GAMM Workshop for CSE

CSE as a Core Ingredient in a New Technological University in Engineering and Medicine

Khalifa University and Abu Dhabi's 2030 Vision

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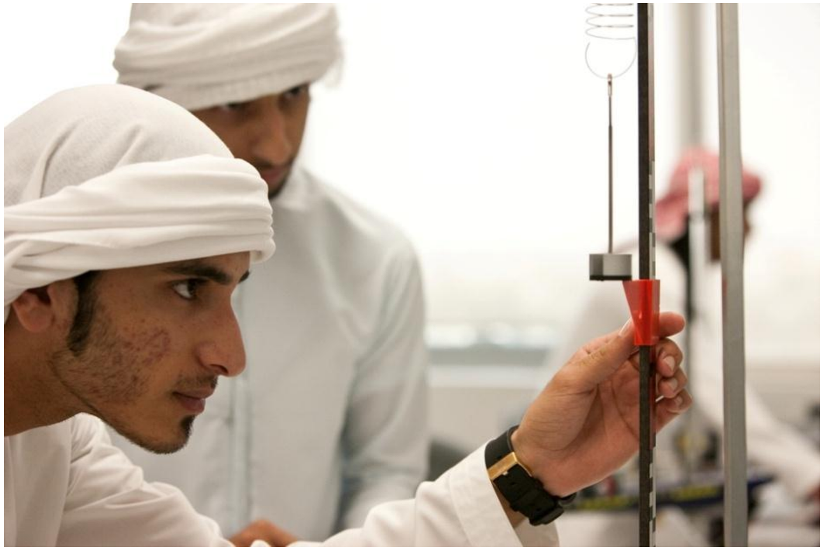
My Context: Formation of Khalifa University



Prior Oil Boom of the 1970s and 1980s

- Investments in physical infrastructure
- Population size in most of the GCC region was relatively small
- Relatively underdeveloped social sector: healthcare, education, investments in human capital
- The internet, communications and PC revolution were just showing signs of emergence

Current Middle East Challenges:

- Sustainably grow and diversify economies
- Develop resilient, adaptive and technology-driven sectors based in the region
- Efficiently channel government surplus revenues into these growth areas
- Investments in human capital: education and healthcare

Khalifa University and Regional Transformation

- Notably distinct focus on Research and Technology
- Close alignment with growing industries based in the region
- Public, non-profit institution, sponsored by Abu Dhabi
- Two campus: Sharjah and Abu Dhabi
- Approximately 1,400 students, over 120 faculty with an emphasis on teaching excellence and active in research
  - Challenge (Significant), current programs are primarily undergraduate, graduate programs are being formed now

Khalifa University programs

- Parallel expectations and aspirations of Abu Dhabi’s 2030 vision
- Competencies in engineering: aerospace, biomedicine, communications, electronics, mechanical and software (industrial and civil coming)
- Graduate programs: masters in nuclear engineering, information technology, security studies (with more coming)
- PhD programs in Communications, Electrical and Computer engineering (with more coming)

The Economy of the Future

- Thriving knowledge economy with local innovation, talent and expertise
- Developing regionally relevant solutions to economic challenges
- Industrial capacity in critical technology areas:
  - Energy and environment
  - Aerospace and transportation systems
  - Healthcare and medicine
  - Robotics and autonomous systems, systems engineering
  - Logistics, telecommunications and security

A key Strategy for Capacity Building—Partnership Development

- Close collaboration with leading corporations, institutions, think tanks, government agencies and other partners
- Global reach: UAE, Europe, North America and Asia
- Over 20 MOUs signed (Georgia Tech, KAIST, University of Bristol, others…..)
- Offer faculty and students opportunities: research, collaboration, experience and job creation for graduates

Khalifa University: Project Examples

- Etisalat British Telecom Innovation Center (EBTIC)
  - Developing next generation networking technologies
  - Optimize telecommunications networks and processes
  - Over 40 researchers, academics and support staff
  - Business process modeling, predictive analytics, cloud computing, network optimization
  - iCampus for a holistic view of education and networking
- Gulf Nuclear Energy Infrastructure Institute (GNEII)
  - Regional capacity for nuclear energy, safeguards and best practices in regulation
  - Partnerships with Sandia (U.S. Dept. of Energy) and Texas A&M

Key Challenges for us where CSE must play a role

- Critical application areas in engineering where core expertise in simulation/methods development is a must
  - Aerospace Engineering (notable activities in composite structures; CFD also a clear need)
  - Mechanical Engineering (Energy and Materials)
  - Biomedical Engineering (Biomechanics, rehabilitation, bioinformatics as related to genomics and cardiovascular disease)

…etc (Industrial Engineering, Civil Engineering, ECE also)

Key Challenges (cont)

- Further expansion of Ankabut, high speed dedicated Internet access, devoted to education and hosted by Khalifa
  - Current emphasis on network access and services, videoconferencing, grid computing capability
  - Further user-driven facilitation of research and educational computing (high performance and otherwise) greatly needed

Key Challenges (cont)

- Demands placed by new colleges coming online
  - College of Medicine and Health Sciences (very large role of simulation in modern medical curricula, demanding of both infrastructure and faculty expertise)
  - College of Science: Applied Mathematics is a core interest of ours ,both in support of engineering research and curriculum initiatives as well as laying the groundwork for future capabilities in Management/Management Sciences

Key Challenges (cont)

- Design-driven education of engineers with sophistication in use of simulation tools
  - Advantages: history of rigorous mathematical education within our university; recent adoption of new curriculum featuring vertical integration of design education (including CAD and simulation tools); high level of comfort of students with simulation technology
  - Challenge: too high a comfort level with simulation, without requisite fundamentals in numerical methods, and with insufficient design intuition to evaluate results?

My Background

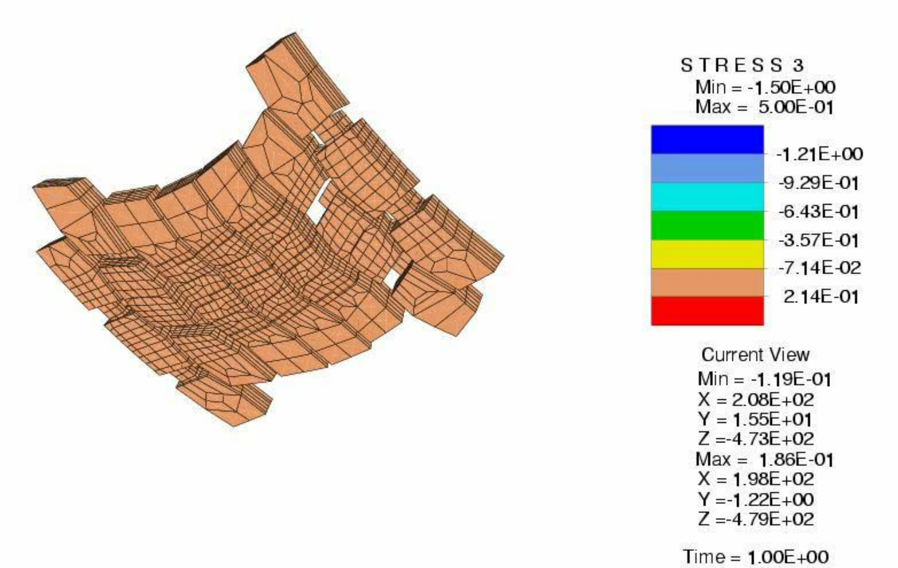
- Training as a mechanical engineer, having taught civil and biomedical engineering also
- Specific research interest: computational contact mechanics
- Perspective I bring to this discussion: boundaries should be as invisible as possible
  - Between scientific questions of interest and interests of industrial and governmental partners
  - Between engineering scientists, mathematicians and computer scientists

Goal of our Research

Finite Element algorithms for large deformation, deformable-to-deformable contact in quasistatic and implicit dynamic analysis, suitable for:

- High fidelity prediction of frictional behaviors in a wide variety of physical settings (stick slip behavior in forming operations; microslip damping phenomena giving rise to structural damping; self-contact and frictional dissipation in tire rolling)
- Accurate treatment of impact phenomena, with careful attention in particular paid to conservation/dissipation of momenta and energy
- Increasingly, incorporation of tribological complexity in our capabilities for contact simulation (including lubrication)

An example from our collaboration with Michelin:

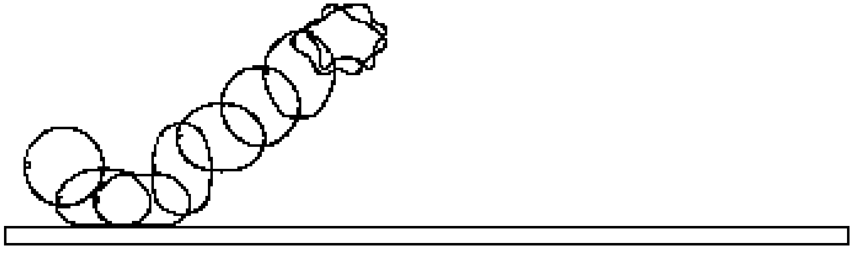


Some Past Efforts Relevant to this Goal

Energy-Momentum Formulation of Impact Interaction

Motivation: many traditional finite element integrators for impact interaction are only linearly stable, and in nonlinear impact calculations can readily produce unstable behavior

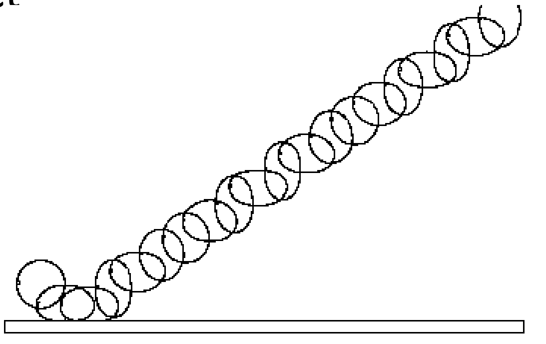
Example:HHT integration of ring impact



Idea: develop algorithms for impact that explicitly conserve energy (when appropriate), as well as linear and angular momentum

Accomplishments of this work (see Laursen & Chawla [1997]; Chawla & Laursen [1998]; Laursen & Love [2002]; Love & Laursen [2003]):

- Stable algorithms for conservative (frictionless) contact without introductionn of nonphysical damping
- Introduction of surface and bulk dissipation (inelasticity) in a manner consistent with underlying thermodynamics
- New notions of temporal accuracy, and corresponding implementations,within an energy-momentum framework



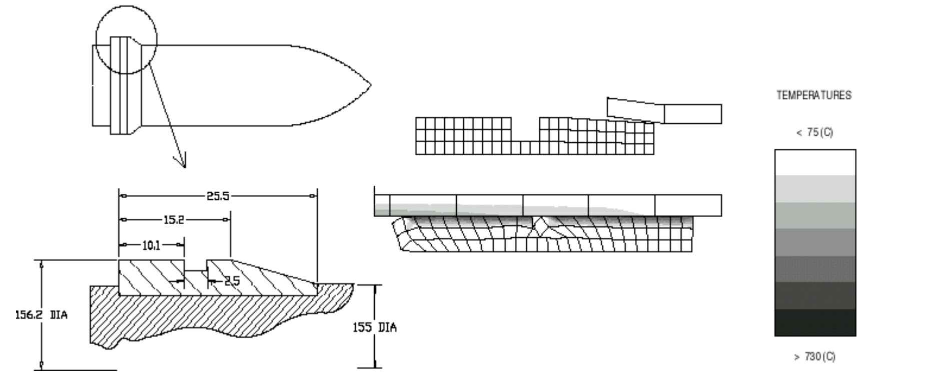
Stable, energy-momentum solution

Past Efforts (Cont.)

Complexity on Interfaces: Multifield Coupling and Tribological Modeling

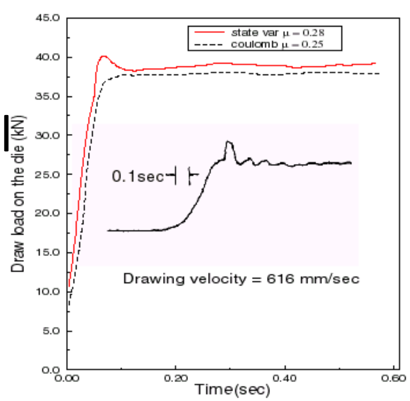
Motivation: many applications demand sophisticated interface constitutive laws to describe observed phenomena

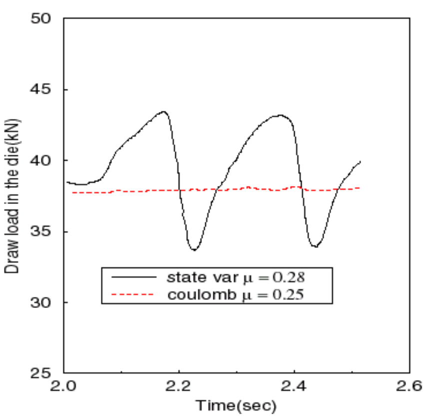
Example: chatter instabilities in drawing applications (Oancea and Laursen [1997, 1998])

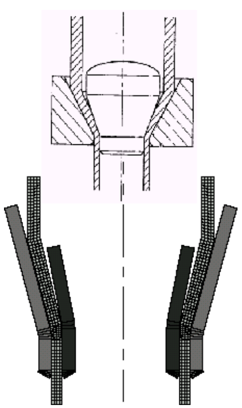


Accomplishments of our research:

- Theoretical framework enabling stable extension of mechanical descriptions to encompass thermomechanical coupling
- Implementations of frictional rate dependence, enabling simulation of unstable slip (see above)



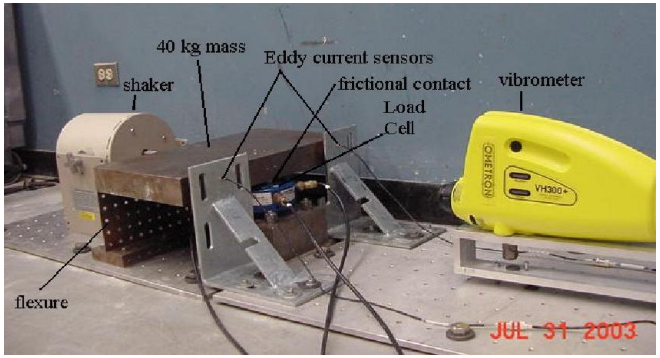


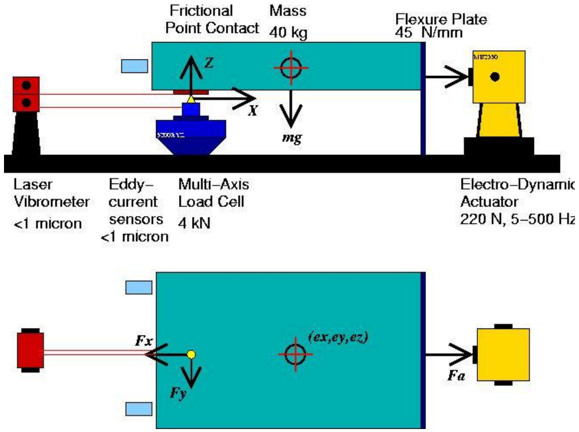


Past Efforts (Cont.)

- ***Microslip Damping/Hysteresis Prediction without Phenomenology***

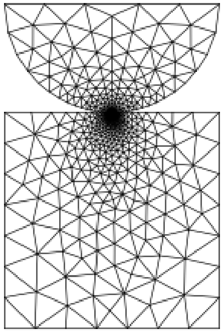
  Many structural damping applications are limited by reliance on phenomenological results, in which distinctions between bulk compliance and surface effects cannot be drawn

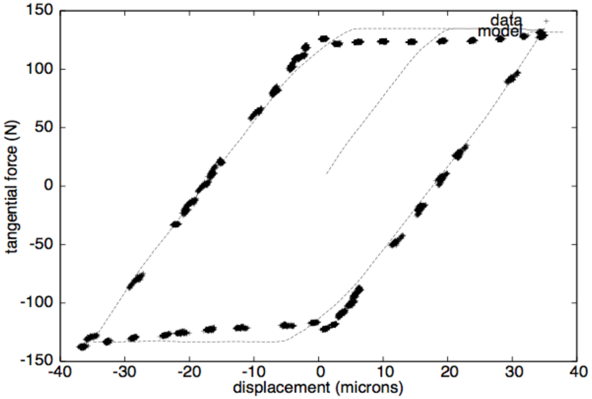




(Greer [2004]):

  – Good representation of hysteretic behavior in finite element models using no phenomenological parameters (friction law only requires two inputs which are readily measured experimentally: mu and interface st





Summary

Our University is attempting to build a distributed capability in CSE with the following characteristics

- Clear commitment to quality undergraduate instruction, including mathematical rigor (heavier than most engineering schools in the US) and design-based curriculum making heavy use of simulation, but not as a substitute for hands-on
- A mathematics faculty that will be heavily biased toward applied math
- Engineering faculty in most disciplines; departments arranged disciplinarily for undergraduate offerings
  - Undetemined how computer science will ultimately appear in our structure
- Graduate studies structured more along interdisciplinary lines, employing institute and center structures
- Strong responsiveness to industrial partners in our research agenda (no national funding agency as yet with real buying power)

Seamlessness between disciplines in approach to CSE is in our view important