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CALL FOR PAPERS
Crash Dynamics Session

Comparison of Calculated ATD Head Kinematics from Accelerometer and Angular Rate Sensor Data to Photometric Analysis Data in Dynamic Aircraft Seat Impact Testing

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In aerospace seat development and certification testing, Anthropomorphic Test Device (ATD) kinematics, particularly head trajectory, can be difficult to evaluate. Most commonly, ATD kinematics are determined through photometric analysis from high-speed video of the dynamic impact test. Recent improvements of software have improved on correction methods for parallax, perspective, depth, and scale factor through calibration of a camera sensor, lens, and focus setting combination. While these improvements have increased accuracy and efficiency in post-processing the kinematics, the major fault of photometric analysis still remains target visibility. The target, or object of interest, must remain in view of the high-speed camera. In aerospace seat testing, inherent test setup requirements lead to many instances resulting in loss of target visibility mainly due to ATD arm and leg flail in forward facing seats and large head rotation in side and aft facing seats. Auxiliary targets, also referred to as Mohawk targets, can be used to help triangulate the target of interest in visibility loss; however, there are cases where the target of interest and auxiliary targets can both become obscured or auxiliary targets may not be practical due to possible contact with representative aircraft structure which may influence the ATD head kinematics. Thus, another method to evaluate ATD kinematics from accelerometer and angular rate sensor data can be beneficial.

The measurement of linear acceleration and angular velocity, from angular rate sensors, in the local frame (i.e. ATD head CG) can be used to determine the ATD kinematics with six degrees of freedom (6 DOF) in the global frame [1-3]. Using rigid body kinematics principles, the local accelerations and angular velocities can be transformed to provide global acceleration, global velocity, and global displacement.

This study will provide comparisons of the ATD head trajectory calculated from the accelerometer and angular rate sensor data to 2D photometric analyses in various aircraft seat developmental and certification tests. With most previous research completed on component level testing and rigid seat tests, this study will examine the reliability of a calculated head trajectory from instrumentation over a large set of aircraft seat tests with varying seats, ATDs, and sensor packages. Results will be compared for dedicated head path tests with a 0 deg yaw and flat floor configuration

as well as head path data gathered in 25.562 Test 2 with a +/- 10 deg yaw and seat track deformation applied.

References

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[2] R.D. Huculak and H.M. Lankarani, “Use of Euler Parameters for the Evaluation of ATD Head Trajectory from Angular Rate Sensor and Accelerometer Data in Aircraft Seat Certification Testing,” *Int. J. Crashworthiness*, 18:2, pp. 174-182, 2013.

[3] Y.S. Kang, K. Moorhouse, J.H. Bolte IV, “Measurement of Six Degrees of Freedom Head Kinematics in Impact Conditions Employing Six Accelerometers and Three Angular Rate Sensors (6aω Configuration),” *Journal of Biomedical Engineering*, Vol. 133, November 2011.