Occupant Motion Tracking in Rollover using 3D Optical Systems

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I. INTRODUCTION

3D optoelectronic stereophotogrammetric systems such as Vicon (Vicon MX, Vicon, Los Angeles, CA, USA) that use many ground-based cameras have been developed mainly for the measurement of rigid body kinematics. They are widely used in biomechanics to capture the human body motion by tracking the trajectories of spherical retroreflective markers attached to a body or body region. Non-contact optical measurement systems like Aramis (GOM mbH, Braunschweig, Germany) are based on a different type of motion tracking technology that relies on only two cameras and allows for three-dimensional multi-point deformation measurement of a speckle pattern applied onto a surface. The Aramis software is used usually to measure strain, but the system has been shown to be effective also in measuring vehicle deformations from inside of a car [1]. While the Vicon system has been utilized extensively to characterize occupant surrogate motion in simulated crash tests [2-3], the Aramis system has been used to capture the kinematics of the human body (thorax) only once – in the table top tests [4], where the applied deformation was relatively small (up to 15 mm in all three Cartesian directions). The goal of this study was to compare the measurements obtained with both systems for the kinematics of a crash test dummy in rollover impact – a scenario with larger overall displacement than the one seen in the table top tests.

II. METHODS

One rollover crash test using a parametric rollover buck [5] was performed and the kinematics data for the leading side occupant (a dummy) were captured at 500 Hz with Aramis and Vicon systems simultaneously. The optical system for Aramis utilized two on-board high speed imagers (NAC P-cams, NAC Image Technology, Simi Valley, CA) with 6 mm lenses on each camera (Schneider Optics, Hauppauge, NY). The imagers were mounted on a camera bar, which was then attached to the buck structure behind the dummy (Figure 1a). To track the dummy motion, a black-and-white speckle pattern was applied along the dummy spine. The Vicon system utilized 30 cameras. For direct comparison with the Aramis measurements the retroreflective markers were secured to the spine and the pelvis of the dummy, along the black-and-white speckle pattern (Figure 1b).

After the test a 9-point moving average was used on the Vicon data to eliminate isolated spikes. To facilitate Aramis data processing only every third data point obtained during the simulated rollover impact was imported into the software.

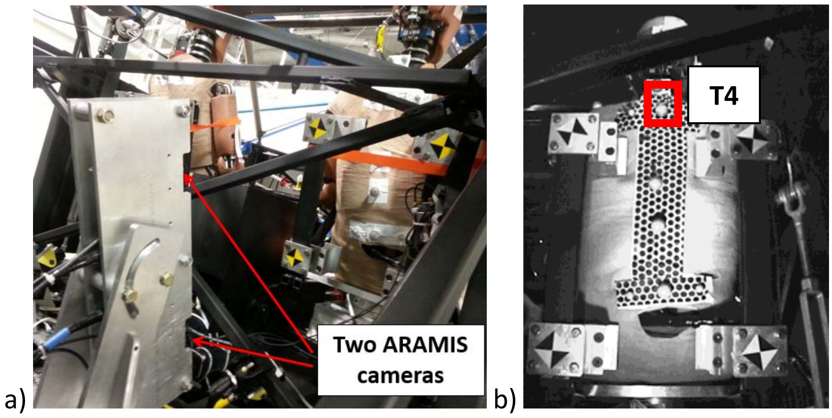

Figure 1. a) Aramis setup, b) Aramis camera view with T4 reference point marked

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The kinematics data measured by both systems were processed and presented (for the T4 reference point marked in Figure 1b) in the rollover buck local coordinate system. Local axes were defined using the Society of Automotive Engineers standard for vehicles [6].

III. INITIAL FINDINGS

The results from Vicon and Aramis showed very good agreement in terms of magnitude and the shape of the time-history curves, for all presented displacement components (Figure 2). Slight differences between the systems, especially local peaks seen in the Vicon data and not seen in the Aramis data, were caused by lower data point resolution used for Aramis than for Vicon in the post processing phase. The average difference – in the entire considered time range – between both systems was 1.5 mm for the X displacement component, 0.3 mm for Y, 2 mm for Z, and 1.5 mm for the resultant.

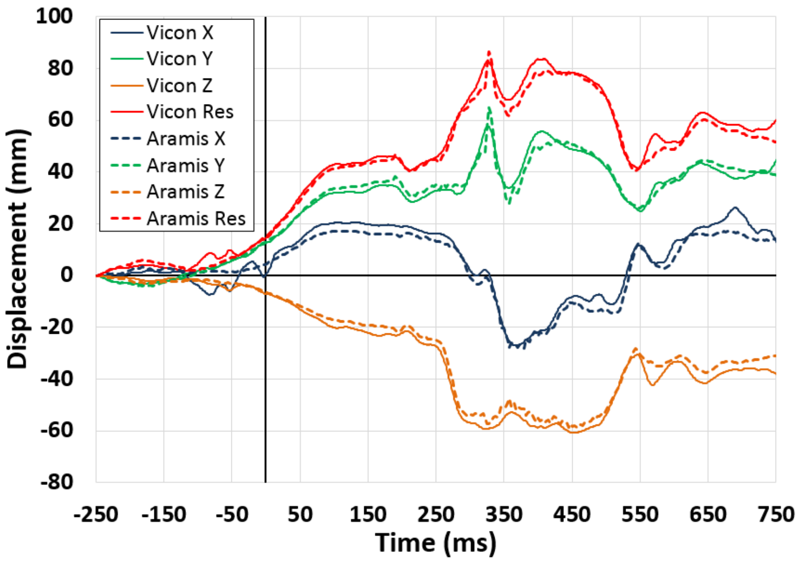

Figure 2. Displacement time-history of T4 reference point

IV. DISCUSSION

Aramis and Vicon need calibration prior to testing. The result of the calibration process is a calibrated space covering an analyzed structure. The dimensions of this space can differ greatly between both systems. During the described rollover test the calibrated volume for Vicon covered the entire buck with the occupants inside (calibrated space: 6 m x 6 m x 5 m). The calibrated space for Aramis covered only the thorax and the pelvis of the leading side dummy (1 m x 0.8 m x 0.8 m). Additionally, the Aramis setup only permitted tracking the posterior thorax, and a second system would be required to track the anterior side. Another way to cover more space would be to use a different setup (different camera bar, lenses etc.), but this approach could reduce the resolution of the measurements substantially.

While the Vicon system can be used to capture various ranges of motion, spherical targets require additional hardware to be attached to the body/specimen which is sometimes impractical. Another difference is that Aramis can be utilized in closed spaces (e.g. occupant compartment of a vehicle), while Vicon requires a line of sight between off-board cameras and on-board occupant retroreflective markers. Aramis was shown to provide nearly identical occupant kinematics as the 3D kinematics measured by the Vicon system and because of that it can be used in situations when the line of sight is impossible to be maintained.

V. REFERENCES

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