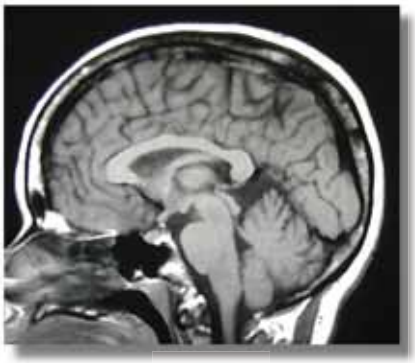
The Royal Academy of Engineering

Towards the next generation surgical simulators

Leverhulme Trust Senior Research Fellow

Prof. Stéphane P. A. Bordas & Dr Pierre Kerfriden

School of Engineering, Cardiff University



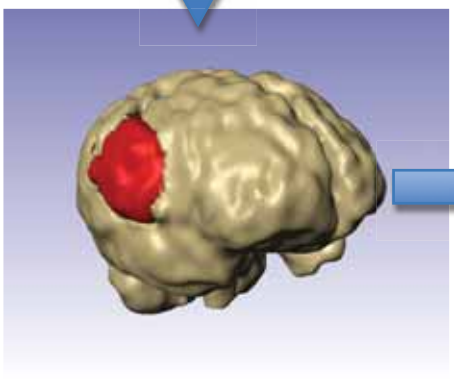
Segmentation
& geometry generation
(SimpleWare, Prof. Philip Young,
Leverhulme RAENg fellow)

"A surgeon trained on a simulator is twice as fast and twice as accurate as one who has not been. It reduces errors, making surgery much safer. Simulation works and the NHS must be able to provide it to make a difference to patients." *Sir L. Donaldson NHS chief medical officer*

Aim: provide in real time realistic force feedback during cutting in surgical simulation.

Requirements for surgical simulation

- Handle extremely complex organ geometries
- Simulate cutting, prodding, etc. in real time
- Reproduce material response faithfully for a realistic surgical experience during simulation
- Control the error and validate results

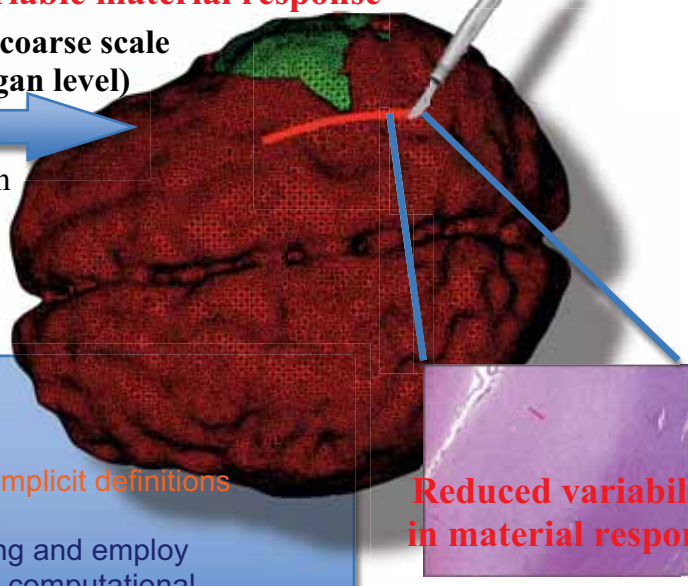


Mesh generation
(SimpleWare)
& Implicit
Geometry

Highly variable material response

at the coarse scale
(organ level)

Predict realistic reaction force



Reduced variability in material response

at the fine scale
Damage and failure
leading to cuts
at the coarse scale

Proposed paradigm

- Avoid meshing complex boundaries through implicit definitions of the geometry at the coarse and fine scales
- Simulate cutting without meshing or remeshing and employ adaptive model order reduction to reduce the computational time by several orders of magnitude on parallel supercomputers
- Handle material response at the fine scale where variability is reduced through a multiscale approach
- Estimate the approximation error to suitably adapt the mesh

The Leverhulme Trust

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD