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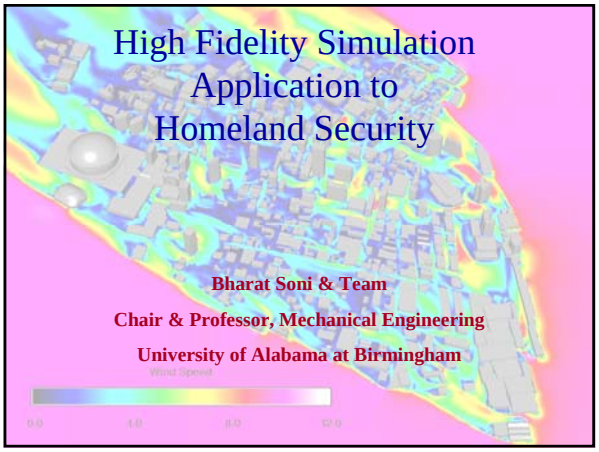
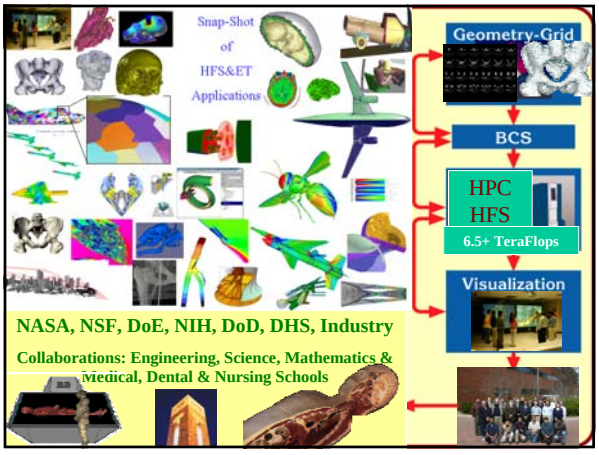
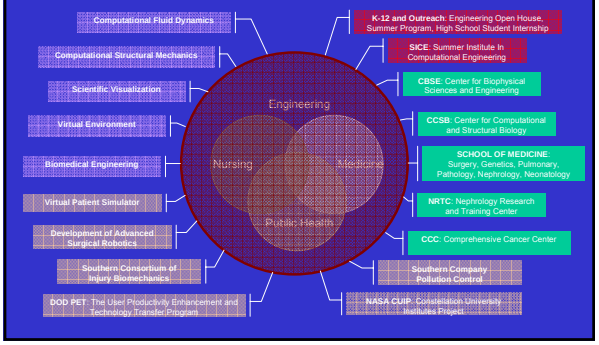




Collaborative R&D&E at UAB



Applications, Physics, Mathematics & Numerics

- Aircraft, Automobile, Engine & Propulsion Design & Analysis
- Biomedical & Bioengineering(Heart, Lungs, Capillaries,…)
- Atmospheric Science, Climate & Weather Prediction
- Electromagnetic & Radar Tracking
- Ground Water Contaminant Transport
- Ocean Modeling
- Submarine & Space Vehicle Design & Analysis
- Remote Sensing
- Oil Exploration

$$Q_t + F_x + G_y + H_z = S$$

* Maxwell Equations
* Schroedinger equation
* Boltzmann equation
* Einstein equation of general relativity
* Hydrodynamic device simulation equations
* Equations of Elasticity
* Navier-Stokes equations
* Nonlinear transport equations with complex constitutive equations

$$\int_{\Omega} \frac{\partial Q}{\partial t} d\Omega + \oint_{\partial\Omega} F(Q)\cdot\vec{n}\, ds = \int_{\partial\Omega} F^{v}(Q)\cdot\vec{n}\, ds$$

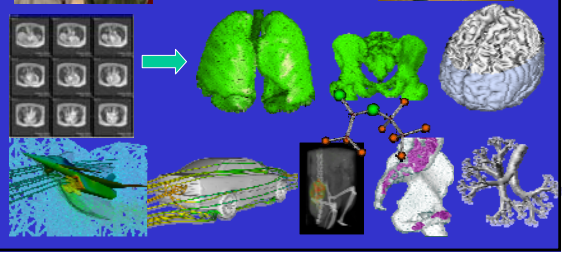
Continuum Algorithm Development in Parallel Environment

MECHANICAL ENGINEERING

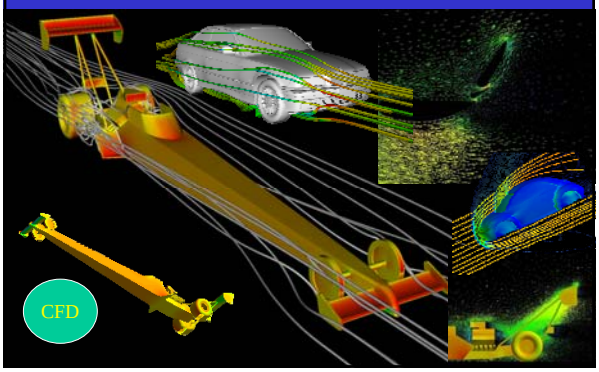
Enabling Technology Laboratory

Geometry Reconstruction & Registration, Meshing, Visualization, Virtual Reality, Data Mining, Feature Extraction/Detection, Software/Hardware Infrastructure

Stereoscopic & High-Resolution Visualization Infrastructure



Automotive Aerodynamics Simulations

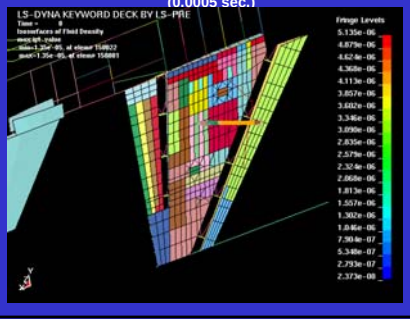


Store Separation & Flexible wing Aircraft

Defense and National Security Applications

• Vulnerability/survivability modeling of missile impacting wing

Modeling Impact & Detonation
(0.0005 sec.)

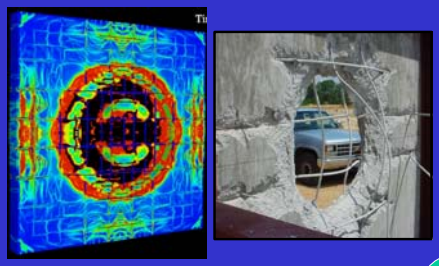


Defense and National Security Applications

- Vulnerability/survivability modeling of missile impacting wing:
  - Effect of fragmentation

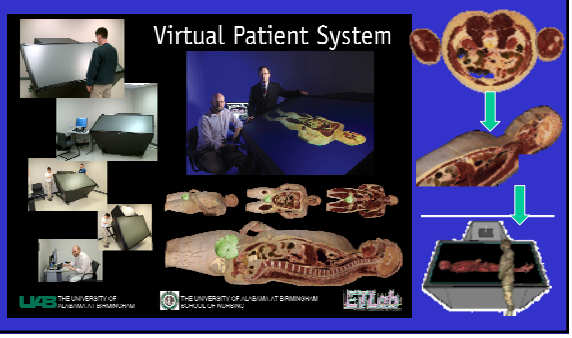
CSD

Detonation Simulations

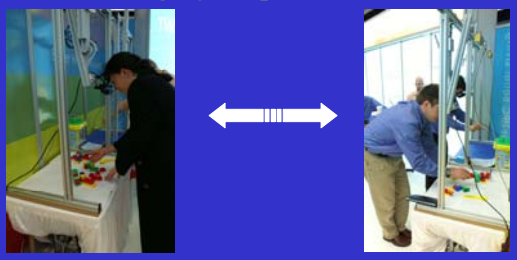


CSD

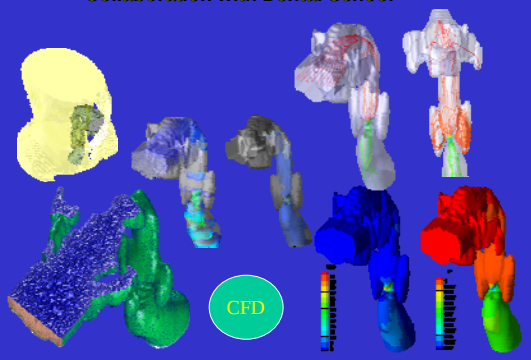
Technology Development - In Progress
Virtual Patient – Collaboration with Nursing School
Patent Application Filed!



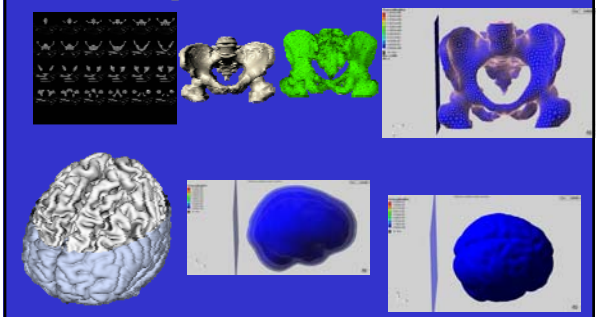
Technology Development in Progress
Remote Surgery – Collaboration with Surgery Department



Flow through neck airway of Sleep Apnea Patient
Collaboration with Dental School



Impact Simulations
Computational Biomechanics



Computational Modeling & Simulation of Human Respiration System

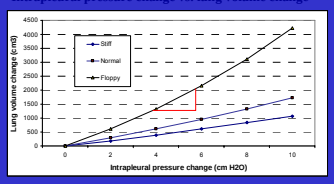
CFD + CSD

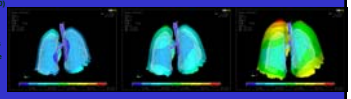
Collaboration: School of Medicine

Computational model includes

- 68K 3D tetra elements
- Initial lung volume (FRC) : 2267 cm³ (Mean FRC of 5 young men : 2290 ± 660) from Cluzel (2000)
- Linear elastic material
  - Normal (E= 9.8 cmH₂O, ν = 0.40) from Ganesan (1995)
  - Stiff (E=14.7 cmH₂O, ν = 0.40) 50% more stiff, fibrosis
  - Floppy (E= 4.9 cmH₂O, ν = 0.40) 50% less stiff, emphysema
- Apply external (intrapleural) pressure (-2, -4, -6, -8, -10 cm H_2O) and then, calculate lung volume changes
- Simulation by finite element code, ANSYS

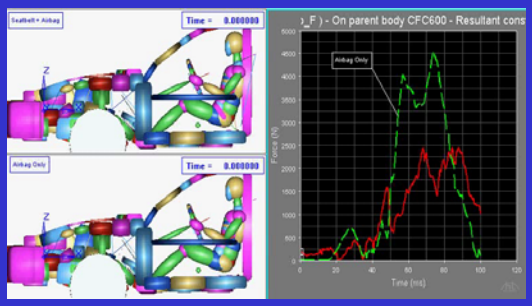
Intrapleural pressure change vs. lung volume change





Stiff, ΔP_{pl}= -10 cm H_2O Normal, ΔP_{pl}= -10 cm H_2O Floppy, ΔP_{pl}= -10 cm H_2O

Real Safety Message
Wear Your Seatbelts!

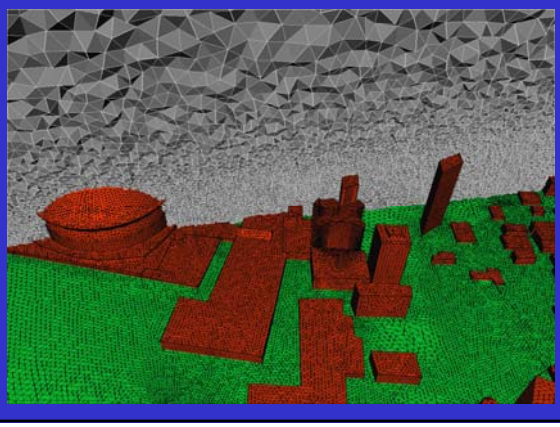


Bio-Chem Pollutant Dispersion
Urban Environment

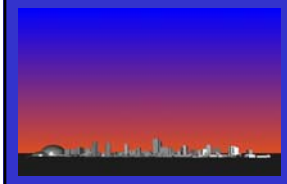
- Discrete Geometry (Urban area) – VRL, DEM,…etc.
- Discrete Physical Domain/Grid Generation (Region of Interest for simulation)
- Solving the Governing Equations
- Visualization and Interpretation of Results

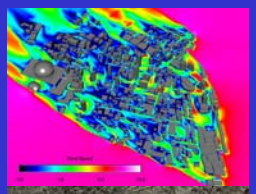
New Orleans City

New Orleans City



Pollutant Transport: City of NO





MSCI/NASA Sponsorship

Streamline Pattern (Contd.)

Behavioral rules

- Much known about behavior during crises and disasters from numerous studies
- Studies also show that members of general public hold strong pre-conceived notions about disaster behavior---many of which are *not* accurate, but inform their behavior nonetheless
- Common behaviors and motivations include: resistance to evacuation, resistance to shelter-in-place, desire to find and join family members, belief that authorities will not be reliable, concern for home and property

Adding agents to the evacuation model

- Agents initially distributed inside buildings
- Leave buildings at a rate λ, affected by policy actions, news broadcasts, timing of arrival of emergency workers, other events
- Once outside building, pick a target destination: home, school, etc. May be informed by desire to find family members or protect property
- Move toward target, avoiding hazards; movement rate determined by *congestion*

Agent-based Congestion Models

- Work by Peyton Young at Brookings on congestion and evacuation
- Individuals choose an evacuation route in response to desired destination (home, school, hospital), local congestion, and location of hazards
- The more agents who choose a given route, the more congested it becomes

Initial Model

At each location, each agent can take one of two possible directions (four at an intersection)

Let $N_{jd}(t)$ be the number of agents on a stretch of road at j heading in direction d at time t.

Average velocity: $v_{jd}(t) = a/(b + \sqrt{N_{jd}(t)})$

Quantal response model

Agent i's utility for heading in direction d is the utility of goal u_{id} minus the time to reach it:

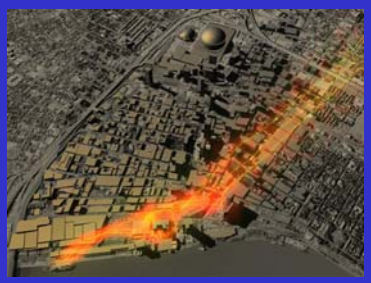
$$u_{ijd}(t) = u_{id} - c_{id} / v_{jd}(t)$$

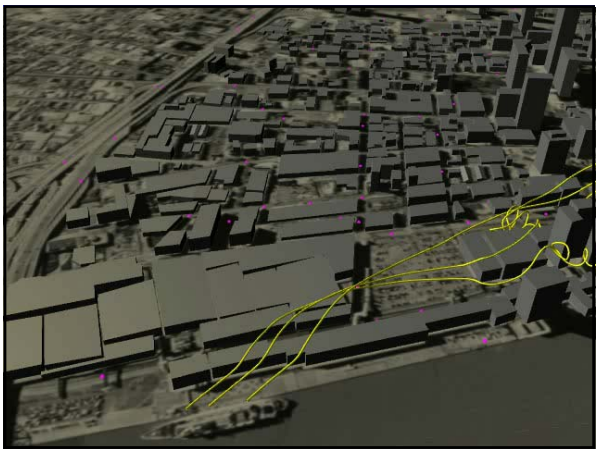
Agent i chooses direction d at location j with probability proportional to $e^{\beta u_{ijd}(t)}$

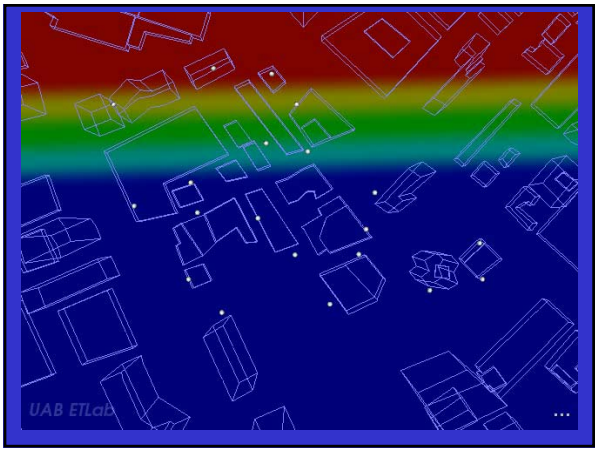
Outcomes studied

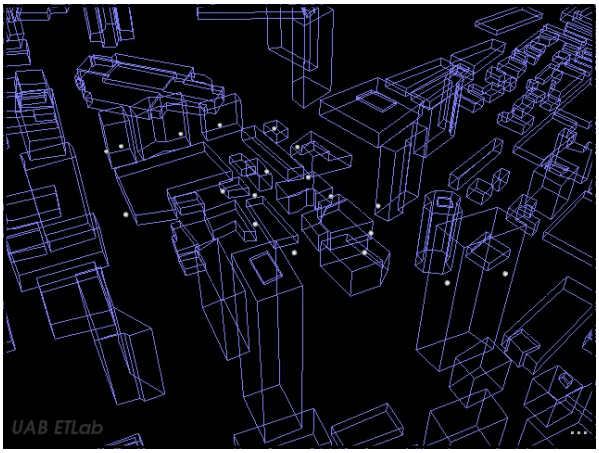
- Short-run and long-run congestion dynamics
- Time required for agents to reach safety, to reach final destinations
- Responsiveness to policy interventions designed to minimize or distribute congestion (e.g. forbidden routes, timing of exit, choice of destination, etc.)

Streamline Pattern






UAB ETLab


UAB ETLab

City of Baltimore 2009-2010

- Develop faster than real-time simulation involving:
  - Bio-Chem Pollutant Transport
  - Population Behavior
  - Transport Modeling
- Available to Hand-hel Palm of the first responder in real-time

Modeling & Simulation System Vision