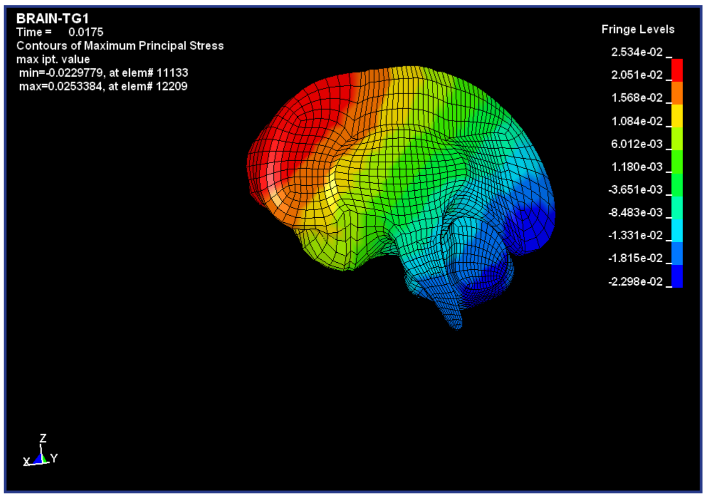
Argonne NATIONAL LABORATORY

Computational Structural Mechanics

Computations performed on TRACC's high-performance computers (HPCs) will greatly reduce the time for transient dynamic bridge analysis, crash analysis (auto, train, aircraft), and human injury assessment.

Background

Computational structural mechanics is a well-established methodology for the design and analysis of many components and structures found in the transportation field. Modern computer simulation tools, such as the finite element method, play a major role in these evaluations, and sophisticated software, such as the commercially available LS-DYNA® code, is available for the applications. These models are used, for example, in crashworthiness assessments of vehicles, such as autos, buses, trucks, trains, and aircraft, under accident conditions. Occupant models are also often included to determine occupant response, evaluate occupant risk and the potential for developing injury reduction mechanisms. Similar analyses are performed for highway safety systems, such as roadside hardware.



Motor vehicle crashes are the major cause of traumatic brain injury in the United States. Numerical modeling by the NHTSA at TRACC provides valuable insight into brain response during crashes (courtesy of Dr. Erik Takhounts of the NHTSA).

Bridges are a critical component to the nation's travel infrastructure. The TFHRC is conducting high-performance computer simulations at TRACC to evaluate bridge safety and reliability under extreme and complex loading conditions (courtesy of Dr. Shuang Jin of the Federal Highway Administration NDE Center).

Other examples of the use of computational structural mechanics in the transportation field include the design and analysis of important components of the highway infrastructure, such as bridges. In these applications, models are being developed to determine the response of bridge structures to traffic loadings; wind loadings, which may result in so-called flow-induced vibration; and hydraulic loading, which may develop during severe weather flooding of bridges.

The level of modeling detail in these applications is being increased substantially to provide greater confidence in the computed results. The use of high fidelity models with hundreds of thousands of elements requires the use of massively parallel computers, such as those available at the U.S. Department of Transportation's Transportation Research and Analysis Computing Center (TRACC) operated by Argonne National Laboratory, and appropriate software, such as LS-DYNA, that can take advantage of this parallel computing environment.

TRACC's Software

TRACC has a 288 CPU (core) license with Livermore Software and Technology Corporation for use of the LS-DYNA suite of codes, which includes LS-DYNA, LS-PrePost®, and LS-OPT®.

LS-DYNA, which is continuously being upgraded, contains many features that can handle the complexities embedded in USDOT's structural and media-structure interaction problems. The solvers include both explicit- and implicit-time integration schemes and a robust Eigen problem solver. The software also uses both finite-element methodology and the newer mesh-free methodology, an important factor in the choice of the software. It also employs the traditional Lagrangian, Eulerian and Arbitrary Lagrangian Eulerian formulations for solving problems involving continua.

For Users

Scripts for ease of use have been developed by TRACC's expert staff and are posted on the TRACC external wiki (**https:wiki.anl.gov/tracc/TRACC**) along with commands for checking job status. The latest information on using the code can be found on the wiki.

Desktop virtualization is available to users, enabling them to interact with the cluster from a remote location. The NoMachine NX server is installed on the cluster, and the NoMachine NX client is available at no cost to the user – providing an efficient and easy way to view finite element models, develop and modify input files, and display computational results.

TRACC's expert staff is available for consultations on computational mechanics issues and development of collaborative projects. Staff is also available to assist with software- and HPC-related issues.

Current Projects

In one project, the Federal Highway Administration's Turner Fairbank Highway Research Center (TFHRC) has used TRACC's cluster to investigate the chaotic motion of the Bill Emerson Memorial Bridge subjected to traffic loads. The finite element model consists of over 1 million elements. Ten days of computing time using 256 CPUs (cores) were required to simulate 100 seconds of traffic flow.

In another project, the Human Injury Research Division of the National Highway Traffic Safety Administration (NHTSA) is working on traumatic brain injuries resulting from crashes. The TRACC cluster allows in-depth investigations to differentiate injuries between various regions of the brain for many accident scenarios.

For futher information, contact

Ronald F. Kulak

TRACC Senior Computational Structural Mechanics Leader

630.578.4245

kulak@anl.gov