Marker-less Tracking of Head Motions in Abrupt Vehicle Manoeuvres

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I. INTRODUCTION

Interest in the effects of pre-crash vehicle manoeuvres on occupant posture and position has increased with the development of automated pre-crash systems that can apply braking or steering inputs. A range of studies have been conducted to quantify occupant motions resulting from hard braking, abrupt lane changes, and other manoeuvres. One challenge in gathering large amounts of data under realistic conditions has been the need for extensive instrumentation. Most studies have used marker-based tracking systems, based on either video digitizing or semi-automated tracking of retroreflective or active markers (e.g. [1]). We have developed a system for automated tracking of occupant head position using a single Microsoft Kinect version-2 sensor. The version-2 sensor measures the 3D location of objects in the visual field using a time-of-flight sensor. It provides better resolution and accuracy than the version-1 sensor used in previous studies of occupant posture and position [2].

II. METHODS

The Kinect sensor was mounted on the dashboard of a sedan, near the windshield. Figure 1 shows the view of the right-front passenger obtained from the sensor. As part of a larger study, head scans of study participants were obtained using a handheld Sense scanner (3D Systems). Each participant experienced a series of abrupt vehicle manoeuvres on a test track, including maximal straight-line braking and a rapid lane change. Passenger kinematics were captured using the Kinect sensor, which records 3D depth data at 30 Hz. The depth data were converted to a 3D point cloud and a custom spatial calibration was applied [2]. The head position and orientation were tracked throughout the vehicle manoeuvres by fitting the head scan to the 3D point cloud data. The head shape is fitted to the data using an adaptive iterative closest point method.

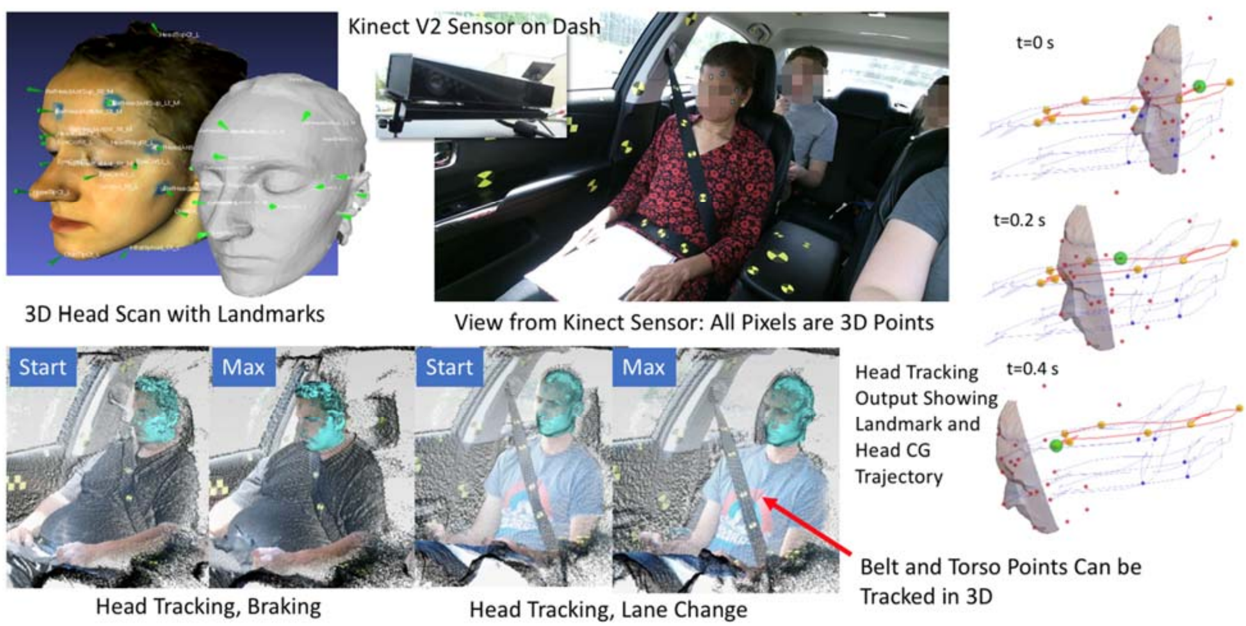

Fig. 1. Tracking methodology.

III. INITIAL FINDINGS

The root-mean-square error of the system compared with coordinates measured with a FARO Arm mechanical coordinate digitizer (FARO Technologies, Lake Mary, FL, USA) is 2.1–3.0 mm, depending on spatial location. The trajectory of a point on the head in a braking manoeuvre was compared with video-based tracking using TEMA software (Image Systems AB). The mean error over a two-second event was 2.4 mm. Over 300 events from more than 90 participants have been recorded and tracked using the system.

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IV. DISCUSSION

Marker-less tracking using 3D sensors has the potential to enable accurate, large-scale, naturalistic recording of occupant postures and motions. The current model-based approach has the potential to be more effective than earlier applications of depth cameras to occupant tracking [2]. The fitting approach requires a reasonably accurate initial estimate of head position and orientation to provide an accurate result. For some applications of the method, we have used manually picked points at the start of an event to determine the initial head position and orientation. In other applications, we have used image-based feature recognition to identify the face location. As the method has been applied in experimental settings, we have used a subject-specific head model, which would not be practical in naturalistic settings. However, we are also able to obtain good results by fitting a statistical head/face model to the data from the sensor.

V. REFERENCES

[1] Ólafsdóttir, *et al*., IRCOBI, 2013.
[2] Arbogast, et al. *TIP*, 2016.