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Designing concurrent full-body gestures for intense gameplay☆,☆☆

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ABSTRACT

Full body gestures provide alternative input to video games that are more natural and intuitive. However, full-body game gestures designed by developers may not always be the most suitable gestures available. A key challenge in full-body game gestural interfaces lies in how to design gestures such that they accommodate the intensive, dynamic nature of video games, e.g., several gestures may need to be executed simultaneously using different body parts. This paper investigates suitable simultaneous full-body game gestures, with the aim of accommodating high interactivity during intense gameplay. Three user studies were conducted: first, to determine user preferences, a user-elicitation study was conducted where participants were asked to define gestures for common game actions/commands; second, to identify suitable and alternative body parts, participants were asked to rate the suitability of each body part (one and two hands, one and two legs, head, eyes, and torso) for common game actions/commands; third, to explore the consensus of suitable simultaneous gestures, we proposed a novel choice-based elicitation approach where participants were asked to mix and match gestures from a predefined list to produce their preferred simultaneous gestures. Our key findings include (i) user preferences of game gestures, (ii) a set of suitable and alternative body parts for common game actions/commands, (iii) a consensus set of simultaneous full-body game gestures that assist interaction in different interactive game situations, and (iv) generalized design guidelines for future full-body game interfaces. These results can assist designers and practitioners to develop more effective full-body game gestural interfaces or other highly interactive full-body gestural interfaces.

1. Introduction

Full-body based interaction (e.g., Kinect) has enabled more natural and intuitive input for video games. However, game gestures developed by designers may not always be the most suitable gestures for players. Indeed, players have reported difficulties in playing some full-body based games, particularly in interaction-intensive games (e.g., First Person Shooters/Action/Adventure) where several actions/commands may have to be executed at or nearly at the same time (e.g. Gamespot, 2011). Thus one key challenge in designing effective game gestural interfaces lies in defining suitable, efficient gestures that enable players to effectively perform multiple game actions/commands simultaneously and with ease.

Several studies in relation to full-body game interaction have been conducted (e.g., Hoysniemi, 2006; Norton et al., 2010), but few studies have considered the intense-dynamic nature of game environments in general. When a player's hand is occupied with "Shooting Zombies", which other body parts and gestures might the player prefer to perform simultaneous actions such as "Reload" or "Use First Aid Kit" with. Since a literal "Jump" or "Climb" action can be tiring, is it likely that users will prefer a less tiring, more efficient gesture? What gestures would veteran gamers and non-gamers devise or envisage to enhance their interaction experiences?

To investigate these potentials, three user studies were conducted. In the first study, to explore general user preferences of game gestures, we used a user-elicitation approach asking participants to define their preferred gestures for different game actions/commands. We found a high consensus (agreement score) between participants' gestures as most participants defined physical gesture (mimicking real-world actions) with 1-hand as the most preferable input body modality. We also found a difference in preferences between gamers and non-gamers.

In the second study, to also consider simultaneous use of gestures where physical gestures may not always be possible, we asked participants to rate the suitability of different body parts (one and two hands, one and two legs, head, eyes, torso) for each game action/command. This second study was intended to help

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designers consider a set of suitable and alternative body parts, since an alternative body part may be needed to execute other simultaneous gestures while a certain body part is already occupied. Through the study, we identified a set of suitable and alternative body parts and gestures for different game actions/commands.

In the third study, to develop a simultaneous gesture set, we initially asked three participants to define their preferred gesture set using the user-elicitation approach. However, we found that there was little consensus among participants. In addition, participants mentioned that it is difficult to imagine possible combinations of gestures. To assist participants, we adapted the original user-elicitation approach and introduced a novel choice-based elicitation approach. We found that this approach has a positive effect in assisting participants to discover and create suitable gestures, which resulted in a consensus set of simultaneous game gestures. Based on the three studies' findings, we highlight potentially useful design guidelines.

2. Related work

Our work built upon three research areas: (i) game gesture design, (ii) gesture design using a user-elicitation approach and (iii) full-body interaction. Our reviews revealed that the study in the *simultaneous use* of game gestures remains underexplored.

2.1. Game gesture design

There are several challenges regarding full-body game interaction (Gerling et al., 2012; Hoysniemi, 2006; Norton et al., 2010). The challenges include the fact that (i) video game actions do not always have real-world counterparts such as casting magic; (ii) the naturalness of full-body games is limited by space limitations, e.g., people cannot really walk; (iii) people's physical capabilities vary (child vs. young adults vs. older adults); and (iv) full-body games can be tiring and attract injury.

To explore full-body game interaction, the common traditional approach is the Wizard of Oz approach, where participants perform their preferable gestures with "wizard-generated" interaction. Höysniemi et al. (2004) used the Wizard of Oz approach to investigate full-body game interaction for children with basic game tasks such as running and jumping. They raised issues with the approach such as possible interaction delays and the possible effect of the avatar's movement on children's movements. Norton et al. (2010) also used the Wizard of Oz approach to explore full-body game interaction with basic game tasks including running, jumping, climbing, and crouching. By analyzing video recordings and interviews, they found that users can adapt to physical limitations of full-body interaction effectively. For example, users may perform natural locomotion first (e.g., physically walking forward and backward) but will switch to compensating locomotion (e.g., walking in place) when physical space is limited. In addition, they made an initial observation that although hand and arm are considered the most used body modalities they may not always be prominent as arms may be busy with other commands. This is coherent with our initial argument.

We build upon these studies to include more various game actions/commands, and to particularly consider the simultaneous use of game gestures, which remain underexplored.

2.2. Gesture design using user-elicitation approach

The Wizard of Oz approach might suffer from possible interaction delays and can be time-consuming in preparing the setup (Höysniemi et al., 2004). One recent, inexpensive approach to design suitable gestures is the user-elicitation methodology, originally based on the guessability technique (Nielsen et al., 2004; Wobbrock et al., 2005), where participants were asked to define gestures for commands/actions. The methodology was proposed under the assumption that game gestures created by designers do not necessarily match users' mental models and may suffer from a large gulf of execution. Comparing with the Wizard of Oz approach, instead of providing "wizard-generated" interaction and feedback, the user-elicitation approach first provides visual cues (i.e., video clips) demonstrating the effect of each command/action, then asks the participants to perform their preferred gestures to trigger the effect, without any further feedback.

Regarding effectiveness, Morris et al. (2010) and Wobbrock (2009) suggested that a user-elicitation approach can produce more preferable gestures, compared to gestures designed by HCI experts who are likely to develop more "physically and conceptually complex gestures than end-users". Regarding learnability, Nacenta et al. (2013) compared memorability between three gesture sets: an author-defined set, a user-defined set, and a randomly-defined set and found that the user-defined gestures are easier to learn and remember.

Motivated by the usefulness of the approach, many works have been conducted for different user groups. For example, Kane et al. (2011) employed a user-elicitation approach to study how blind people use touch screen gestures. They found differences in gesture preferences between blind and sighted people, e.g., blind people prefer edge-based gestures. Mauney et al. (2010) also investigated touch-screen gestures but across nine different cultures and found that there is generally a high level of agreement in gesture preferences. Connell et al. (2013) explored child-defined gestures for full-body interaction and found some specific characteristics of children, e.g., children rely more on egocentric (body-centered) gestures but gradually change to allocentric (world-centered) gestures over time. These results suggested that different user groups may have differences in gesture preferences (e.g., non-gamers vs. veteran gamers) and it is essential to understand those differences to design suitable gestures.

The user-elicitation approach also has been used for designing gestures in different interactive devices and contexts, e.g., tabletops (Wobbrock, 2009), mobile phones (Ruiz et al., 2011), humanoid robots (Obaid et al., 2012), TV (Vatavu, 2012), 3D remote object manipulation (Liang et al., 2012b), and phone-to-phone/tabletop/large-display interaction (Kray et al., 2010). Most works resulted with design practices and a consensus set of suitable gestures which were determined by the highest agreed gestures among participants.

In summary, our review shows that the user-elicitation approach can help understand user preferences and develop suitable gesture sets and practices. In addition we also found that little study has been done on user elicitation for full-body based video games, and that considering the dynamic, interaction-intensive nature of video games, thus we were motivated to fill this gap.

2.3. Full-body interaction

Full-body interaction includes the use of body movements and gestures for interacting with computers, which may be categorized into four kinds: (i) full-body only (e.g., Kinect), (ii) full-body plus external devices (e.g., Kinect + artificial gun), (iii) external device only (e.g., Wii Remote) and (iv) body-centric interaction (i.e., using the body as interaction space). In full-body only interaction, users interact with computers (e.g., TV, games) using full-body movements and gestures through motion-camera sensing devices. To enhance realism, full-body only interaction may be augmented with external devices such as artificial gun (Williamson et al., 2011) for