A User-Developed 3-D Hand Gesture Set for Human–Computer Interaction

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Objective: The purpose of this study was to develop a lexicon for 3-D hand gestures for common human–computer interaction (HCI) tasks by considering usability and effort ratings.

Background: Recent technologies create an opportunity for developing a free-form 3-D hand gesture lexicon for HCI.

Method: Subjects (*N* = 30) with prior experience using 2-D gestures on touch screens performed 3-D gestures of their choice for 34 common HCI tasks and rated their gestures on preference, match, ease, and effort. Videos of the 1,300 generated gestures were analyzed for gesture popularity, order, and response times. Gesture hand postures were rated by the authors on biomechanical risk and fatigue.

Results: A final task gesture set is proposed based primarily on subjective ratings and hand posture risk. The different dimensions used for evaluating task gestures were not highly correlated and, therefore, measured different properties of the task–gesture match.

Application: A method is proposed for generating a user-developed 3-D gesture lexicon for common HCIs that involves subjective ratings and a posture risk rating for minimizing arm and hand fatigue.

Keywords: HCI, human–computer interaction, gesture, fatigue, usability

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INTRODUCTION

Three-dimensional hand gestures for human–computer interaction (HCI) involve using hand and finger motions or postures to signal a command or task to a computer or mobile device, whereas 2-D gestures involve signaling commands by touching a sensing surface, such as a tablet or screen. Two-dimensional gestures may involve a variety of motions, such as flicking to change windows or spreading fingertips to indicate enlarge, but are limited to the sensing of fingertips on a surface. By contrast, 3-D hand gestures offer a greater set of motions limited primarily by the image-capture technology. Recent motion-capture technology, especially high-resolution sensors designed to capture just hand gestures, is expected to lead to an increase of 3-D hand gesture input systems and gesture languages.

Such 3-D hand gesture recognition systems provide an opportunity to enhance or even bypass the keyboard, mouse, and touch screens. Other advantages of 3-D hand gesture systems are that they can be used in a sterile noncontact environment, like operating rooms (Wachs et al., 2008); allow interactions with multiple people simultaneously; can facilitate multicultural interaction when language is a barrier; allow biometrics screening; enable sign language–based communication; allow technology to be secure and prevent vandalism; and improve manipulation of objects with large 3-D screens.

The use of 3-D hand gestures for HCI has the potential to create a more intuitive, creative, and productive experience than traditional input devices or 2-D gesture input (Ni, Bowman, North, & McMahan, 2011; Wachs, Kolsch, Stern, & Edan, 2011). It also has the potential to make HCI more comfortable. Although some research has been done in this area (Farhadi-Niaki, Etemad, & Arya, 2013; Nacenta, Kamber,