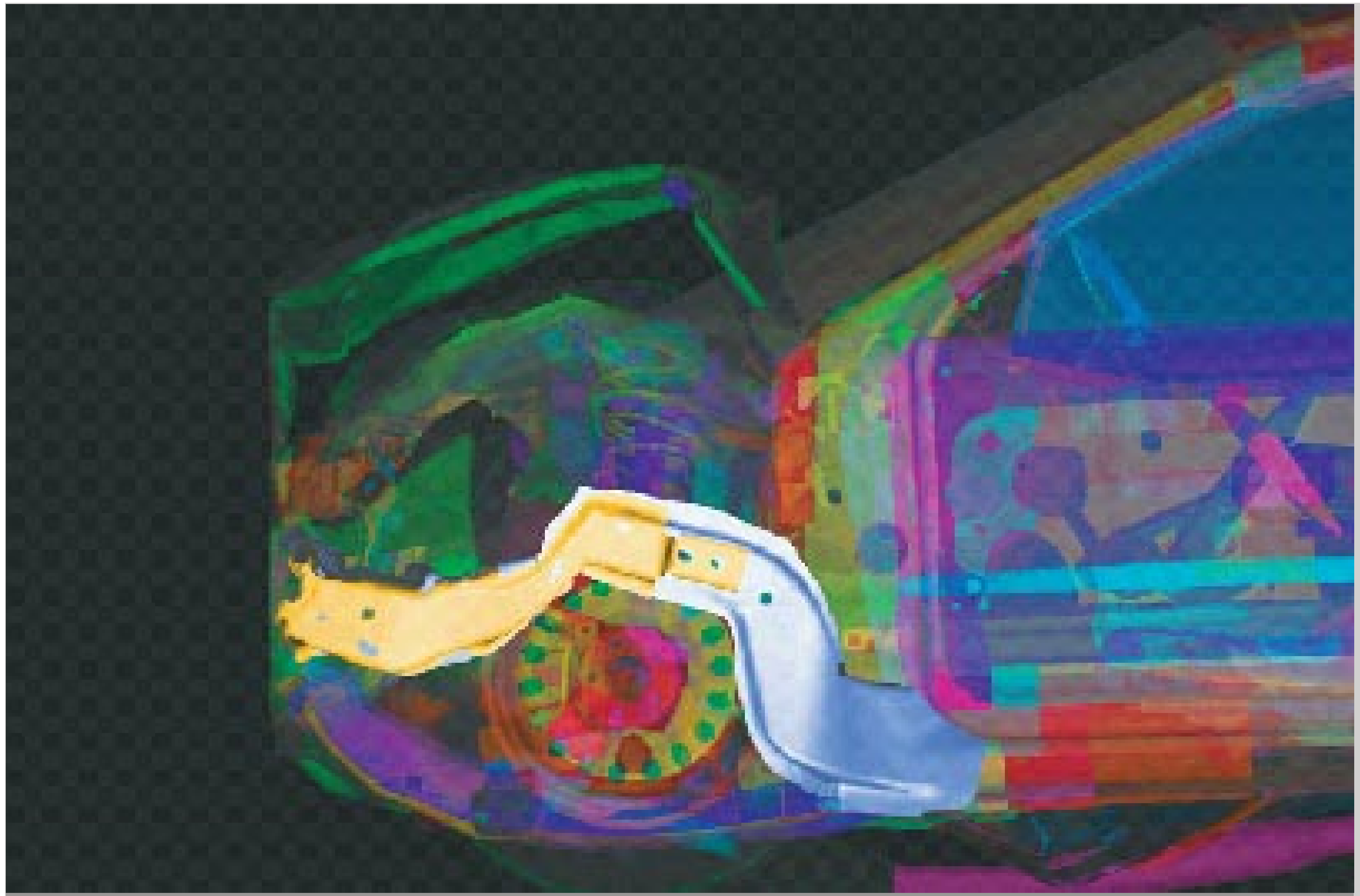

GPU-Based Interactive, Stereoscopic Visualisation of Automotive Crash Simulations

The automotive industry is aggressively moving from physical prototyping to virtual prototyping to reduce time-to-market, lower development costs, and to support innovation and sustainability. Simulation technology in key disciplines such as vehicle crash worthiness, noise and vibration, and fluid mechanics has matured to a high level. To further this technology, VPAC developed a GPU-based algorithm (shader) that achieves a high frame rate while also interactively and immersively visualising production-scale crash simulations, an important tool in developing safer vehicles for passengers and other road users. The development of the visualisation algorithm is part of a broader effort at VPAC to develop a Virtual Integrated Design Environment (VIDE) and is a key component of the Information Engagement Environment (IEE), a next-generation engineering work space being developed by VPAC in collaboration with the automotive industry. The field of human–computer interaction and, specifically, interactive visualisation is a key focus of this major development. The objective is to develop an activity-based interface that maximises the bandwidth of information flow between the information environment and the human engineer.

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For a given load case or crash scenario, slight variations in load case parameters or design leads to a distribution of crash outcomes. The deformation of a vehicle during a crash is considered to be chaotic in the mathematical sense. Minor variations of inputs and numerical round-off will lead to a distribution of crash responses. Noise in the inputs arises from manufacturing and material variations, as well as load case variations such as for speed and angle of impact. Thus, it's this distribution of responses that gives the true assessment of the crash performance and safety of the vehicle design. Even with high-performance computing resources available to the automotive design engineer today, a comprehensive design space study based on a comprehensive set of load cases and taking into account statistical variation is beyond current computational capabilities. Therefore, engineering insight, supported by advanced interactive visualisation, must close the gap between the raw information provided by the simulations and deriving a balanced design. Thus, the challenge of interactive visualisation is to utilise, support, and take advantage of the cognitive ability of humans to find structure in visual information.

The Visualisation challenge

Requirements for the interactive visualisation technology were established from interviews and field trials with crash engineers. We found that a key requirement was the ability to interactively examine two full-scale crash simulations overlaid or side-by-side. Simulation results are selected on demand from a set of precomputed simulations. The crash models consist of several hundred parts; parts can be assigned individual or group-based visualisation-material properties, for example, for the overlay mode, a design variant can have a transparency switched on for all or some of its parts.

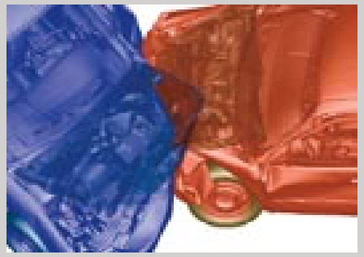
Once the data is loaded, the engineer may hide part groups and zoom into areas of interest. The engineer can choose to shift from viewing the crash as a stationary observer, to following the crash fixed to a particular part, or even to the point of view of a crash dummy. The large number of parts and the complexity of the crash evolution make a stereoscopic-based visualisation environment highly effective and intuitive. However, the need to render two camera positions increases the requirements on the graphics pipeline.

The engineer navigates the model using a space ball and selects the most appropriate centre of rotation. Space-balls are standard input devices for CAD work stations and have proven effective in navigating the virtual space.

Performance

The visualisation algorithm's performance for the two-car crash impact model ranges from 36 to 70 frames per second (fps) in non-stereo mode. A full view of the car (where all parts are visible) in stereoscopic mode is at 22 fps. In practice, however, the crash engineer zooms into regions of the model of interest for a more detailed study, and in this case, the frame rate rapidly increases beyond 40 fps. The minimum interactive frame rate for the visualisation of two simultaneous two-car crash benchmarks (>3.5 million nodes) is 28 fps. The algorithm uses per-part, per-frame bounding-box information to cull vertices not visible in the current view.

VPAC's algorithm helps visualise multiple production-scale crash simulations in interactive, immersive engineering environments.



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Reference