. The summer school gives the opportunity to specialists from the different domains to work together on this highly interdisciplinary project. Another benefit is the release of any results concerning any experimental studies conducted during the summer school. We hope to extend our knowledge about the user's interaction with VA in augmented reality environment. This is particularly important if we take into consideration the possible applications of AR-based application in a real life in the near future.

7. Profile of team:

a. Leaders

Radoslaw Niewiadomski – postdoc researcher at Telecom ParisTech

Radoslaw Niewiadomski received the PhD degree in Computer Science in 2007 from the *Universita degli Studi di Perugia*, Italy. Currently he is a post-doc at the Telecom ParisTech.
His research interests include nonverbal communication and expressions of emotions by an ECA, multimodal interfaces and interactive applications.

Mohamamd Obaid – Research assistance / PhD student at the HITLab NZ - University of Canterbury

Mohammad Obaid completed his Bachelors and Masters degree at the Computer Science and Software Engineering Department at the University of Canterbury, in which he gained First Class Honours for his Masters degree. His Masters' research project focused on the area of Non-Photorealistic Rendering, where he developed an algorithm for Automatic Painterly Rendering applications.
Mohammad Obaid currently submitted his Ph.D. thesis and is due to gain his doctorate degree in May 2011. His PhD is in the field of Computer Science and Software Engineering with a major in Computer Graphics. His studies are conducted at the HITLab NZ and the Computer Science and Software Engineering Department at the University of Canterbury.

His research interests include: Non-Photorealistic Rendering, 3D Computer Graphics and Animation, Affective Computing, Image Processing and Computer Science for Kids.

b. Other researchers:

We search researchers working on:

- physiological data and its interpretation,
- nonverbal behavior,
- dialogue management,
- 3D computer animation (in particular walking) and motion capture data,
- auditory spatial modeling,
- ai skills such as planning and scheduling algorithms,
- vision recognition.

8. References

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