Applied Ergonomics 45 (2014) 1196–1207

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Towards successful user interaction with systems: Focusing on user-derived gestures for smart home systems

Eunjung Choi, Sunghyuk Kwon [1], Donghun Lee [1], Hogin Lee, Min K. Chung*

Dept. of Industrial and Management Engineering, Pohang University of Science & Technology (POSTECH), Republic of Korea

ARTICLE INFO

Article history:
Received 18 March 2013
Accepted 20 February 2014

Keywords:
Hand gesture
User-derived hand gestures
Gesture-command association

ABSTRACT

Various studies that derived gesture commands from users have used the frequency ratio to select popular gestures among the users. However, the users select only one gesture from a limited number of gestures that they could imagine during an experiment, and thus, the selected gesture may not always be the best gesture. Therefore, two experiments including the same participants were conducted to identify whether the participants maintain their own gestures after observing other gestures. As a result, 66% of the top gestures were different between the two experiments. Thus, to verify the changed gestures between the two experiments, a third experiment including another set of participants was conducted, which showed that the selected gestures were similar to those from the second experiment. This finding implies that the method of using the frequency in the first step does not necessarily guarantee the popularity of the gestures.

1. Introduction

Recently, many researchers have focused on developing more natural user interfaces that facilitate interaction between users and systems. More specifically, with advanced technologies, the trend has been geared towards developing more intuitive devices, and one of the efforts is a gesture-based interface that recognizes any physical movement without the help of a traditional device such as a mouse or a keyboard (Saffer, 2008).

Previous studies on gesture-based interfaces have focused on either 2 dimensional (2D) gestures utilizing a touch-screen controlled by a finger or a stylus pen, or 3 dimensional (3D) motion-recognition systems accompanied by sensor-gloves or handheld devices. More recently, the trend of developing 3D gesture recognition technologies, such as Microsoft's Kinect, has allowed different gesture-based interfaces to provide users with easier control of the devices without any extra equipment (Bhuiyan and Picking, 2011; Kim et al., 2011). Consequently, recent research studies have begun to pay more attention to 3D free hand gestures (Henze et al., 2010; Kim et al., 2011; Mauney et al., 2010).

Meanwhile, in the earlier studies, due to the limitation of the gesture recognition technologies, gesture interfaces could not recognize many postures or motions, and only a few gestures were suggested by designers or engineers based on their specialized knowledge (Buisine and Martin, 2007; O'Hagan et al., 2002; Sears and Arora, 2002). However, some of these gestures are difficult to discover and adopt because they are arbitrarily associated with commands (Yee, 2009).

More recently, as the image processing technology for faster computation has become possible, and subsequently the number of gesture-activated functions has increased, intuitiveness has become an important consideration in gesture design (Blackler et al., 2010; Lee et al., 2010; Lepinski et al., 2010; Park, 2012). Therefore, the issue has expanded to determining the gestures for more intuitive interaction with the products. Lately, various researches have started to focus on matching gestures with commands by involving users in the initial stage of designing gestures to fully use the users' experiences: user-centered approach (Akers, 2006; Epps et al., 2006; Grandhi et al., 2010; Henze et al., 2010; Kuhnel et al., 2011; Lee et al., 2010; Mauney et al., 2010; Mitchell and Heap, 2011; Neßelrath et al., 2011; Nielsen et al., 2003, 2004; Stern et al., 2008; Wobbrock et al., 2009).

The aforementioned studies followed a similar procedure to suggest gestures for commands (Fig. 1). In such case, the frequency

* Corresponding author. San 31, Hyoja-dong, Nam gu, Pohang, Gyeongbuk, Republic of Korea. Tel.: +82 54 279 2192; fax: +82 54 279 2920.

E-mail addresses: lovecej@postech.ac.kr (E. Choi), shyuk.kwon@samsung.com (S. Kwon), bell7738@postech.ac.kr (D. Lee), bluestar@postech.ac.kr (H. Lee), mkc@postech.ac.kr (M.K. Chung).

[1] Present address: Visual Display Division, Samsung Electronics Co. Ltd., #129, Samsung-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do 443-742 S, Republic of Korea.

http://dx.doi.org/10.1016/j.apergo.2014.02.010
0003-6870/

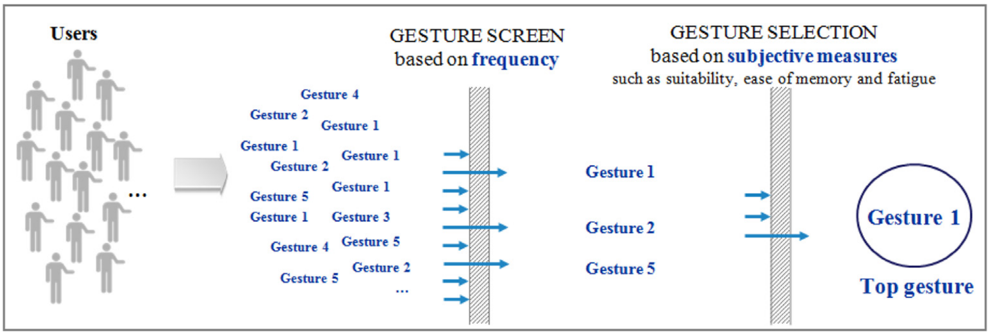

Fig. 1. The procedure of the previous studies to select a top gesture for each command.

ratio is commonly used to eliminate awkward gestures, and to select popular gestures among the users. More specifically, the users were asked to derive a gesture for each command. Once the gestures were collected from the users, similar gestures for each command were grouped together according to the physical shapes/ motions of the gestures. Then, a gesture with the highest frequency (Top gesture) was suggested as the final gesture for a command. In addition some of the gestures with high frequency for each command were selected and then were estimated in terms of subjective measures such as suitability, ease of memory, and fatigue. Finally, one of them was selected as the final gesture for the command.

However, these steps can introduce several issues. Firstly, users have a limited set of gesture candidates in their mind, and they end up selecting one of them as the best gesture for a command during an experiment. Therefore, if they observe other gestures that they had not thought about during the experiment, they could change their selection. Secondly, if a skilled user in designing gestures is included in a participant group; a gesture that he/she derives could be the most suitable gesture for a command. However, following the aforementioned step is likely to neglect the meaningful gestures due to their low frequency. However, there are no studies on these issues. Thus, we made hypothesis to identify the issues as follows.

- Users may change their selection after observing other gestures.
- A gesture derived from only a few users might be a better gesture.

To verify the hypothesis, two experiments were conducted. In the first experiment, we followed the procedure of the previous studies: deriving gestures for a command from users and selecting a gesture with the highest frequency (Top gesture) for each command. In the second experiment, we asked the same users to select the most suitable gesture for each command after observing all of the user-derived gestures acquired in the first experiment, and then, selected a top gesture for each command. Moreover, the top gestures between the two experiments were compared to identify whether the top gestures in the first experiment were maintained in the second experiment, and whether the gestures that a few users derived in the first experiment became popular gestures. Finally, in order to verify the changed gestures between the two experiments, a third experiment including another set of participants was conducted.

2. Methods

Two experiments were conducted to identify aforementioned hypothesis (see Fig. 2). Two experiments were designed as within subject test. The first experiment focused on the acquisition of hand gestures mapping with structures within a house and appliances, and also studied the participant's reason for choosing a certain gesture. The experiment of deriving gestures for each command from the users was based on the user-centered approach similar to the previous studies (Akers, 2006; Epps et al., 2006; Grandhi et al., 2010; Henze et al., 2010; Kuhnel et al., 2011; Lee et al., 2010; Mauney et al., 2010; Neβelrath et al., 2011; Nielsen et al., 2003, 2004; Wobbrock et al., 2009).

The main issue in the second experiment was to identify whether the participants would change their own gestures after observing the gestures derived by the others in the first experiment. More specifically, the top gestures between the two experiments were compared after finishing the both experiments. Thus, the same participants took part in both of the experiments. In the second experiment, the participants were asked to select the most suitable gesture for each command from the gesture list, which included most of the gestures that the users derived in the first experiment.

2.1. Finding gesture commands

First, to select commands of various products, we collected the commands from the smart-home system. Then, to find proper gesture commands for smart-home appliances, previous researches of which targets for smart-home systems were investigated, and a brainstorming session with four researchers was carried out. Among the commands from the previous studies, we collected a motion-recognized remote controller (Ouchi et al., 2005; Pan et al., 2010; Wilson and Shafer, 2003), a glove-type interface (Dipietro and Sabatini, 2008; Ng et al., 2011), and a touch-sensitive interactive system (Saffer, 2008; Seifried et al., 2009), as well as the commands that were used in Kuhnel et al. (2011) and Neßelrath et al., 2011 By doing so, a total of 40 commands in smart-home appliances were collected.

To select target commands, a brainstorming session with four experts was carried out. During the session, all of the commands collected from the previous stage were used as the basic information. In addition to the commands from the previous researches, the structures within the house that involved interactions on a day-to-day basis were also selected. As a result, a total of 38 commands for 11 products were selected: Air conditioner, TV, Audio player, Phone, Light, Desk Lamp, Curtain(s), Blind, Door(s), Window(s), and Faucet (see Table 1).

2.2. Experiment 1

2.2.1. Participants

A total of thirty students in POSTECH voluntarily participated in the experiment, of which fifteen were men and fifteen were women. They were all right handed, and no participant had musculoskeletal disorders in his or her arms and hands. The mean age was 23.2 (sd: ±2.89; rage of age: 19–30). None of the