Interactive Chair: Proxemic Approach to the Design of 3D User Interface

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Abstract

Conventions in 3D user interface hardly facilitate our natural body motions. As social interaction and collaboration are more emphasized in recent trends of 3D games, the *proxemic* theory needs to be considered as the fundamental framework to regulate social interaction. Since gaze and distance are major influences on proxemic behaviors, this study proposes an interactive chair to translate body movements into gaze and distance control in the virtual world. By exquisitely arranging typical sensors on the chair to detect sitting postures, we were able to achieve dynamic and transitional data from users. Future work is aimed toward more accurate and diverse detection of postures.

Keywords

Virtual environment, proxemics, interpersonal space, interactive chair, 3D navigation, gaze control, tangible user interface

ACM Classification Keywords

H5.2. User Interfaces

Introduction

The evolution of three-dimensional (3D) games has formed strong conventions in their user interface, ranging from game controller design for video consoles to keyboard mapping in PC-based games. The ability to skillfully use them often becomes the major objective to be achieved by game players. In particular, rapid and accurate manipulation of joystick, arrow keys or mouse is emphasized for navigating, reaching and aiming behaviors in most first-person shooting games, where users' tasks are very specific and limited. However, such interface design enforces users to artificially interpret between their intention and action, by ignoring the way in which our body is naturally used to behave in the physical world. This problem becomes clearer when social interaction and collaboration are more emphasized rather than competition between users, as can be seen in recent trends of 3D games (e.g. Massively Multiplayer Online Role-Playing Games (MMORPGs) and 3D Online Communities). In these cases, the range and patterns of interpersonal activities are much closer to our ordinary behaviors in the physical world. Players frequently have conversations with one another, and can be easily influenced by merely the existence of others. In this study, particularly, the *proxemic* theory is considered as the fundamental framework to regulate social interaction between people, in both physical and virtual worlds. However, the conventional interface hardly facilitates proxemic behaviors in virtual environments, because interpretation through joystick, keyboard or mouse does not involve our body-conscious reactions by which interpersonal space can be formed and recognized.

Proxemics and Interpersonal Behaviors

Edward T. Hall described that we are surrounded by a series of socio-cultural boundaries which allow us to understand human behaviors [1]. He coined the term '*Proxemics*' and developed the proxemic classification of four distance zones – intimate, personal, social and public distance. His system hypothesizes humans exhibit behavior which we call territoriality, and in doing so, they use the senses to distinguish between one space or distance and another. More recently, Bailenson et al. demonstrated that participants in virtual environments also tend to exhibit proxemic behaviors [2]. They found participants gave more personal space to the virtual agent who engaged them in a mutual gaze. In addition, when the virtual agent invaded their personal space, participants moved farthest from it. While this experiment clearly suggests that gaze and distance are major influences on proxemic behaviors, no studies have been made on the design of user interface which would support smooth gaze and distance control for users. This study is aimed at, in this context, investigating right methods to design the *proxemic user interface*. Accordingly the chair was chosen as a means to translate our natural body motions into actions of perception and navigation in the virtual world.

Interactive Chair

In everyday life, we spend most of time sitting on chairs. While our both hands get busy with holding a book, writing a memo, or manipulating keyboard and mouse, the rest of our body is suspended on the seat or backrest of the chair. Although human body is frequently used to express our need or intention in the form of posture or action, the use of chair has excluded such feedback from our daily experience with computer. The interactive chair, as we propose herein, is expected to provide more intuitive ways of interaction by sensing or responding to our bodily actions. A chair can be naturally applied in navigating the 3D space that utilizes the spatial orientation and the perspective mechanism associated with our physical body.

In this project, we presume a typical office setting as the user environment, in which a user sits on a swivel chair and stares at a desktop display. The target applications are 3D games or equivalent (e.g. *World of Warcraft* or *Second Life*) where users typically see the virtual world in the first or third-person point of view. The proposed interactive chair interprets a user's sitting postures in several ways as described below.

A. Control of gaze decoupled from body orientation
By rotating his or her body on the swivel chair, a user can look around the surroundings, while keeping the body constantly oriented in the virtual space. This enables, for example, changing the gaze direction even during walking toward a particular destination. It also allows multiple users to communicate "face-to-face" through their avatars, by providing them with a way to maintain mutual gaze between one another, without necessarily changing the body orientation (like what we normally do in the physical world).

B. Control of the body orientation
The proposed interface shall be also able to translate the user's intention to rotate the entire body orientation (together with the gaze). The distinction between coupled (i.e. gaze + orientation) and decoupled (i.e. gaze only) rotations can be made by utilizing typical sitting postures. For example, putting elbows on either the front-end of desk or the armrests of the chair may change the direction of gaze only.

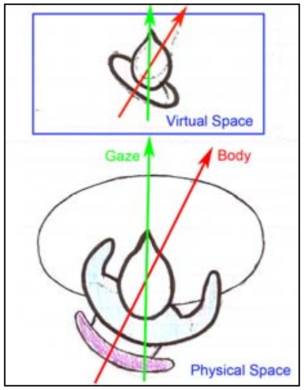

figure 1. Gaze control

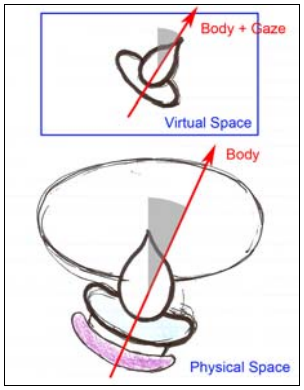

figure 2. Body orientation control

C. Walking forward/backward
Leaning upper body forward, backward, left and right are what we normally do while walking around. By employing such motions as sitting postures, the proposed interface can provide a direct control of 3D navigation. The viewpoint on the screen will stay still when our torso is in upright position; otherwise the camera (and the associated 3D character) will move corresponding to the current leaning direction. Using our physical body in navigating the virtual world can bring us following benefits:

- It does not require the conscious process as much as the use of mouse, keyboard or joystick, since it is normally what we do when we walk around in the physical world
- The use of body for navigating can release both hands free to manipulate other devices, so that more cognitive actions (e.g. chatting, gesturing, grabbing or pointing) can be performed concurrently

▪ Users can control their walking speeds dynamically by leaning forward or backward to certain specific degrees.

figure 3. Leaning postures to control walking speed

Sensing Bodily Motions on the Chair

Tan et al. developed the *sensingChair* as a new input device. Pressure sensing in this prototype was made possible with commercial pressure distribution measurement system. Two sensor sheets, placed inside green protective covers, were surface-mounted on the seat and the back rest of an office chair [3]. But the analysis of pressure distribution in their study required heavy computation process for pattern recognition, thus it was not suitable for tracking dynamic sitting postures continuously.

To the contrary, we designed simpler mechanisms to detect transitional sitting postures. The implementation was performed in several steps as followed:

▪ Step 1 - we measured the distance between the back of human body and the backrest of the chair, by using a commercial ultrasonic range finder named *Ping* (by Parallax). Data from the sensor was converted into the walking speed of the first-person character in the 3D engine.

▪ Step 2 - a typical potentiometer was used to detect the swivel angle of the chair as rotated by the user. A set of force sensor resistors (FSRs) can be additionally applied to the chair so that the existence of a user on the chair can be identified, if it is necessary.

▪ Step 3 - we used the *Torque* game engine to connect with the proposed interactive chair. Source code was modified to enable the serial communication with sensors through the *Arduino Board*, as well as the mapping between sensor data and actions of 3D character in the engine.

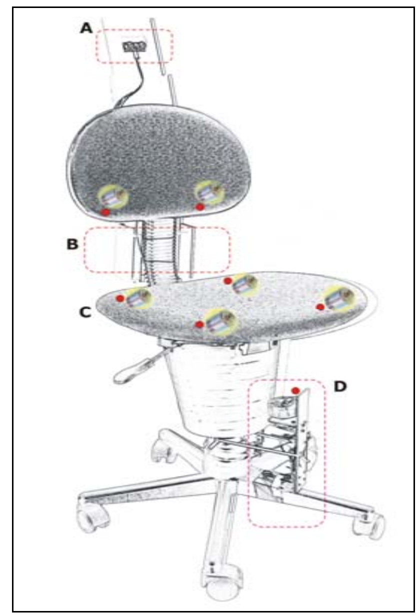

figure 4. Prototype interactive chair

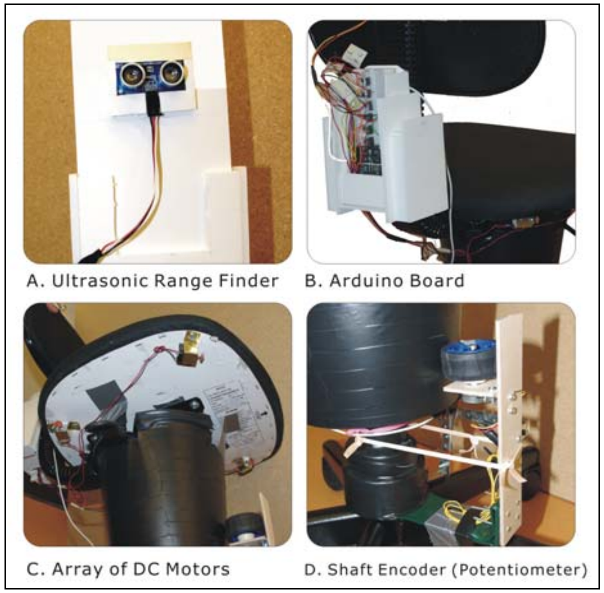

figure 5. Details of sensors and feedback system

Proxemic Feedback

6 DC motors were installed on the grid of the seat so that users can sense the directional feedbacks (i.e. left, right, front and back). This haptic feedback is expected to increase users' awareness of others, especially when someone is approaching from outside of the screen.

Performance Evaluation

* To be done by January 8th, 2008.

figure 6. A user controlling 3D character in *Torque* game engine through the interactive chair

Summary

We have demonstrated a proxemic user interface for 3D applications such as MMORPGs or 3D online communities. Technically, by using typical and inexpensive sensors, we were able to detect dynamic sitting postures of users, which was hard to achieve in prior works. In terms of interactivity, we proposed that proxemic approach is necessary to increase the richness of social interaction in the virtual world. In doing so, we actively took the advantage of natural body motions on the chair. Future work is aimed toward tracking more diverse postures on the chair to increase both intuitivity and accuracy of the interface.

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