AJO-DO

User acceptance of a touchless sterile system to control virtual orthodontic study models

Wan Nurazreena Wan Hassan,[a] Noor Lide Abu Kassim,[b] Abhishek Jhawar,[c] Norsyafiqah Mohd Shurkri,[d] Nur Azreen Kamarul Baharin,[d] and Chee Seng Chan[e]
Kuala Lumpur and Pahang Darul Makmur, Malaysia

Introduction: In this article, we present an evaluation of user acceptance of our innovative hand-gesture–based touchless sterile system for interaction with and control of a set of 3-dimensional digitized orthodontic study models using the Kinect motion-capture sensor (Microsoft, Redmond, Wash). **Methods:** The system was tested on a cohort of 201 participants. Using our validated questionnaire, the participants evaluated 7 hand-gesture–based commands that allowed the user to adjust the model in size, position, and aspect and to switch the image on the screen to view the maxillary arch, the mandibular arch, or models in occlusion. Participants' responses were assessed using Rasch analysis so that their perceptions of the usefulness of the hand gestures for the commands could be directly referenced against their acceptance of the gestures. Their perceptions of the potential value of this system for cross-infection control were also evaluated. **Results:** Most participants endorsed these commands as accurate. Our designated hand gestures for these commands were generally accepted. We also found a positive and significant correlation between our participants' level of awareness of cross infection and their endorsement to use this system in clinical practice. **Conclusions:** This study supports the adoption of this promising development for a sterile touch-free patient record-management system. (Am J Orthod Dentofacial Orthop 2016;149:567-78)

Many countries across the world require electronic patient records.[1] Accessing these records via keyboard, mouse, touch screen, or pad raises the risk of cross infection. Infectious pathogenic microorganisms such as cytomegalovirus, herpes simplex virus types 1 and 2, hepatitis B virus, human immunodeficiency virus, hepatitis C virus, and bacteria that colonize or infect the oral cavity and respiratory tract such as staphylococci, streptococci, and *Mycobacterium tuberculosis* are occupational hazards that can be transmitted by contact, direct or indirect, between dental health care personnel and patients.[2,3] Although gloves are a personal protective barrier between clinicians and patients, they still need to be frequently removed, at some inconvenience, when health care personnel are operating computer input devices during treatment.

This problem of touch-induced risk of cross infection during navigation of medical records may be minimized via a touch-free gesture interface with motion-capture camera devices such as Kinect (Microsoft, Redmond, Wash), with the ability to distinguish color images and the associated depth data, coupled with innovative programming strategies, and has furthered the development of an accurate contact-independent controlling device.[4] This low-cost and easy-to-set-up device may also encourage improved cross-infection prevention in practice, especially in countries where inaffordability is a limiting factor, leading to poorer cross-infection control and safety practices.[5]

[a]Senior lecturer, Department of Paediatric Dentistry and Orthodontics and Clinical Craniofacial Dentistry Research Group, Faculty of Dentistry, University of Malaya, Kuala Lumpur, Malaysia.
[b]Associate professor, Department of Community Health and Health Care for Mass Gathering, Umm Al Qura University, Mecca, Saudi Arabia; and Kuliyyah of Dentistry, International Islamic University Malaysia, Kuantan Campus, Pahang Darul Makmur, Malaysia.
[c]Research assistant, Department of Paediatric Dentistry and Orthodontics, Faculty of Dentistry and Department of Artificial Intelligence, Faculty of Computer Science and Information Technology, University of Malaya, Kuala Lumpur, Malaysia.
[d]Research student, Department of Paediatric Dentistry and Orthodontics, Faculty of Dentistry, University of Malaya, Kuala Lumpur, Malaysia.
[e]Senior lecturer, Department of Artificial Intelligence, Faculty of Computer Science and Information Technology, University of Malaya, Kuala Lumpur, Malaysia.

All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
Funded by University of Malaya research grant (RG401/12HTM).
There is a pending patent application on the motion-based sterile image control for dental care (SK/P1423UM/14).

Address correspondence to: Wan Nurazreena Wan Hassan, Department of Paediatric Dentistry and Orthodontics, Faculty of Dentistry, University of Malaya, Kuala Lumpur, Malaysia; e-mail, wannurazreena@um.edu.my.

Submitted, March 2015; revised and accepted, October 2015.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2015.10.018

Prototypes of gesture-based programs for Kinect have been presented for navigation of radiologic images during operating procedures.[6,7] Furthermore, such prototype programs have been successfully pilot tested during surgical procedures while maintaining operator sterility, demonstrating the potential for improved cross-infection strategies.[8,9]

In view of this potential, we have developed a hand-gesture–based program for practical cross-infection control when accessing patients' electronic records in dental settings. Our prototype was designed to facilitate assessment of the 3-dimensional (3D) digitized dental study models from the sagittal, vertical, and transverse planes. The dental study model was chosen as the object of interest for this program because it is commonly used for baseline records, treatment planning, and monitoring changes. Most currently used digital forms of study models reproduce dental features with an acceptable level of clinical accuracy.[10] It is expected that the future of dentistry will involve their use in place of stone study models for easy access and space-saving storage. Our prototype uses Kinect to provide a sterile method for the dentist to naturally and efficiently manipulate the 3D digital study models with specific noncontact hand-gesture commands.

The rationale of this study was to evaluate the developed system as a method to lower the risk of cross infection in clinical practice. We assessed user acceptance of our proposed hand-gesture user interface for interaction and manipulation of a 3D digital object. We investigated whether the prototype accurately discriminated each hand gesture to be translated for each specific command to the program and at the same time whether these gestures and the system were acceptable to the users.

MATERIAL AND METHODS

Ethical approval for this study was obtained from the Medical Ethics Committee, Faculty of Dentistry, University of Malaya, Kuala Lumpur (DF OT1306/0078[U]).

This section describes the building of a robust hand-gesture recognition system using, as the input device, the Kinect sensor, which captures the color image and the depth map at 640 × 480 pixel resolution. Because the depth sensor of Kinect is an infrared camera, the lighting conditions, the background, and the colors of a patient's skin and clothing have little impact on its performance.[10] In this study, the Kinect sensor was connected via a 2.0 USB connector to an Ideapad Z460 (14-in screen size; Lenovo, Beijing, China), a Core i5-380M processor (Intel, Santa Clara, Calif), a graphic engine (Windows 7 Home Basic; Microsoft), and GeForce with CUDA (Nvidia, Santa Clara, Calif). We used Visual Studio 2010 (Microsoft) with our developed hand-gesture recognition program as detailed in the next paragraph. The aim was to provide a more natural human-computer interface, allowing the dentist to "pick up" the 3D digitized orthodontic study model by moving the hands within the working area, which detects the action as an initiative to move the model, and to "examine" the model by maneuvering the hands in the air.

The system comprises a touchless 2-hand-gesture navigational scheme for 7 commands: translation, zoom in, zoom out, rotate up and down, rotate side to side, select menu, and reset. Translation moves the 3D study model from one location on the screen to another. Zoom in and zoom out increase and reduce the model size, respectively. Rotate up and down refers to the rotation of the model around a horizontal axis, whereas rotate side to side refers to its rotation around a vertical axis. Select menu allows 1 of the 3 options on the right side (menu bars) of the screen to be activated and displayed on the main screen. The options include select the maxillary arch, mandibular arch, or both arches in occlusion. Reset returns the object to its original position and size on the active main screen, as shown in Figure 1, *A*.

The working distance between the Kinect sensor and the participants was approximately 2 meters. Two green circles, representing each hand, appeared onscreen when the users were within the working area (Fig 1, *A*). Detection of unintended movement was avoided by moving the hands out of the working area, as indicated by the disappearance of the green circles. As shown in Figure 1, *B*, translational movement was controlled by moving the left hand in the vertical or horizontal direction. Rotations in the up-and-down and side-to-side directions were achieved by right-hand vertical and horizontal shifts, respectively. For zooming in to the models, the hands moved apart from the center of the body. For zooming out of the models, the hands moved toward the center of the body. Placing the left hand slightly apart from the side of the user's body activated the side menu, as indicated by a color change on the side menu bar. An active cursor then appeared for the right hand to guide toward the desired menu, which is selected by a gentle tapping movement of the hand. Reset was activated when both hands were moved apart slightly from the sides of the body.

Our subject inclusion criteria specified health care associates between 21 and 40 years old with fully functional bilateral hands and good eyesight.

The exclusion criteria included those with medical conditions such as arthritis that may be affected by repetitive hand movements and those, such as epileptics,