Well Conditioned Extended Finite Elements and Vector Level Sets for Three-Dimensional Crack Propagation

Konstantinos Agathos, Eleni Chatzi, Giulio Ventura, Stéphane P.A. Bordas

Permanent Researchers

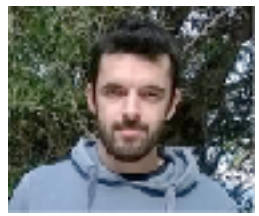

Legato-team Luxembourg

Post-docs









Comp. Sci.

Maths Physicist Maths

PhD Students

Administrative assistant

Computational mechanics & computational materials sciences Multiscale/field interface problems

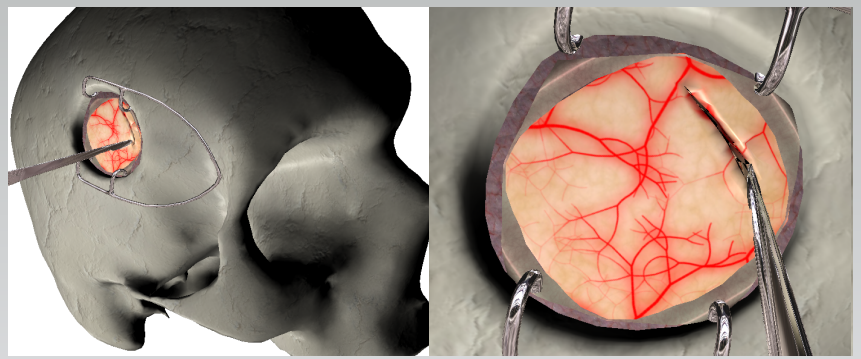
COMPETENCES

DISCRETISATION
discrete and continuum approaches

MULTI-SCALE FRACTURE
aerospace composites, polycrystalline materials

COUPLED PROBLEMS
biofilms, liquid crystals, fluid-structure, batteries

QUALITY & ERROR CONTROL
optimise computational time given an accuracy level



Real-time simulation of cutting during brain surgery, Courtecuisse et al. 2014, Medical Image Analysis

INTERACTIVITY
Reduce computational costs by several orders of magnitude

APPLICATIONS

PERSONALISED MEDICINE

Computer-aided surgery

Computer-aided diagnostics

ENGINEERING

Durability & Sustainability

Energy

Aerospace

http://legato-team.eu — stephane.bordas@uni.lu S. Bordas, B. Peters, A. Zilian and S. Belouettar (LIST)

Computational fracture mechanics:

motivation

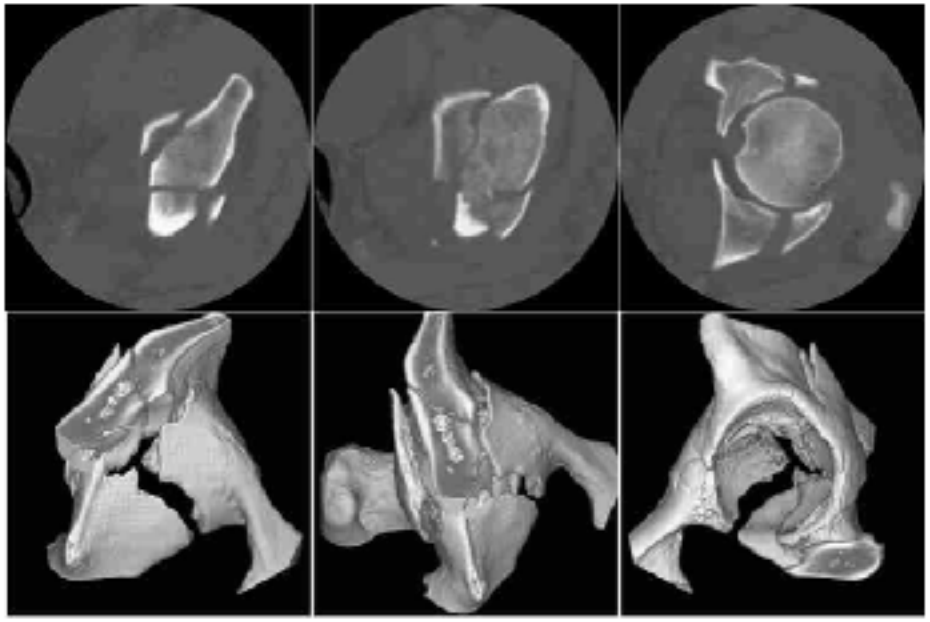
Konstantinos Agathos, Eleni Chatzi, Giulio Ventura, Stéphane P.A. Bordas

Shuttle crash, 2003

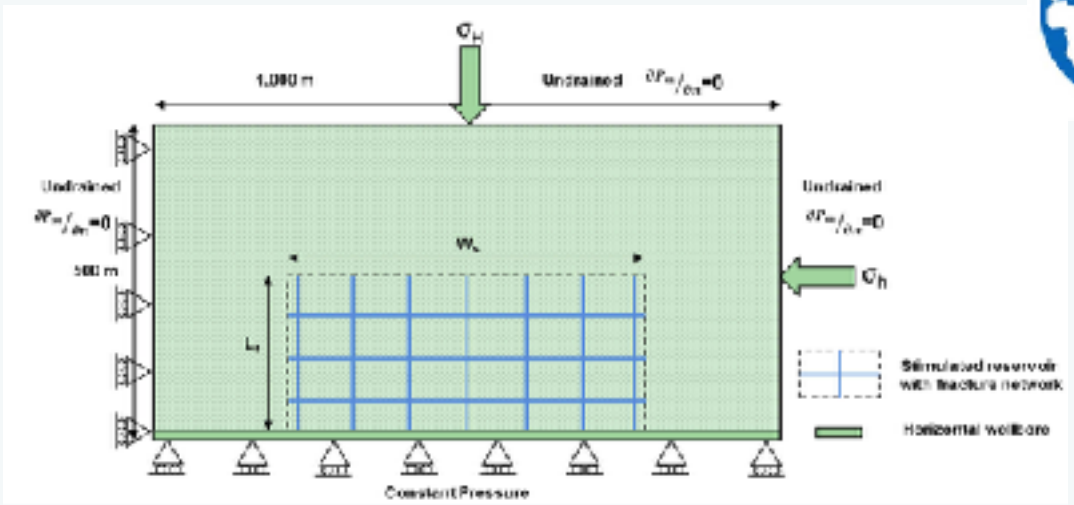
Landslide, Colorado

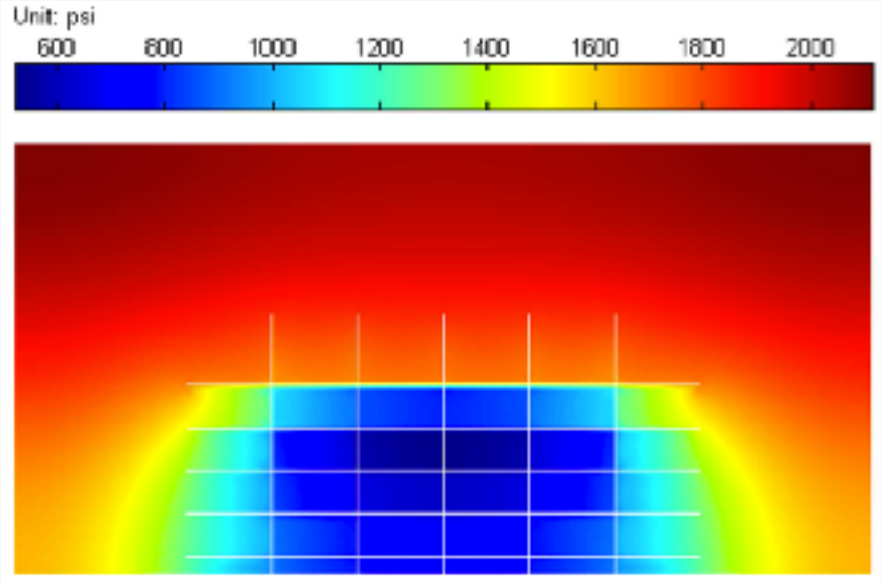
Taiwan earthquake, 2003

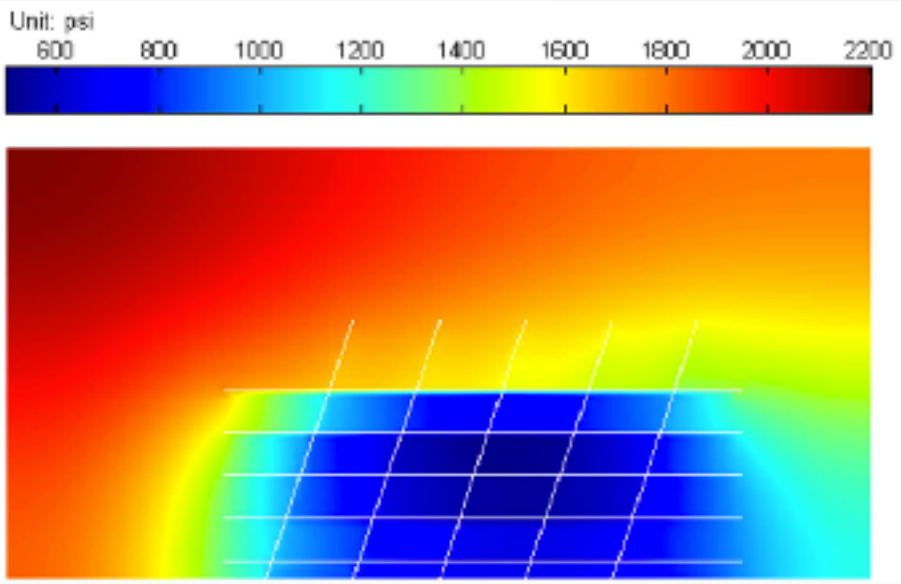
Fragmentation of concrete



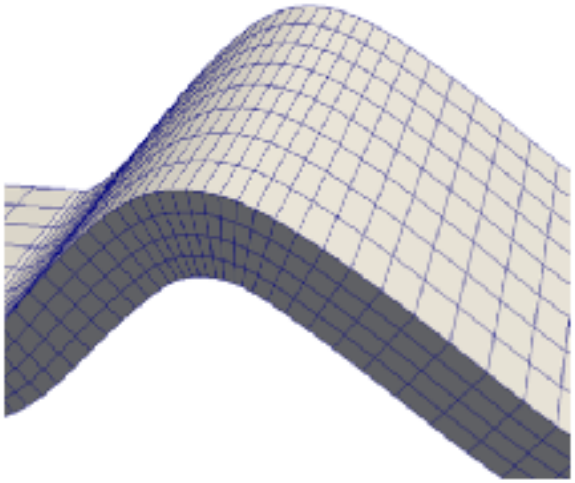
Oil extraction from shale -



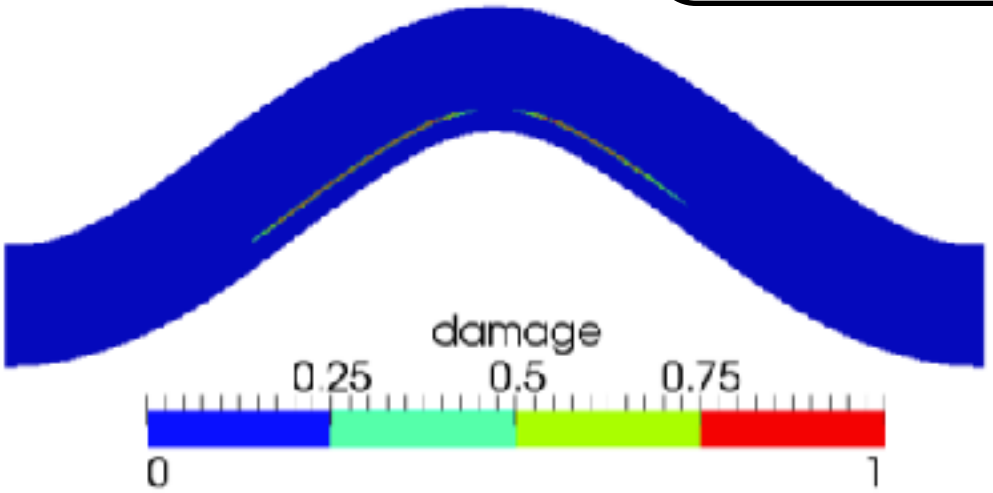




Isogeometric cohesive elements



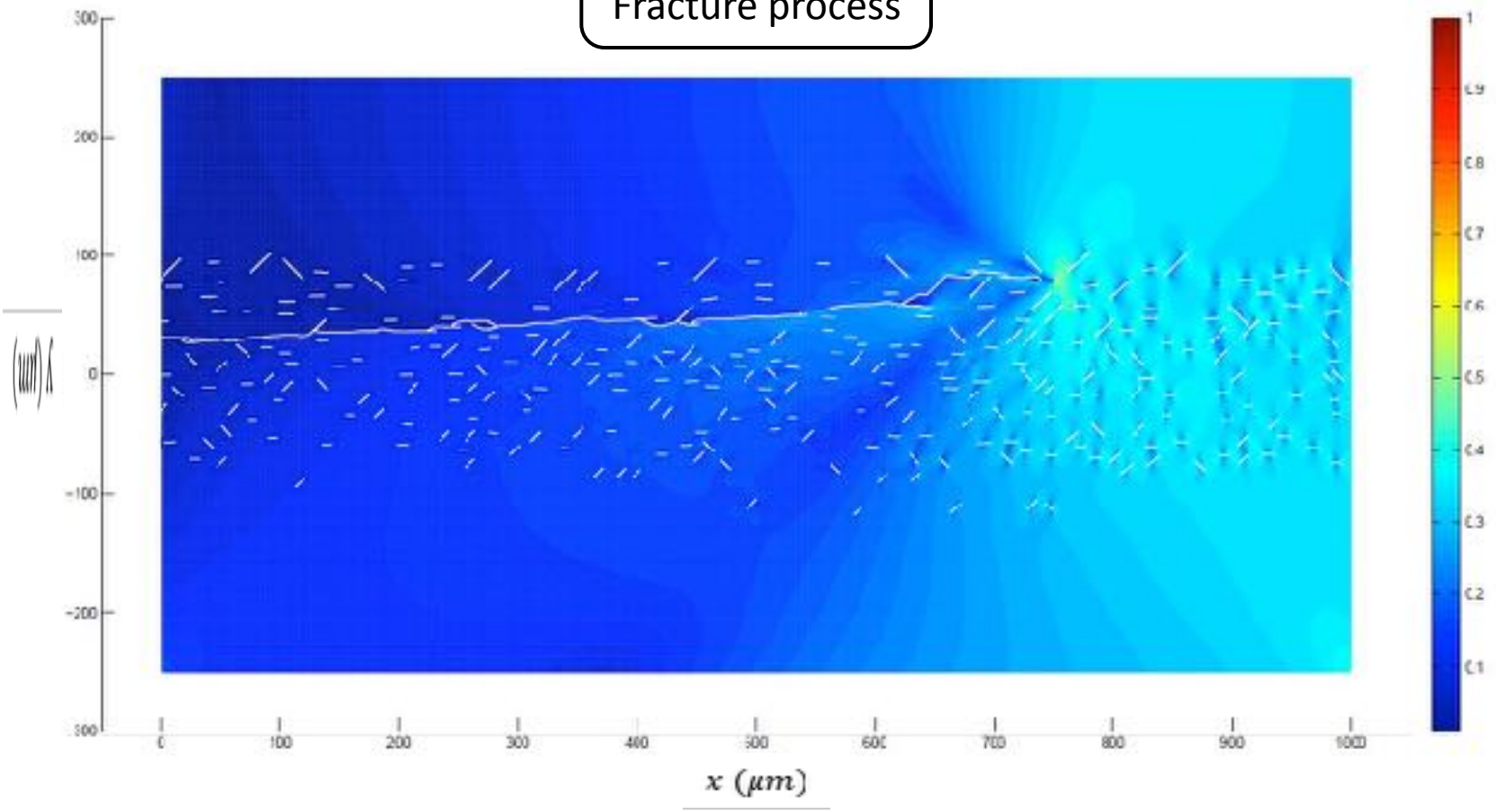
- singly curved thick-wall laminates
- geometry/displacements: NURBS
- trivariate NURBS from NURBS surface(*)
- cohesive surface interface elements



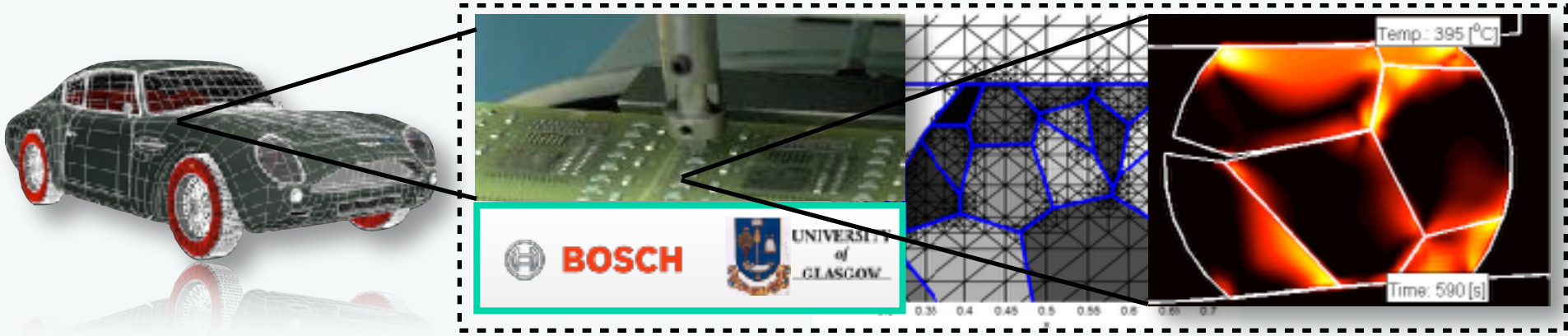
(*)V. P. Nguyen, P. Kerfriden, S.P.A. Bordas, and T. Rabczuk. An integrated design-analysis framework for three dimensional composite panels. Computer Aided Design, 2013. submitted.

Vertical extension of a plate with 300 cracks

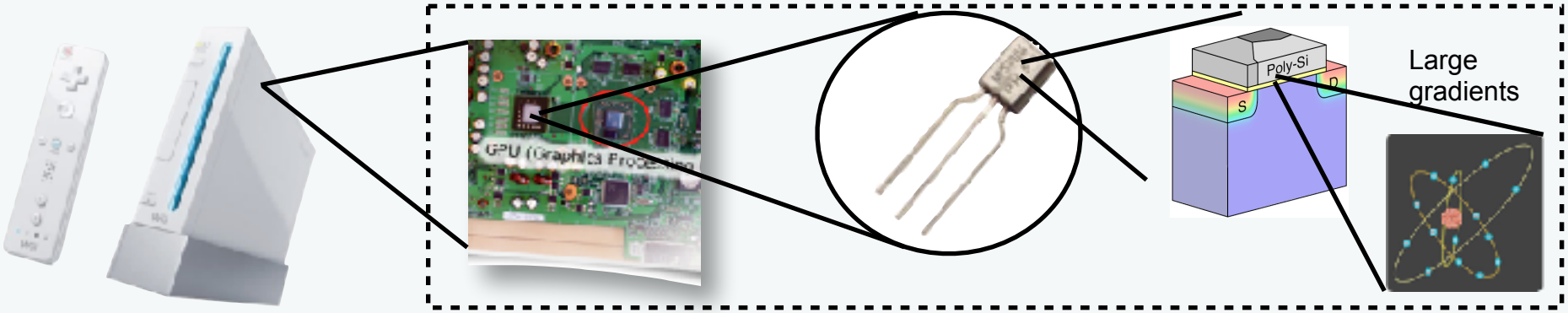
Fracture process



Solder joint durability (microelectronics) - funded by Bosch GmbH (2008-2011) - PhD Alex Menk

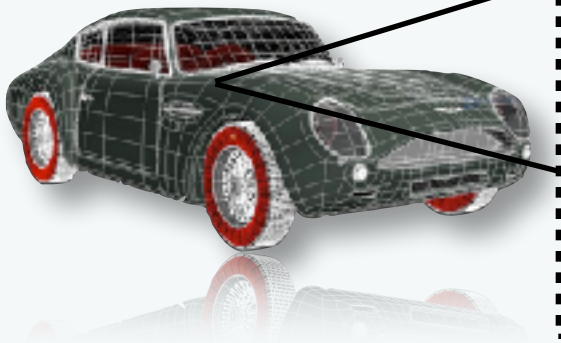


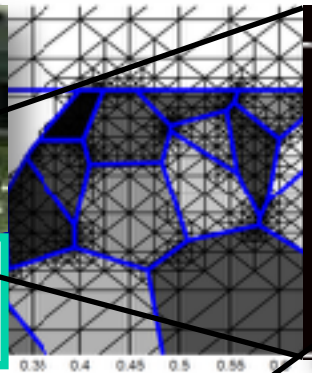
Simulation of nano-Complementary Metal-Oxide Semiconductors (CMOS)

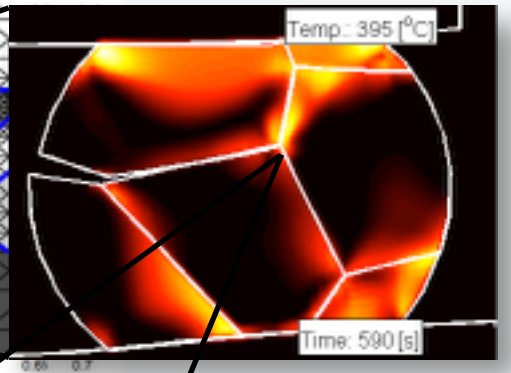


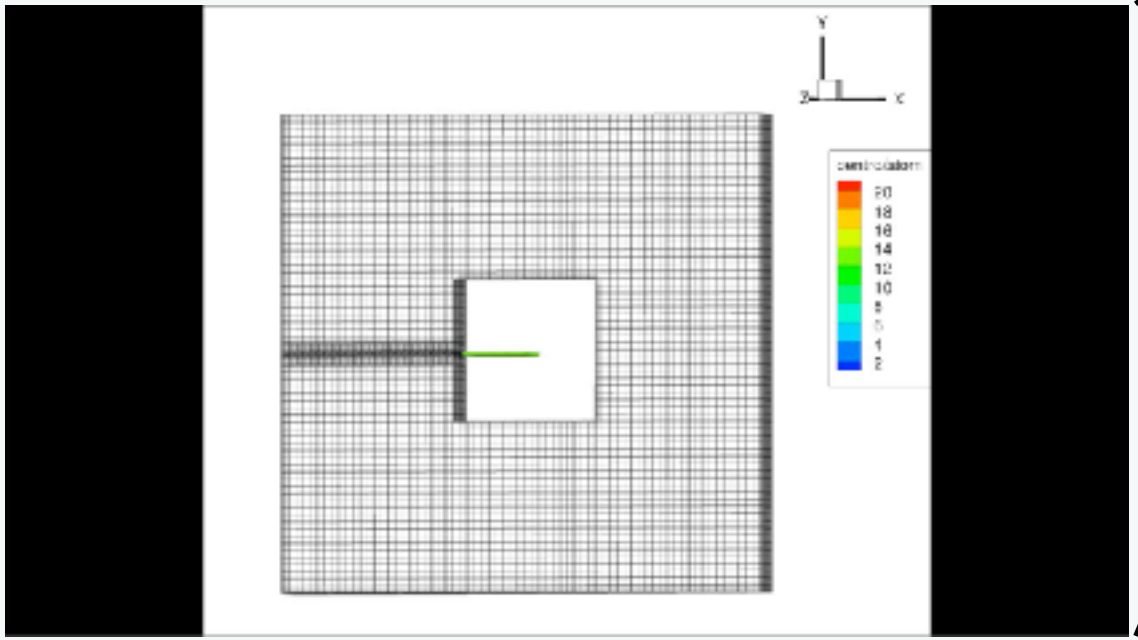
with Asenov, Glasgow -- Robert Simpson's post-doc (EPSRC)

Solder joint durability (microelectronics) - funded by Bosch GmbH (2008-2011) - PhD Alex Menk

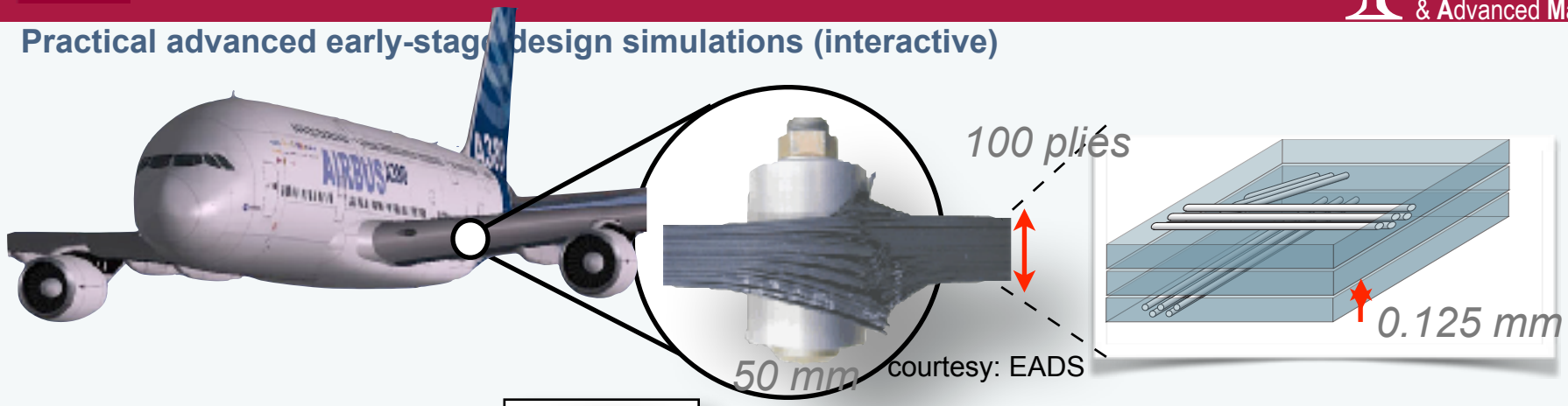








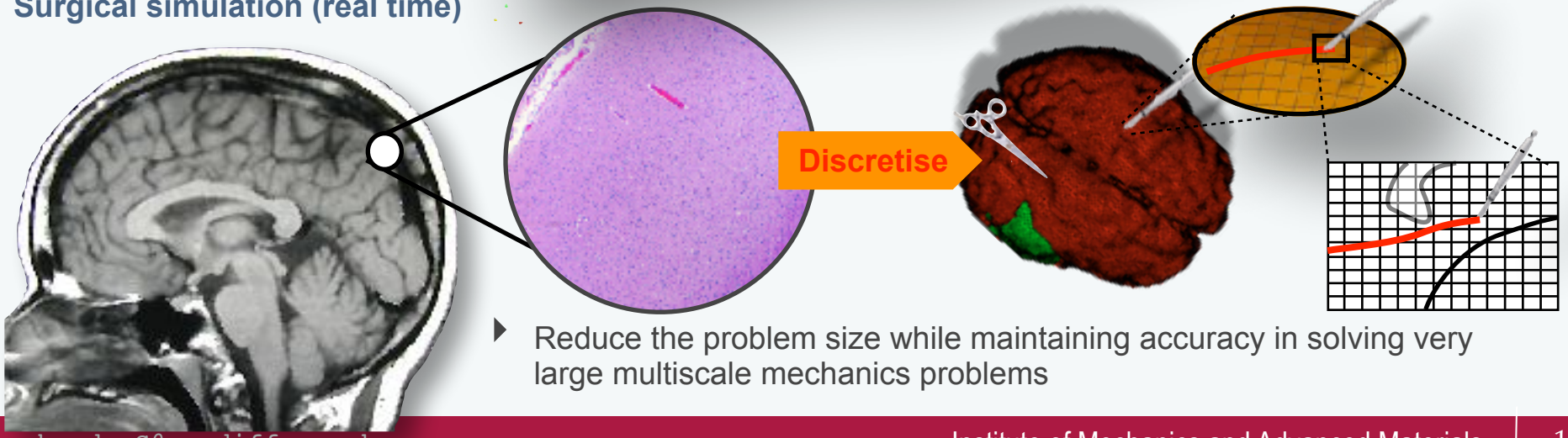
Practical advanced early-stage design simulations (interactive)



Discretise

[Allix, Kerfriden, Gosselet 2010]

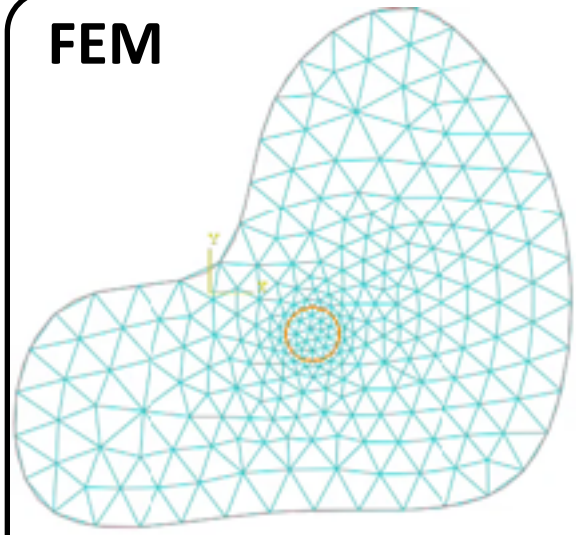
Surgical simulation (real time)

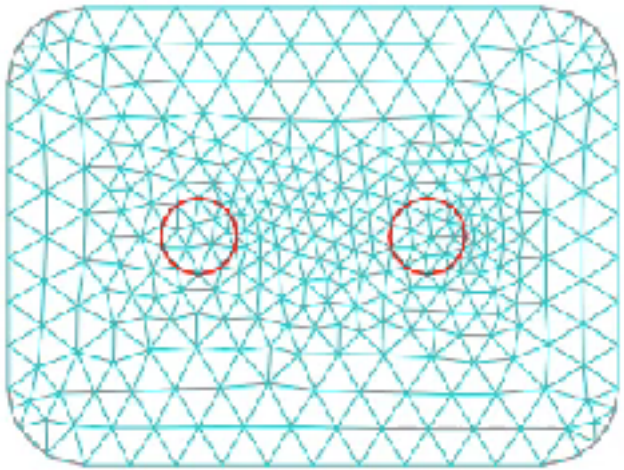


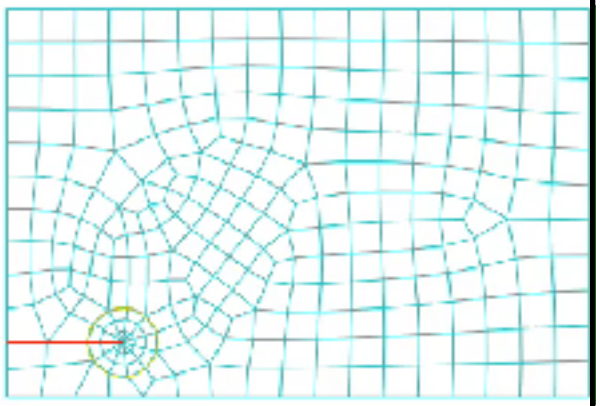
- Reduce the problem size while maintaining accuracy in solving very large multiscale mechanics problems

Free boundary problems

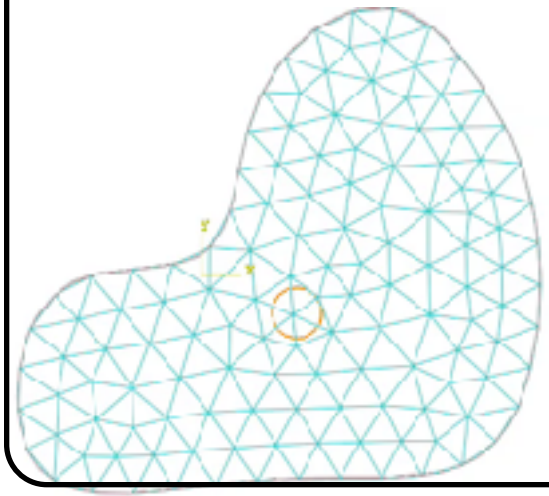
FEM

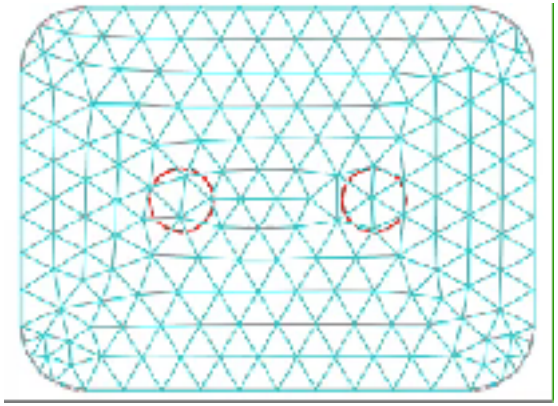


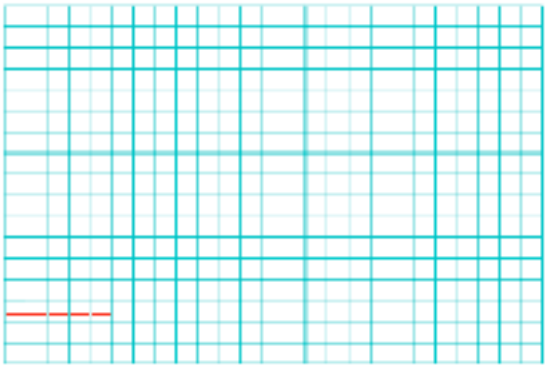




XFEM







Reduce mesh burden

Untie the geometry and analysis

- Meshfree method. (Belytschko, *et al.* 1994)
- XFEM. (Belytschko, *et al.* 1999)
- Immersed boundary method. (Mittal, *et al.* 2005)

Element technology

- Smoothed FEM. (Liu, *et al.* 2006)
- Polygonal FEM. (Alwood, *et al.* 1969)

Boundary discretisation

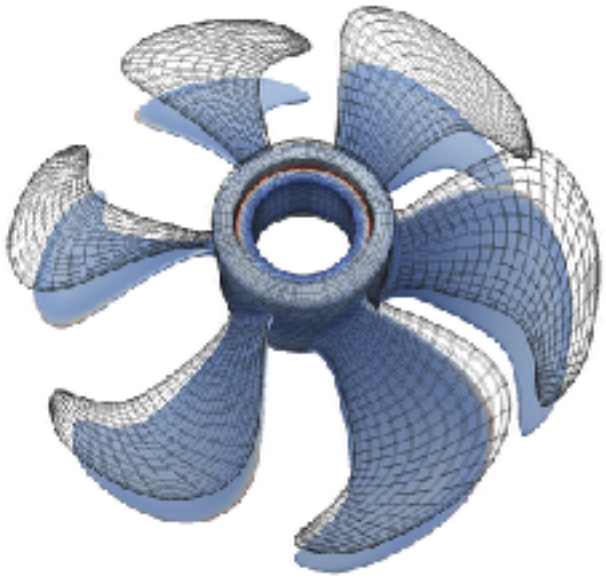
- Boundary element method. (Rizzo, 1967)
- Scaled boundary FEM. (Song, *et al.* 1997)

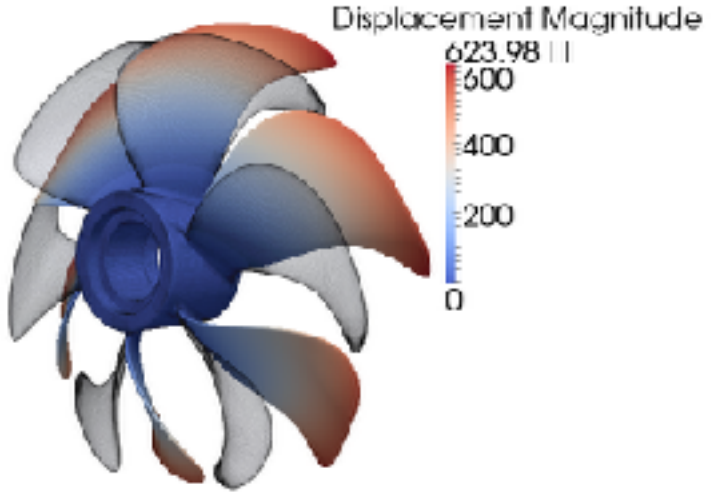
Isogeometric analysis (Hughes, 2005)

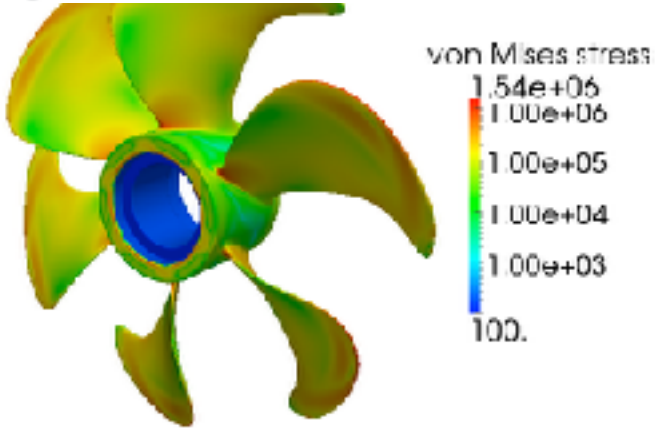
Isogeometric BEM (Simpson, *et al.* 2012)

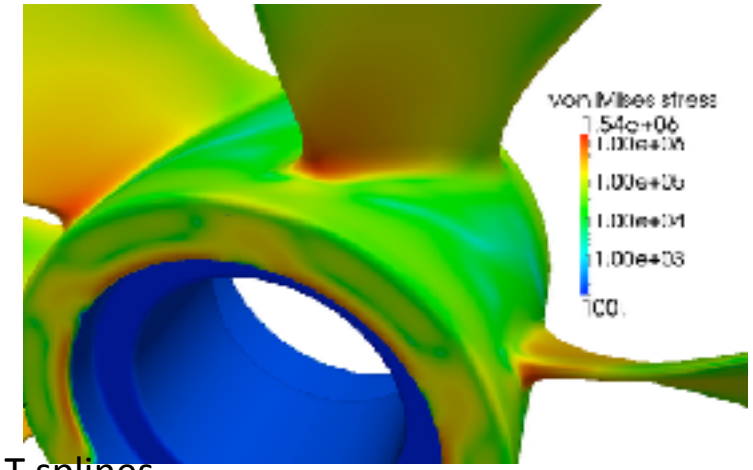
Isogeometric BEM for fracture (Peng, Atroshchenko, SB 2016)

Propeller: NURBS would require several patches - single patch T-splines







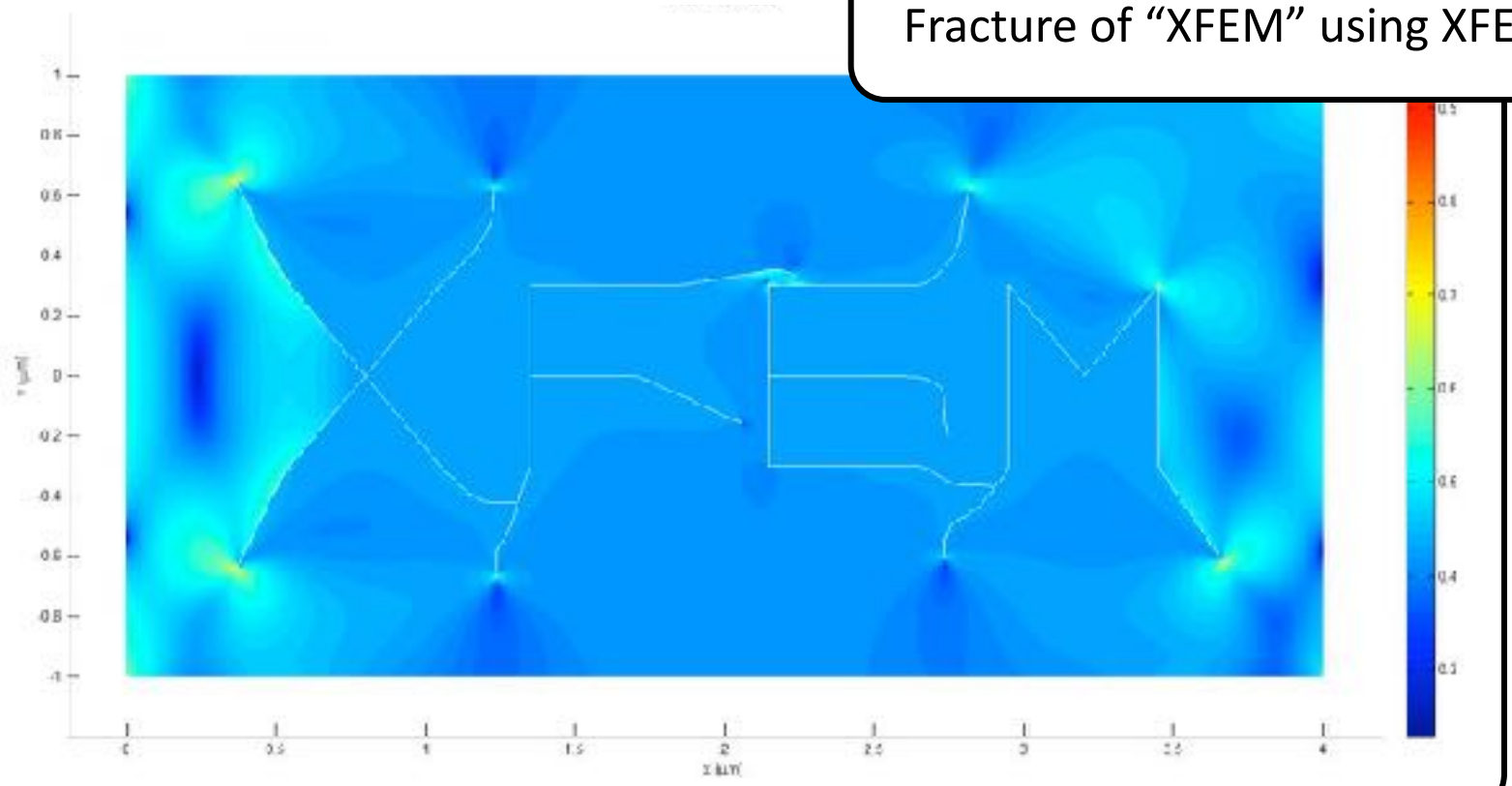


Isogeometric boundary element analysis using unstructured T-splines
MA Scott, RN Simpson, JA Evans, S Lipton, SPA Bordas, TJR Hughes, TW Sederberg
CMAME, 2013.

Extended Finite Element Method (XFEM)

- Introduced by Ted Belytschko (1999) for elastic problems

Fracture of “XFEM” using XFEM



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Computer Methods in Applied Mechanics and Engineering 254, 197-221

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