# **Determination of the Optimal Location of Kinect Sensor for Upper-Limb Virtual Reality** Mojtaba Fathi F., Pilwon Hur, PhD, Na Jin Seo, PhD **Department of Industrial Engineering**

MOTIVATION

- Kinect sensor (Microsoft, Redmond, WA, USA) is a low-cost human motion tracking device with limited accuracy.
- > Methods to improve accuracy of Kinect may increase potential use of Kinect for various applications.
- **Objective**: To determine the best location of Kinect sensor to minimize kinematic error while tracking upper-limb motion.

# APPROACH

- > The best Kinect location would be that with the least kinematic error compared to a conventional motion detection system (3D Investigator<sup>TM</sup> Motion Capture System, NDI, Waterloo, ON, Canada).
- Kinematic error = RMS of differences between Kinect and 3D Investigator<sup>TM</sup>, averaged across upper-limb joint angles
- > Four upper-limb joint angles were examined:
  - Shoulder elevation  $(S_F)$
  - Shoulder azimuth  $(S_A)$
  - Shoulder rotation  $(S_R)$
  - Elbow flexion angle (E)



Fig. 1: upper-limb joint angles

- > 9 Kinect locations were examined:
  - $45^{\circ}$  elevation with  $0^{\circ}$  azimuth angle (A in Fig. 2)
  - $30^{\circ}$  elevation with  $0^{\circ}$  and  $\pm 60^{\circ}$  azimuth (B in Fig. 2)
  - $0^{\circ}$  elevation (right shoulder height) with azimuth angles of  $0^{\circ}$ (center),  $\pm 30^{\circ}$  and  $\pm 60^{\circ}$



Fig. 2: Schematics of the test space relative to the subject. Kinematic errors for 9 Kinect locations (purple bars) were quantified while the subject reached for various targets in space. Locations A and B were found to be the best. C and D were the worst. T is the typical location.

### METHODOLOGY

- > Ten healthy young subjects reached for 21 targets that were placed in front of them in a random prescribed order. They started with the right forearm resting on the desk, and returned to the same resting posture after reaching for each target using the right hand.
- > Subjects repeated the reaching tasks minimum twice for each of the 9 Kinect locations in a random order.
- > Kinect always faced the subject in all of the 9 locations.
- ➢ For motion detection using 3D Investigator<sup>™</sup>, infrared light emitters were placed on the subject's upper limb joints and the desk (for a reference).
- > The four upper-limb joint angles were computed using motion data obtained from Kinect as well as those from 3D Investigator<sup>TM</sup>.



Fig. 3: Joint angles as measured by Kinect and 3D Investigator<sup>™</sup> for a sample trial

- ► RMS of difference between Kinect and 3D Investigator<sup>TM</sup> across the four joint angles (i.e., kinematic error) was computed.
- Repeated measures ANOVA was conducted to determine kinematic error significantly changed with different Kinect locations ( $\alpha = 0.05$ ).

### **CONTACT INFORMATION**

**Department of Industrial Engineering** Mojtaba Fathi F. (fathifi2@uwm.edu)



# RESULTS

- > The best locations of the Kinect sensor for tracking reaching motions were:
  - Right in front of the subject (center with 0° azimuth) but elevated by 45° and 30° (A and B in Fig. 2)
- The worst Kinect locations were:
  - At the shoulder height ( $0^{\circ}$  elevation) toward the left (-60° and -30° azimuth angles; C and D in Fig. 2)
- $\succ$  The typical location of right in front of the subject at the shoulder height ( $0^{\circ}$  elevation angle with  $0^{\circ}$ azimuth, T in Fig. 2) was not the best.
- > The location of the Kinect sensor relative to a subject significantly affected its accuracy for upper-limb motion detection.



Fig. 4: Mean kinematic error for the 9 different Kinect locations. Stars (\*) indicate statistical differences among groups.

### CONCLUSION

- > The location of the Kinect sensor relative to a subject can affect its accuracy for upper-limb motion detection.
- > The optimal Kinect location can reasonably enhance accuracy of Kinect's motion detection.
- > The results of this study help with optimal use of Kinect sensor in various applications including virtual reality games and rehabilitation.

