Providing Innovative Solutions

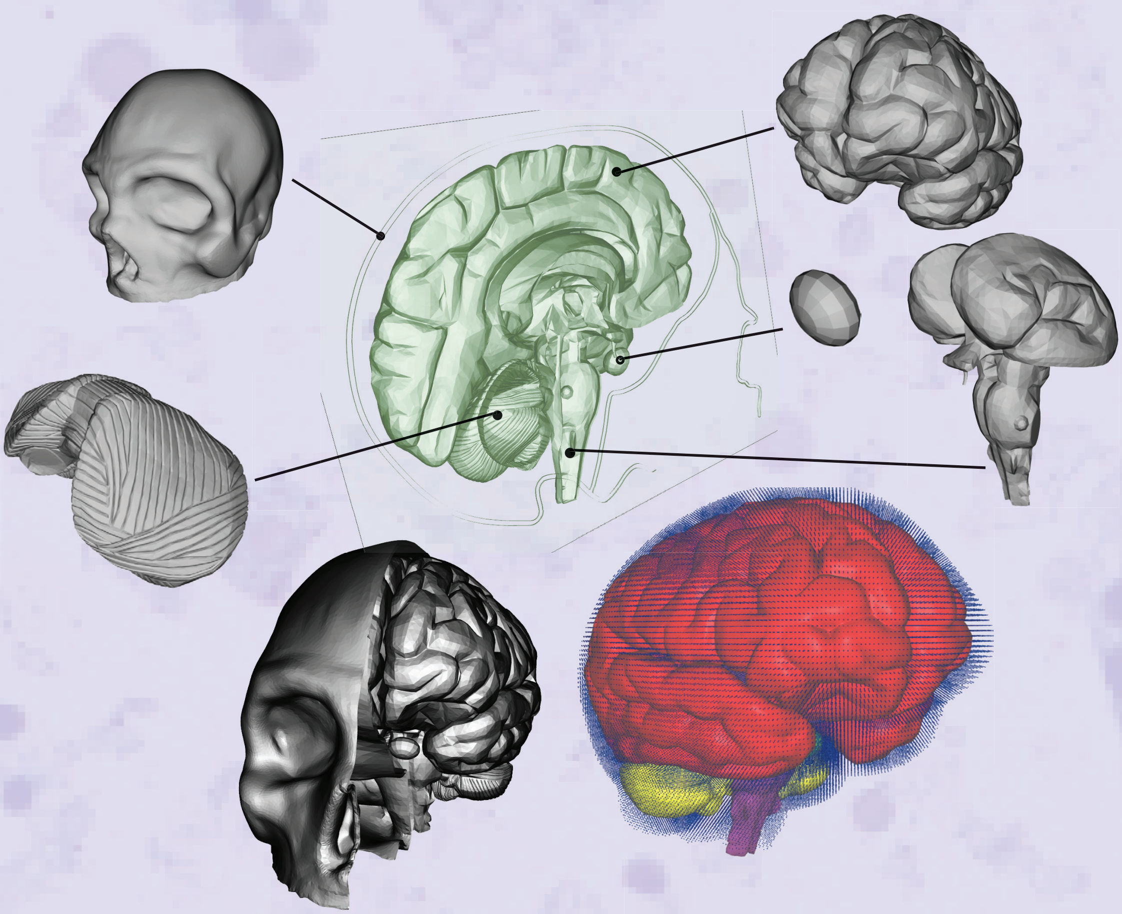
The IMPETUS Afea Solver®

Cerebrospinal Fluid Flow

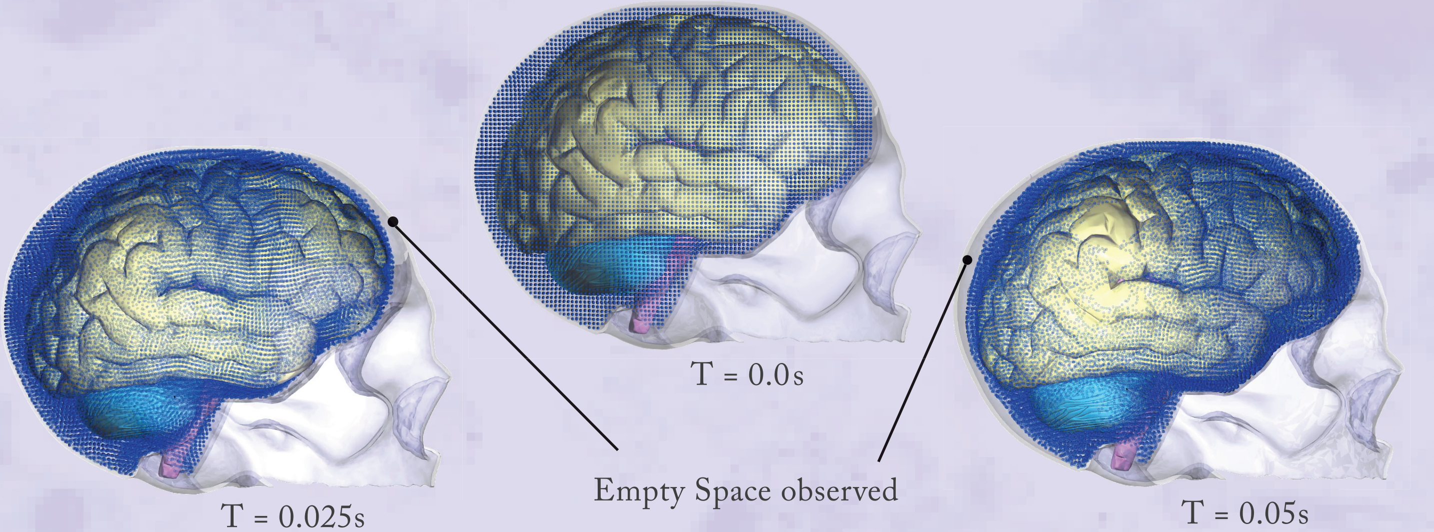
CASE STUDY

At Department of Mechanical Engineering, School of Engineering & Computing Sciences, New York Institute of Technology, Dr. Milan Toma and co-workers have successfully applied the IMPETUS Afea Solver® to detailed modeling of the human head including accurate modeling of the brain and the Cerebrospinal Fluid (CSF).

The primary function of CSF is to cushion the brain within the skull and serve as a shock absorber for the central nervous system. Traditionally, it has been modeled as a continuum e.g., visco-elastic, etc. with the limitations it brings. However, the IMPETUS Afea Solver® offers the accurate and fast γSPH solver to represent CSF as well as the fully integrated high order ASET™ Elements which can handle large deformation and provide accurate results needed to model the complex structural parts of the brain. These advantages, combined with GPU technology, which provides massively parallel processing on a single workstation, have led to the development of the first truly Fluid-Structure Interaction (FSI) model for this application.



The brain alone is a complicated structure, it consists of three main parts, namely the cerebrum, cerebellum, and brainstem. Moreover, the cerebrum consists of two cerebral hemispheres, equal halves of the brain, and is positioned over and around most other brain structures. Each cerebral hemisphere is divided into four lobes by sulci and gyri. The sulci are the grooves and the gyri are the bumps that can be seen on the surface of the brain. The CSF fills a system of cavities at the center of the brain, known as ventricles, and the subarachnoid space surrounding the brain and the spinal cord. The developed model is very comprehensive and captures most of these features. A study was carried out where the model was used to simulate possible whiplash as result of a car crash. This is done by simulating rapid acceleration of the brain and subsequently to rapid deceleration to observe the cushioning effect and dynamics of the CSF.



During the rapid acceleration, the fluid particles can be seen to concentrate at the back of the head, thus preventing the brain from going backward relative to the skull. Under the rapid deceleration, the fluid particles are then concentrated at the frontal lobe, again preventing the brain from moving forward and thus stopping it from impacting the skull. Hence, demonstrating the dumping effect of the cerebrospinal fluid.

Key Features and Benefits:

- ASET™ Elements give accuracy and define the real three dimensional stress state.
- Element technology allows for accurate tetrahedral meshes that are beneficial for modeling complex geometries such as the brain.
- High order elements allow for smoothing of geometric surfaces for accurate contact.
- The γSPH solver is computationally fast and can handle 40+ millions SPH particles.
- Use of γSPH gives accurate pressure fields and "No Tensile Instability".
- Specifying the domain for CFS and the coupling to the structural parts are easy.
- GPU Technology for efficient massively parallel processing resulting in fast runtimes.

CertaSim Providing Innovative Solutions

IMPETUS driving precision

Dr. M. Toma, NYiT: mtoma@nyit.edu

www.certasim.com, sales@certasim.com