The Use of a Virtual Environment for FE Analysis of Vehicle Crash Worthiness

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1. Description of the application area

The advances in computer graphics technology plus the increased complexity of finite element (FE) simulations of the crash behavior of a car body have resulted in the need for new visualization techniques to facilitate the analysis of such engineering computations.

Our VR system VtCrash provides novel computer-human interface techniques for intuitive and interactive analysis of large amounts of crash simulation data. VtCrash takes geometry and physical properties data as input and enables the user to enter a virtual crash and to interact with any part of the vehicle.

2. Relevant VR system implementation issues

The system is designed in an object oriented fashion. The data is structured into a class hierarchy derived partly from the element structure the FE models are built upon. Geometric data comprises labelled nodes with global coordinates for each time step of the simulation and labelled elements which reference the components they belong to as well as their nodes. VtCrash employs efficient data sorting methods to generate new local polygon lists with bidirectional pointers between nodes and polygons, creating a data structure suitable for the animation of all time steps of a crash test.

A hierarchically built scene graph encapsulates the graphics and visual simulation features. The tree is made up of a root-node and environment-control nodes which control the animation. Finally, geometry nodes contain the topological information of the vertices as well as graphic attributes of the polygons like color, transparency and lighting. Geometry nodes can be manipulated interactively at runtime.

In order to meet memory requirements and to maintain high frame rates, the polygon mesh of the model needs to be simplified. Since it is necessary to keep the shape of the model consistent during the animation, the simplification algorithm is applied to all time steps, identifying and preserving those vertices relevant for the animation of the deformation and eliminating the rest. The polygon decimation criteria is geometric in nature and is based on general ideas of [2] and [1].

Our virtual crash test environment is immersive and creates an actual sense of presence within the crash for the user. This is achieved through head-coupled stereo displays and gestural input techniques.

Alternatively, the system can be used non-immersive with a combination of spacemouse and 2D mouse as well as stereo projection technology.

The time evolution of the vehicle deformation can be controlled and manipulated in real time. Structural parts of the vehicle can be picked and isolated for evaluation of details. Occluding parts can be eliminated or made semi transparent. The user can grab a cutting plane , translate and rotate it freely and slice through the vehicle viewing dynamic cross sections.

3. Effectiveness of the VR system

VtCrash provides a much more powerful animation as compared to traditional postprocessors. Since it is user controllable in an intuitive way it enhances the analytical insights into complex scenarios, which is important especially for communication between people with different expertise and background.

References

[1] M. N. Daisuke Nishioka. Reducing polygonal data by structural grouping algorithm. Image Analysis Applications and Computer Graphics, Lecture Notes in Computer Science 1024, ICSC 95, 1995.

[2] W. J. Schroeder, J. A. Zarge, and W. E. Lorensen. Decimation of triangle meshes. In Proc. of SIGGRAPH 92, 1992.