HELMET TESTING METHODOLOGY USING IN SITU X-RAY MEASUREMENTS

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Abstract:
Modern military helmets may have various liner and retention systems that are designed for improved performance and comfort. These liners are optically inaccessible, and their performance is usually inferred from the objective measurements relating to a given threat, such as head kinematics or surface strains and pressures on a headform for impact or blast loading, respectively. The use of external optical videography can provide information on helmet shell deformation, but again is unable to resolve the interaction of the shell with the retention system and liners.

In the present work, we demonstrate a testing approach involving the use of a lab-based high-speed X-ray imaging system to visualize the *in situ* deformation of the helmet system. The X-ray system has a continuous capture rate of 7.5 kHz, enabling a time-resolved tracking of helmet deformation throughout testing. The addition of radiopaque markers enabled us to track the deformation of a wide range of liners to visualize their response under loading. In helmets with padding, we were able to track and measure their deformation, while for those with more complex retention systems, we can track the relative displacement of the retention system to the helmet shell. Direct *in situ* validation of this information can be valuable to the helmet design process. While in this work we focus on technique development under various impact scenarios, these techniques will be applied to blast wave loading scenarios in the future.