Towards a seamless Integration of CAD and Simulation

Introduction

Multi-scale fracture and model order reduction Pierre Kerfriden, Lars Beex, Jack Hale, Olivier Goury, Daniel Alves Paladim, Elisa Schenone, Davide Baroli, Thanh Tung Nguyen

Advanced discretisation techniques Danas Sutula, Xuan Peng, Haojie Lian, Peng Yu, Qingyuan Hu, Sundararajan Natarajan, Nguyen-Vinh Phu

Error estimation Pierre Kerfriden, Satyendra Tomar, Daniel Alves Paladim, Andrés Gonzalez Estrada

Biomechanics applications Alexandre Bilger, Hadrien Courtecuisse, Bui Huu Phuoc

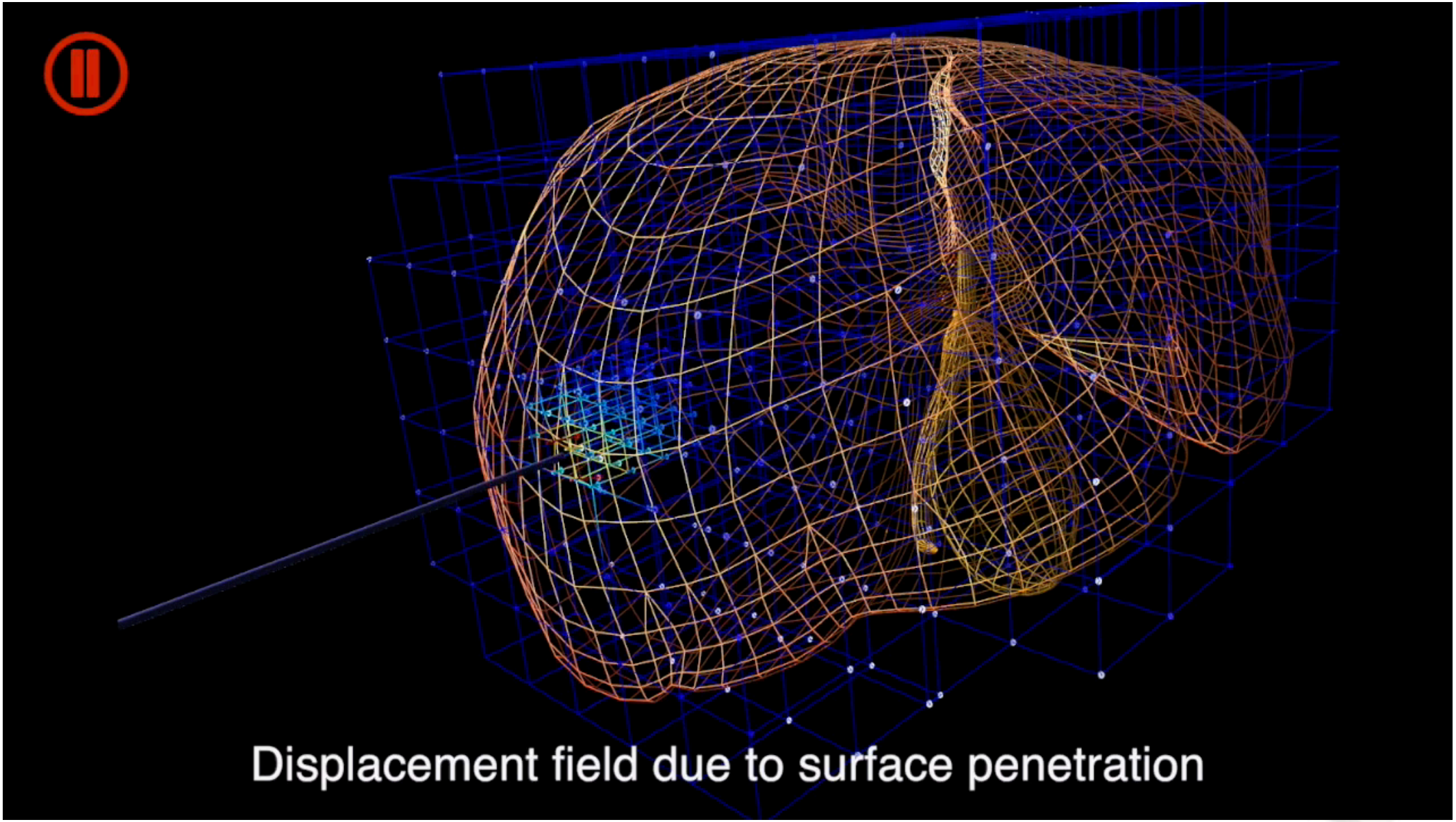
and all the others!

CISM Course, Udine, Italy, 2017 June 5-9

Stéphane P.A. Bordas stephane.bordas@alum.northwestern.edu http://legato-team.eu

Organised by Gernot Beer & Stéphane Bordas

Computer-assisted surgery



Needle insertion in the liver

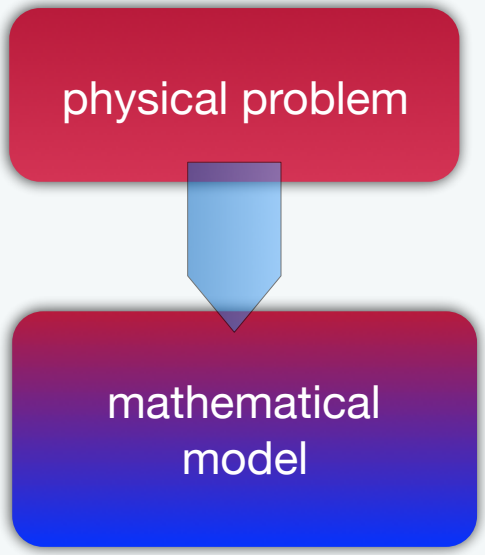
Bui Huu Phuoc, Legato Team, 2017 http://orbilu.uni.lu/handle/10993/29846 http://orbilu.uni.lu/handle/10993/30937


dic Table of the Finite Elements
O'NEILL

Modelling and simulation

physical problem

Modelling and simulation



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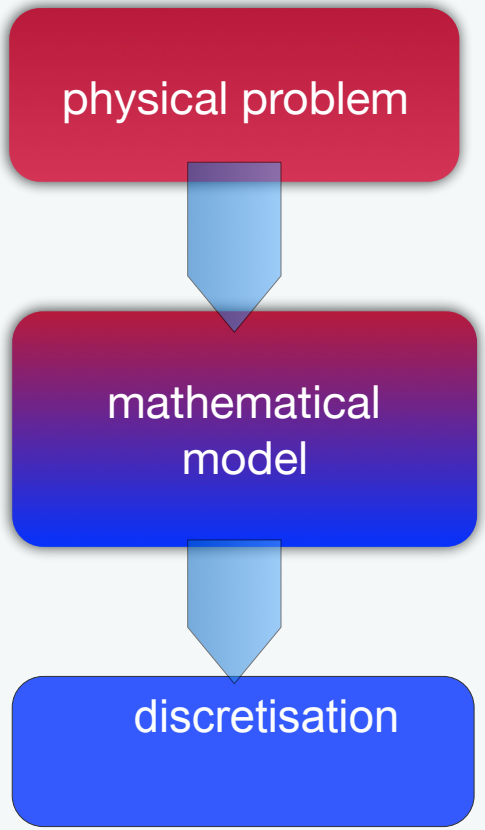

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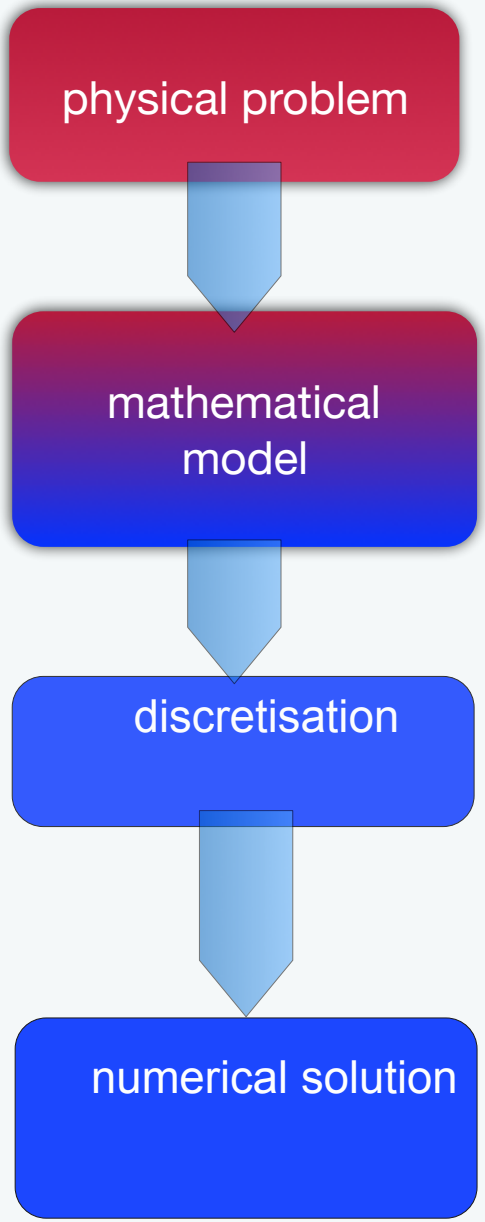

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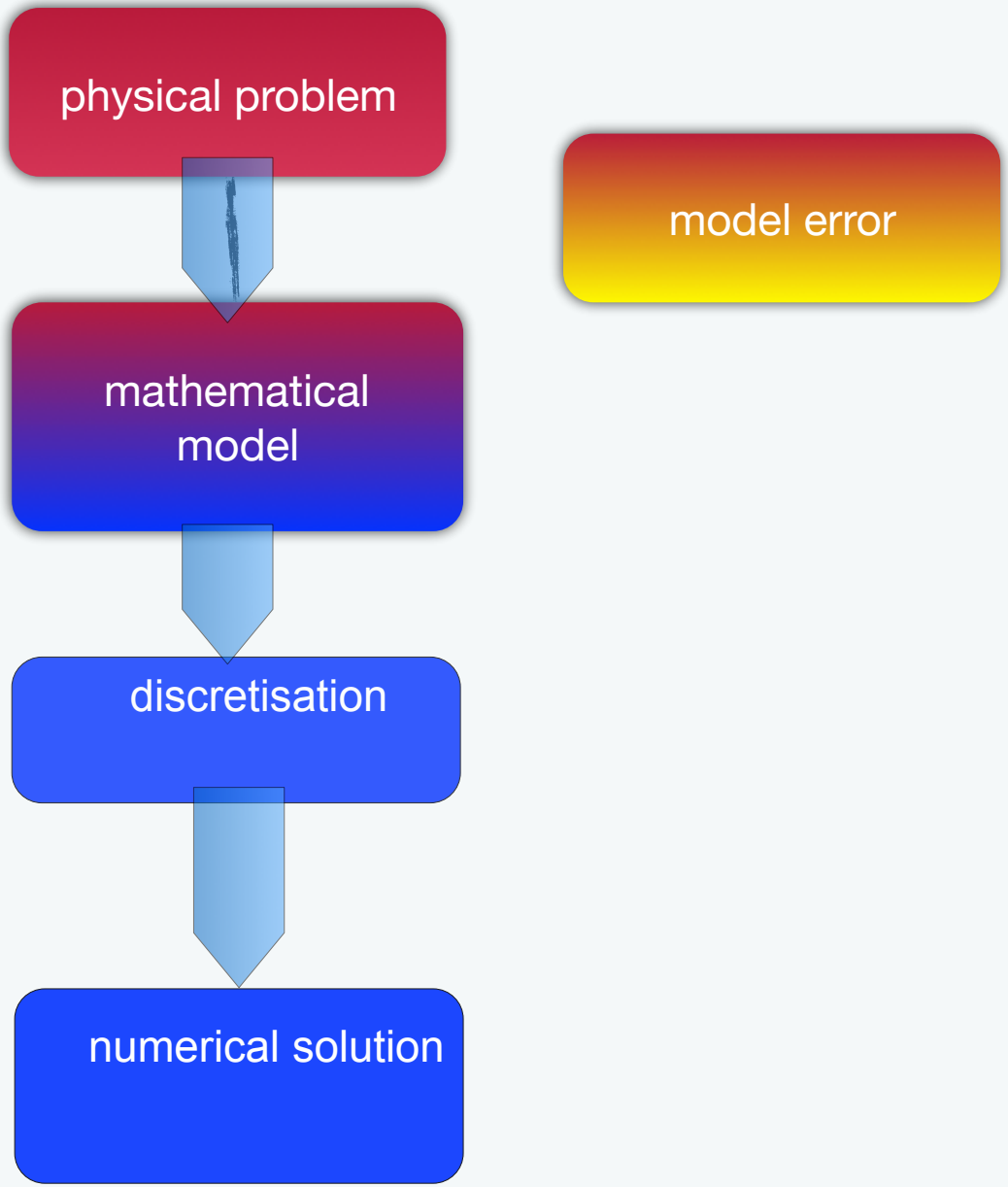

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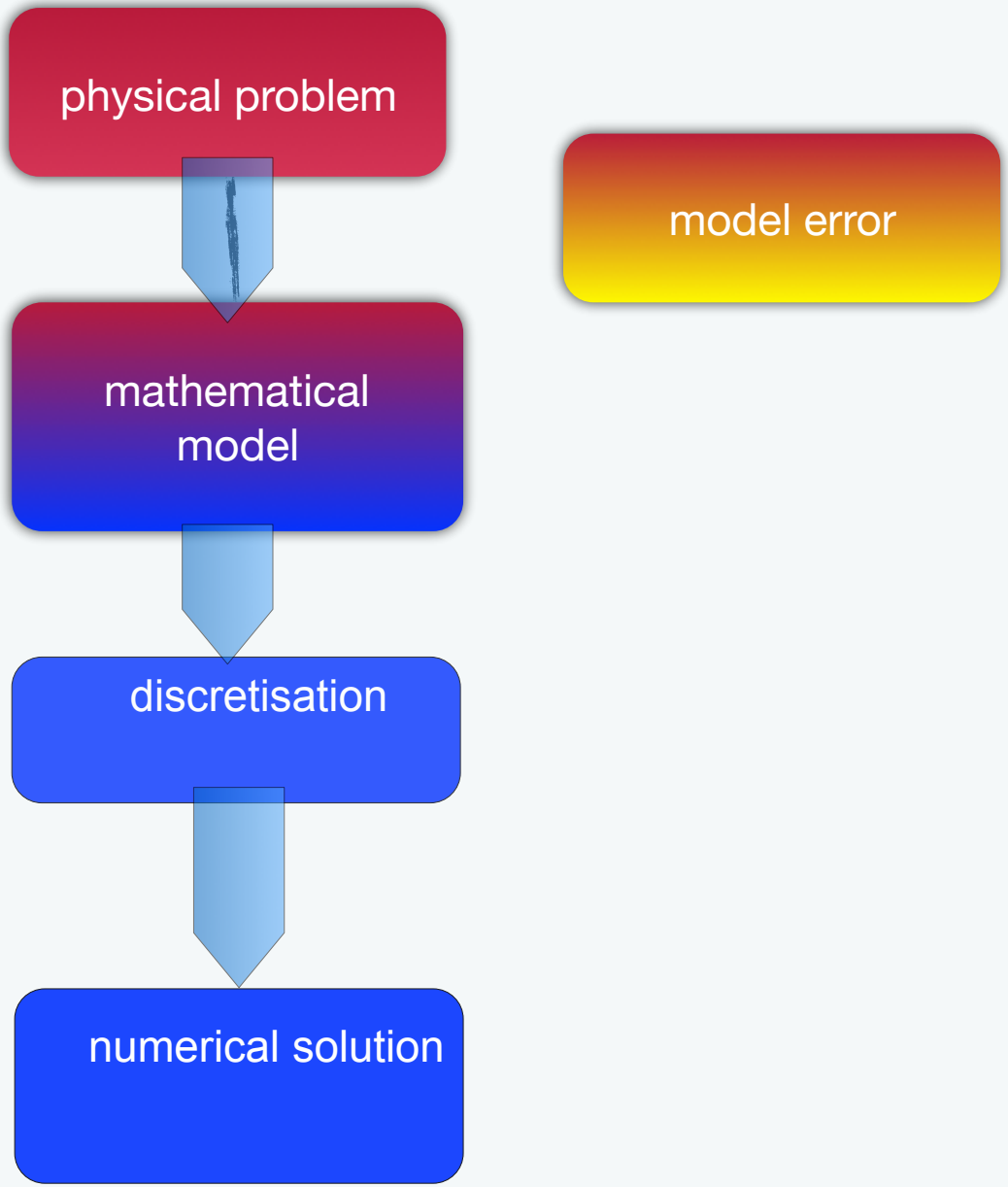

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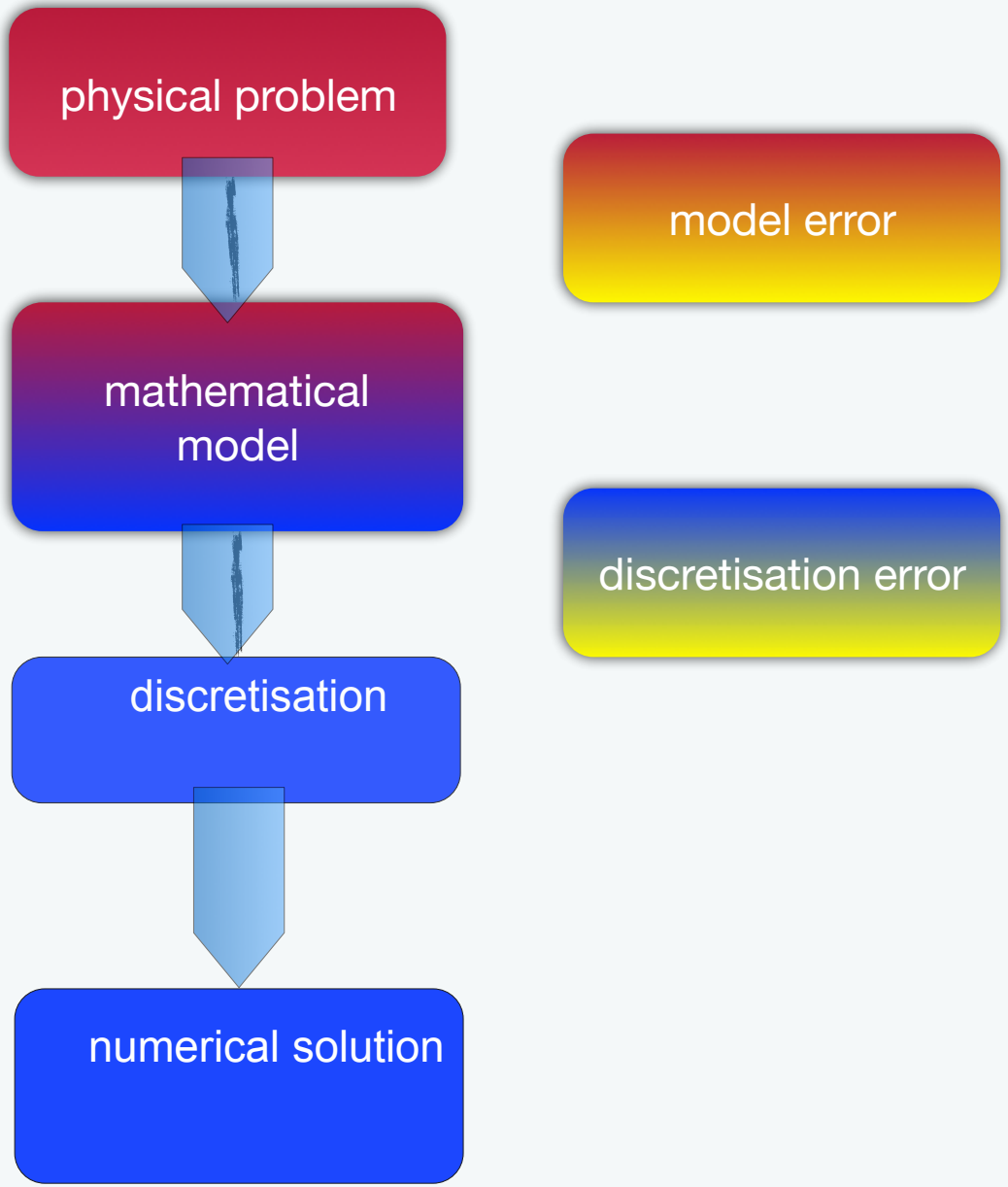

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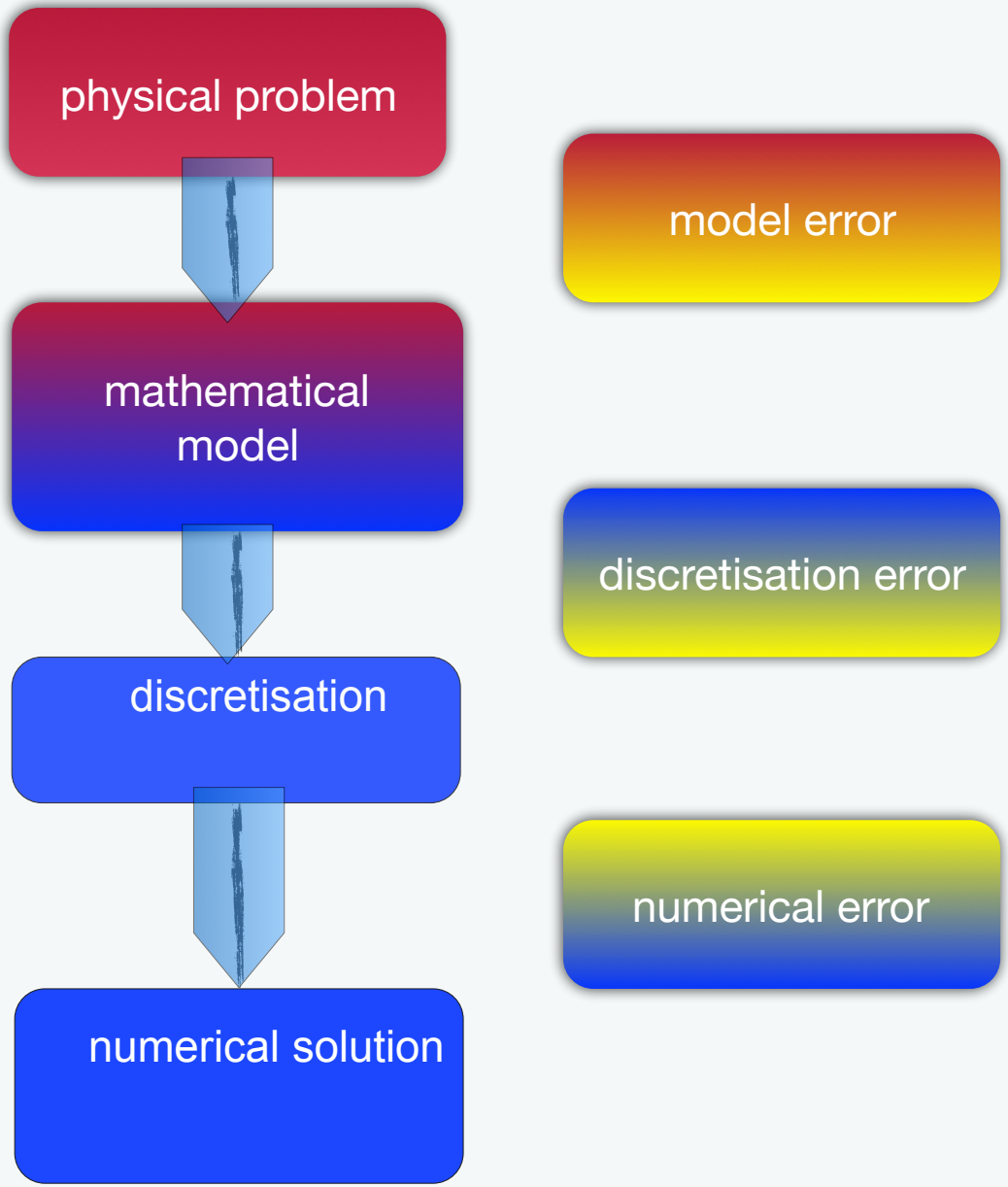

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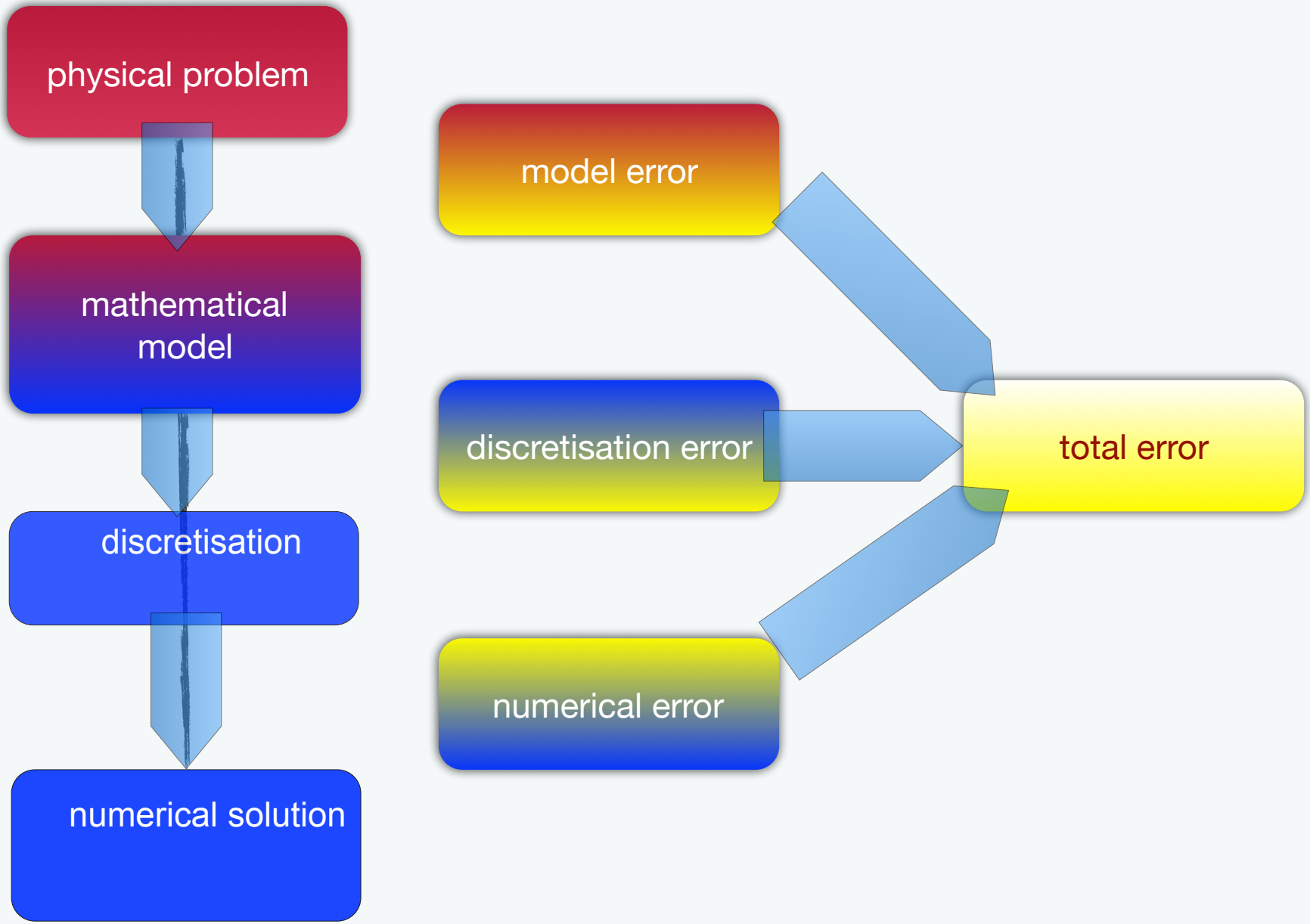

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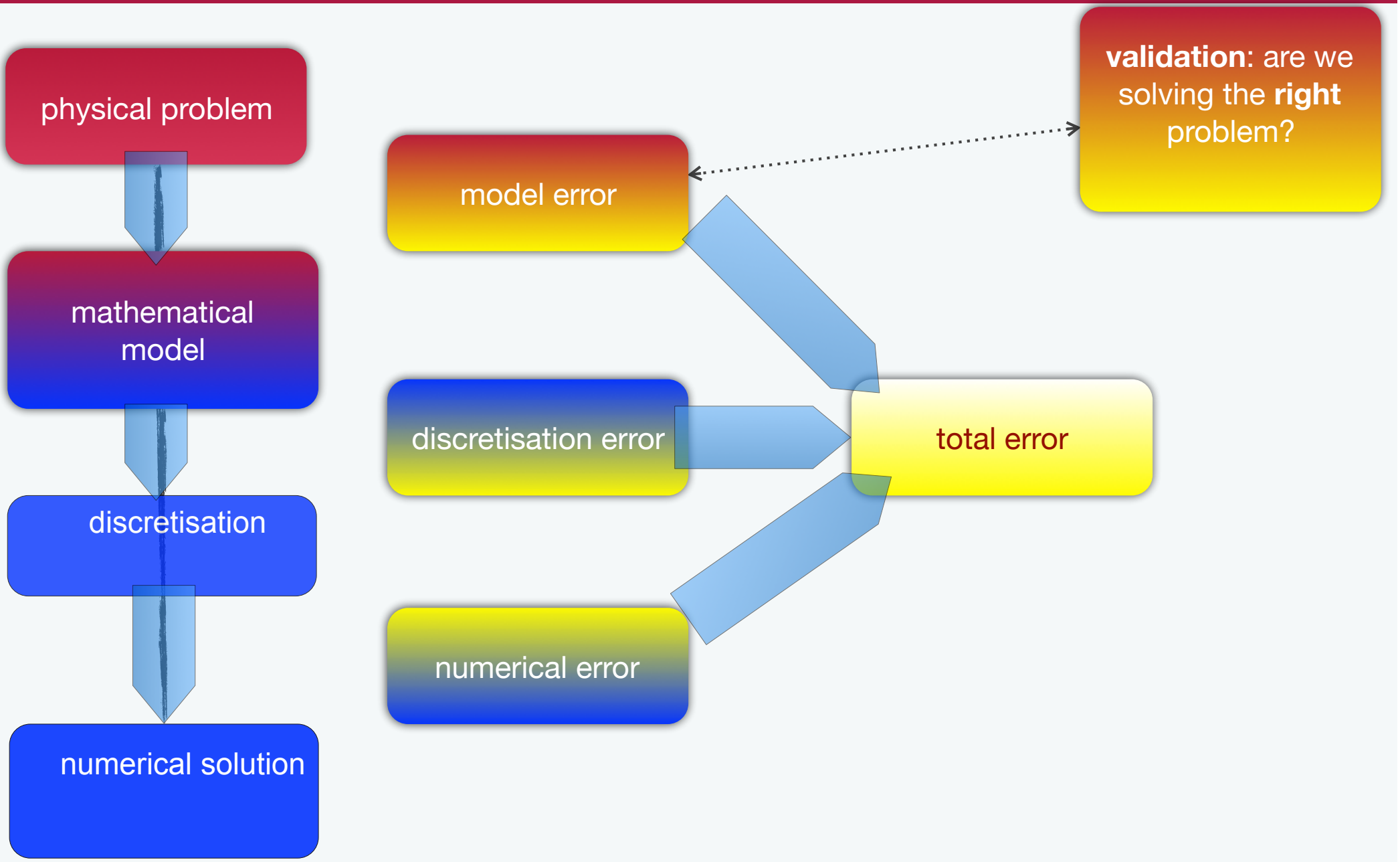

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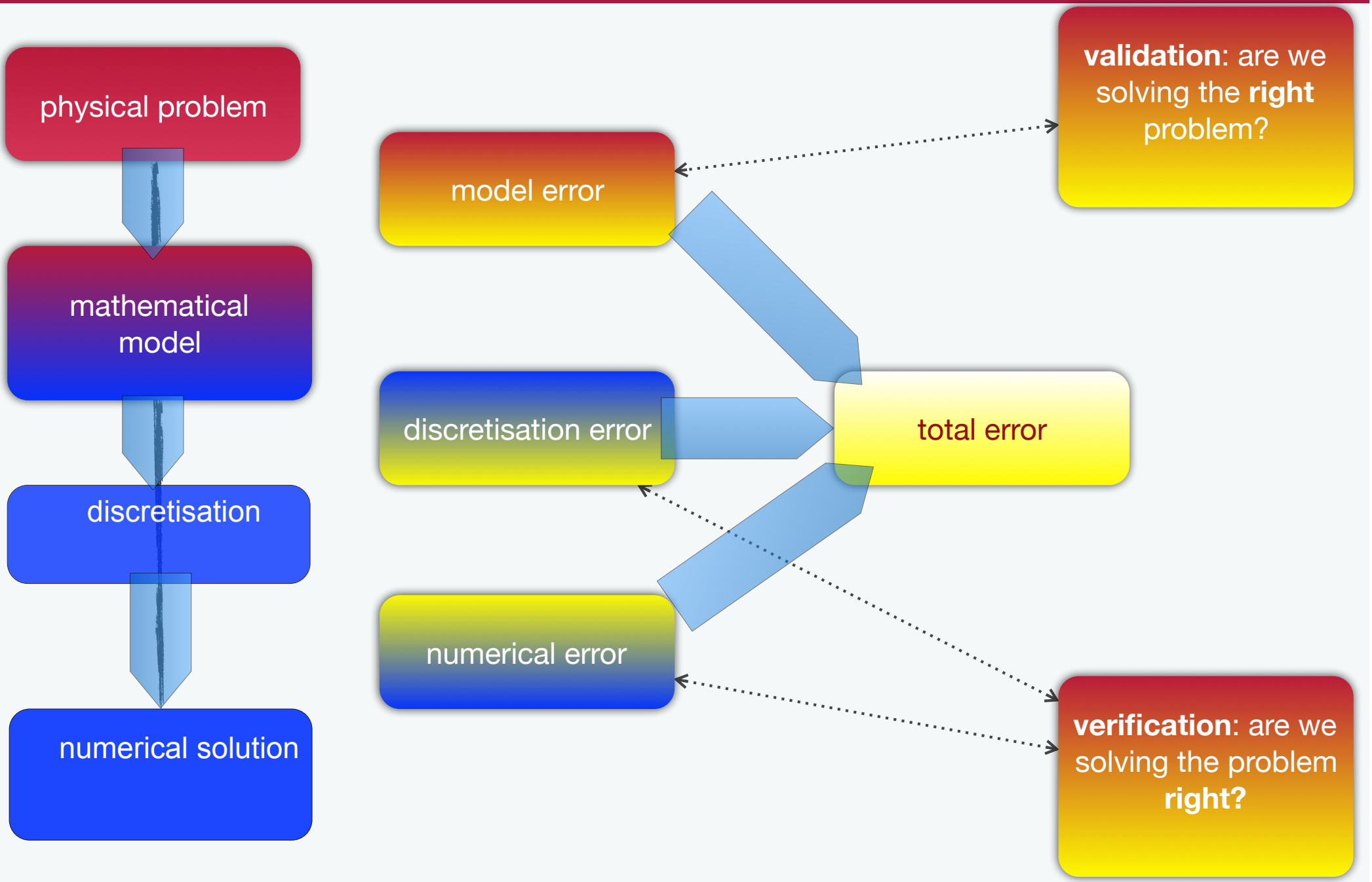

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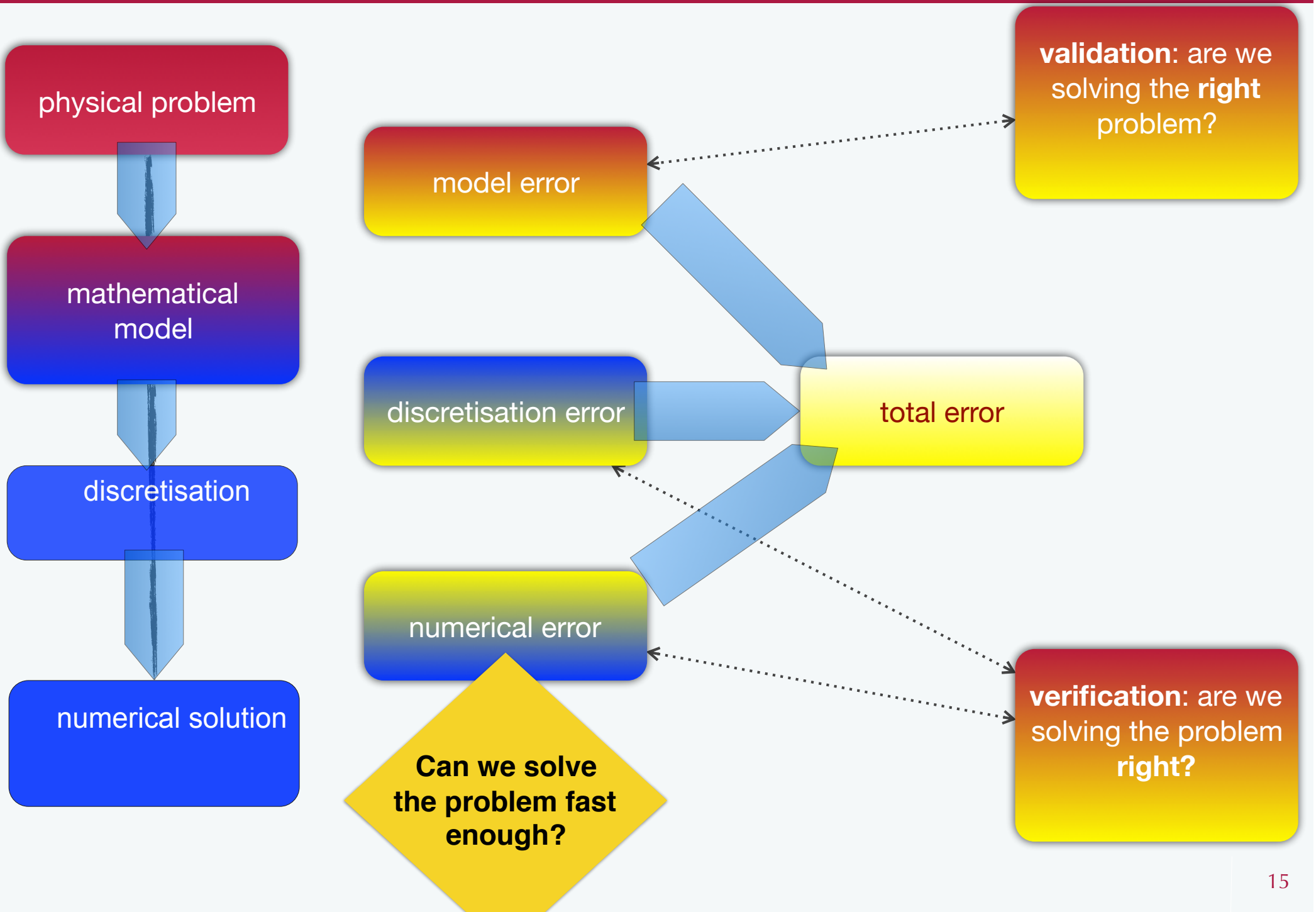

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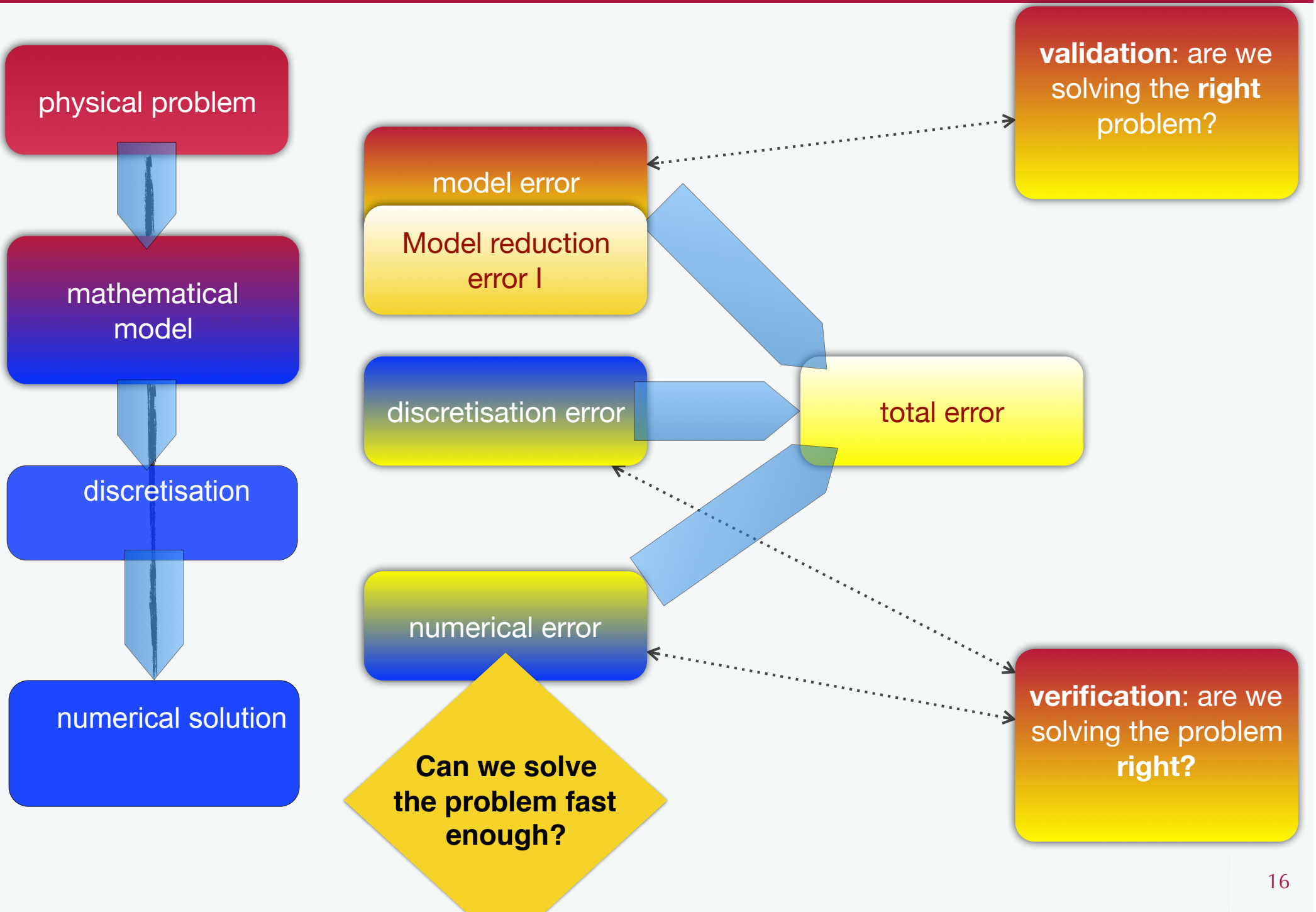

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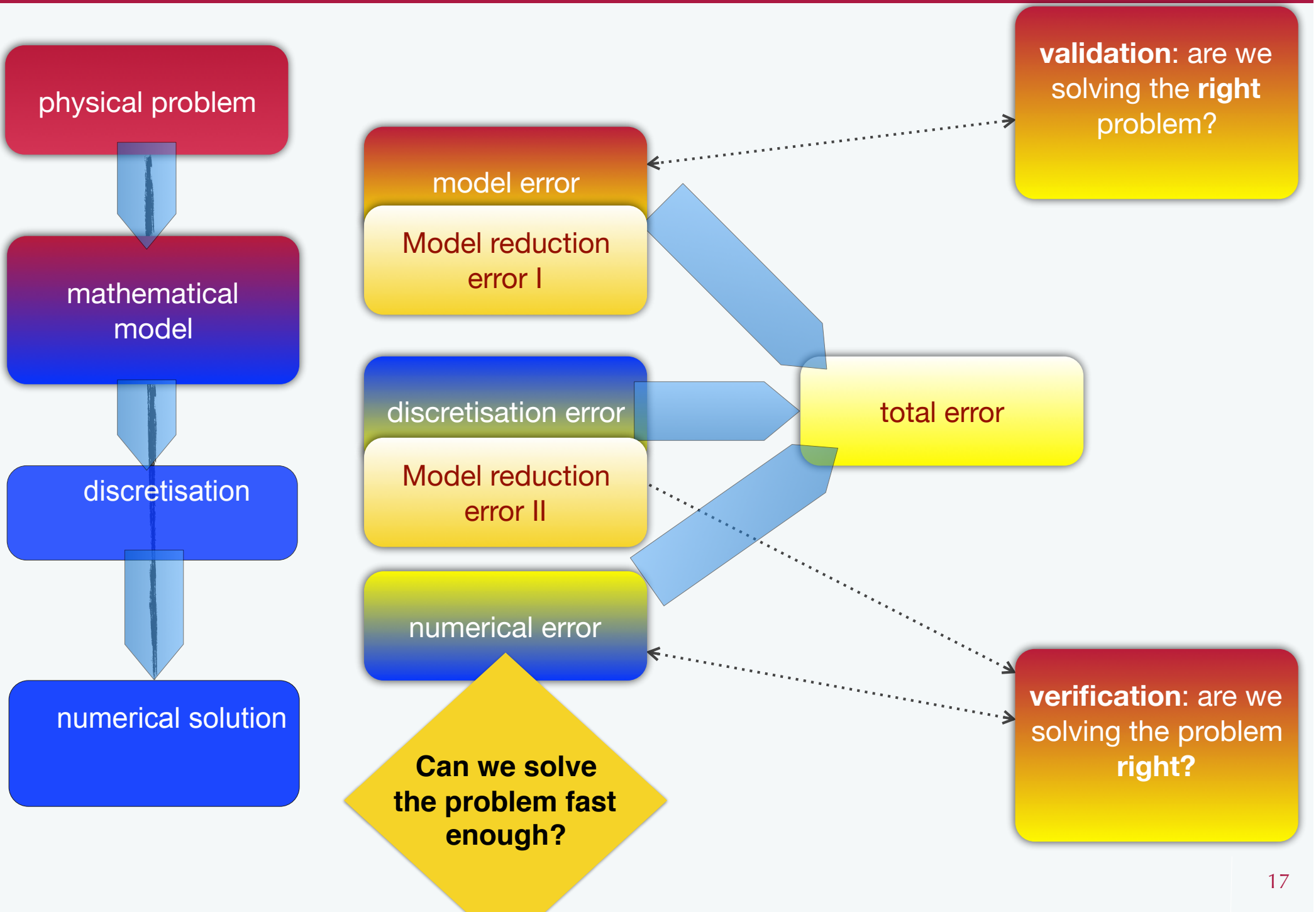
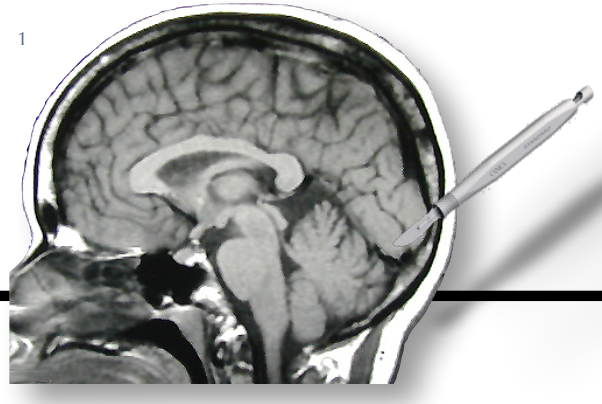


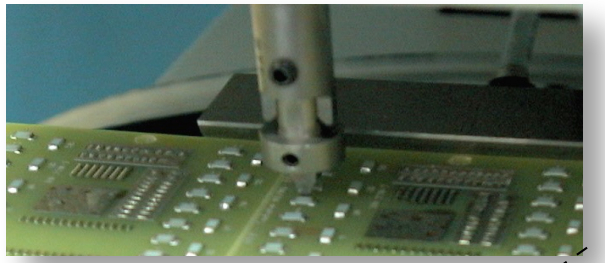
Discontinuities

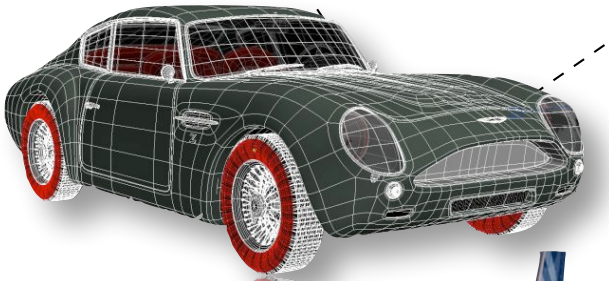


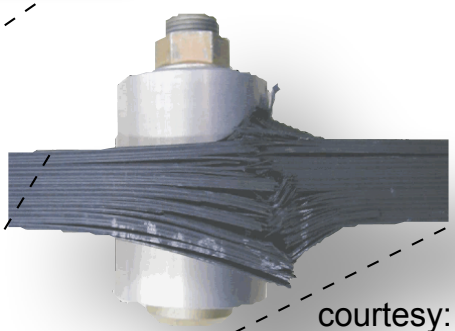
Large scale

Small scale

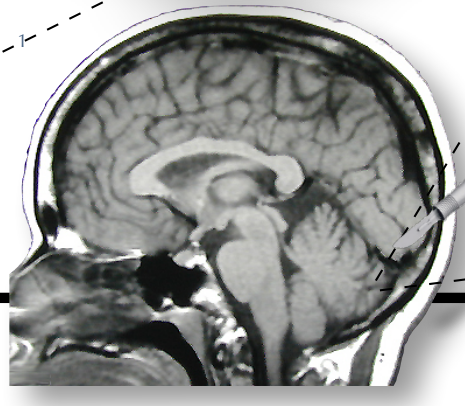
Discontinuities

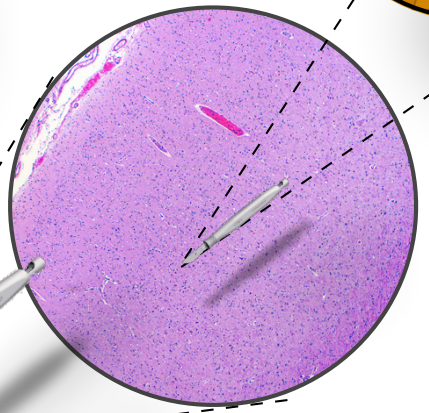


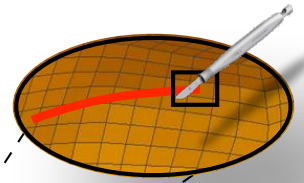




courtesy: EADS



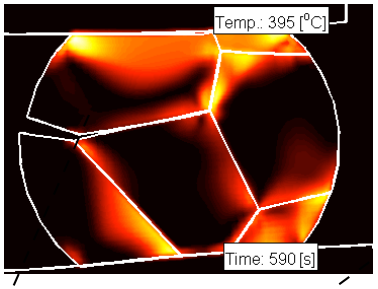


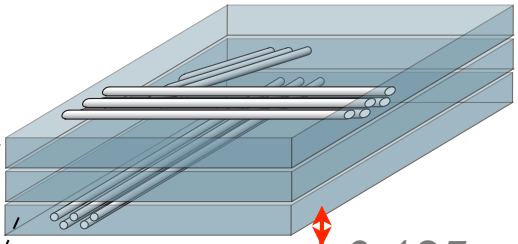


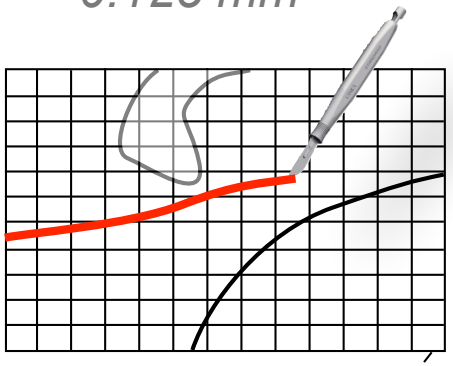
Large scale

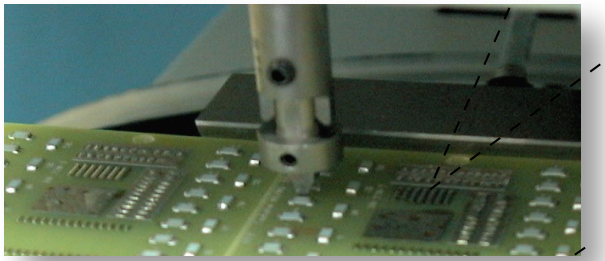
Small scale

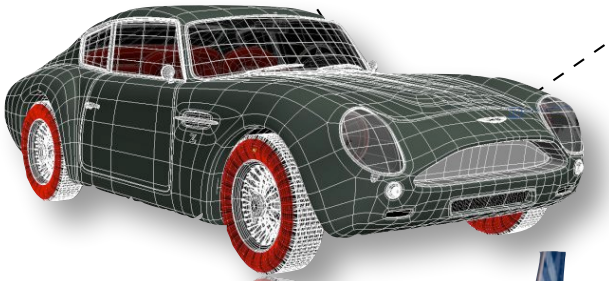
Discontinuities

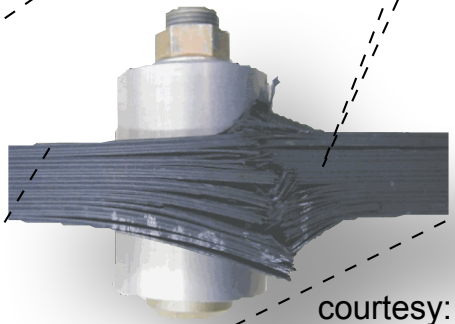












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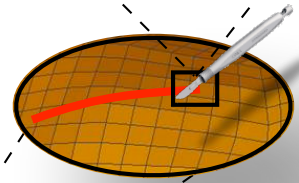
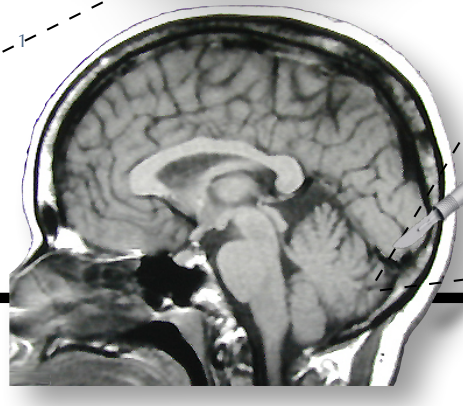
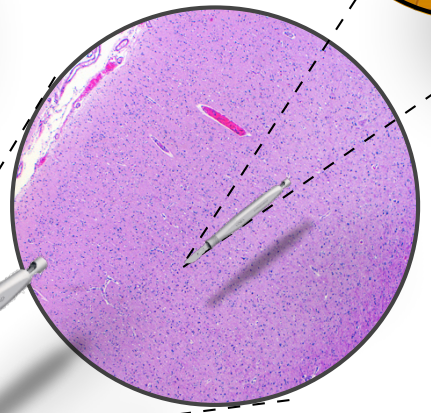






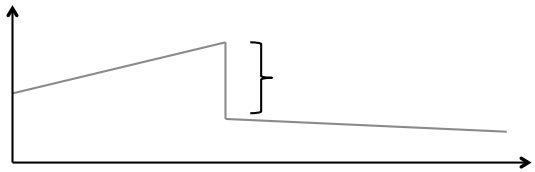
Large scale

Small scale

Classification of discontinuities

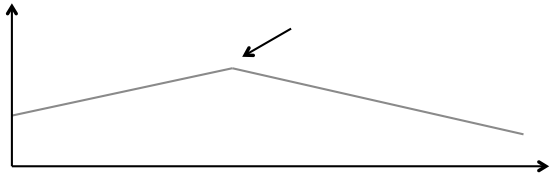
Strong discontinuities

- The primal field of the solution is discontinuous, e.g. cracks lead to strong discontinuities in the displacement field.



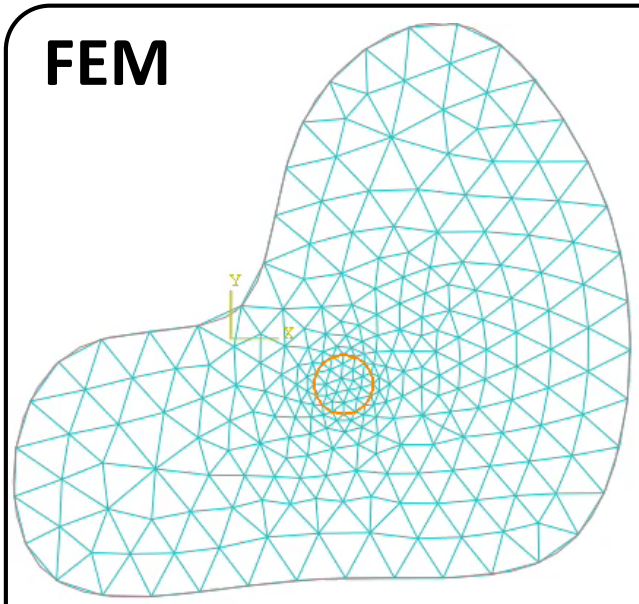
Weak discontinuities

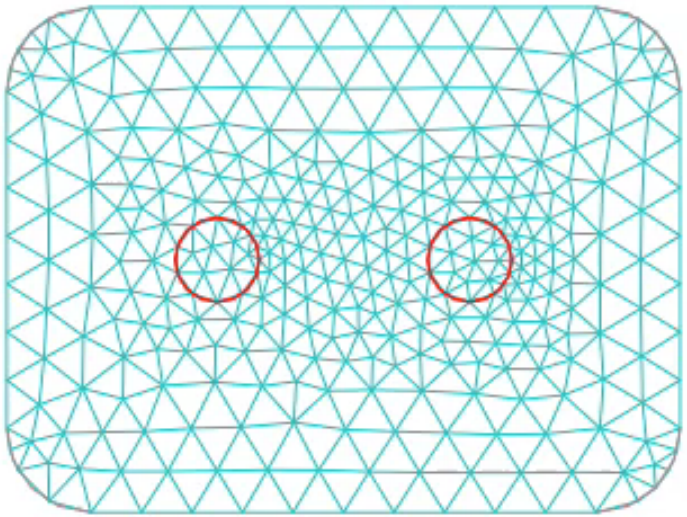
- The first derivative of the solution is discontinuous, e.g. discontinuities in the strain field through a material interface.

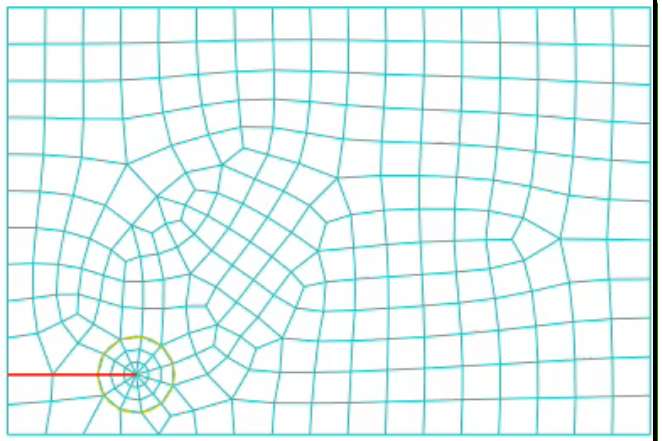


Mechanics of interfaces - or free boundary problems (Avner Friedman)

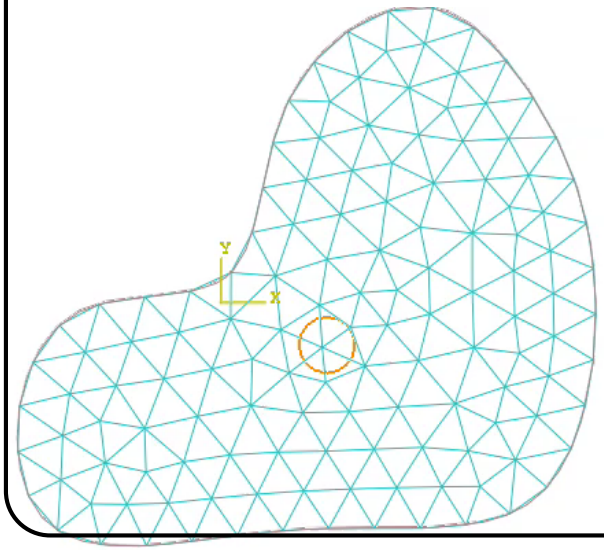
FEM

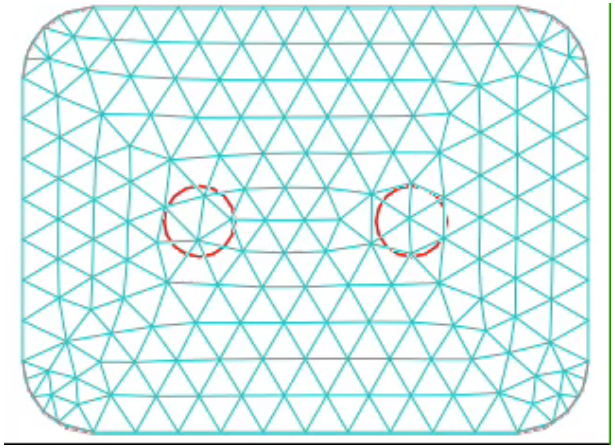


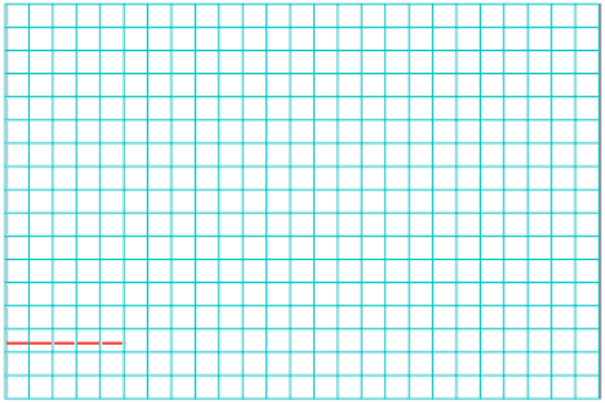




XFEM







Computational mechanics & computational materials sciences Multiscale/field interface problems

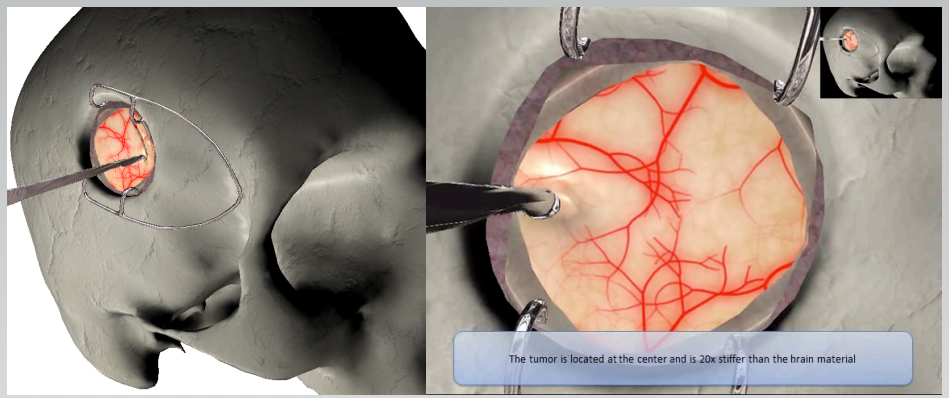
COMPETENCES

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

INTERACTIVITY
Reduce computational costs by several orders of magnitude

APPLICATIONS

PERSONALISED MEDICINE

Computer-aided surgery

Computer-aided diagnostics

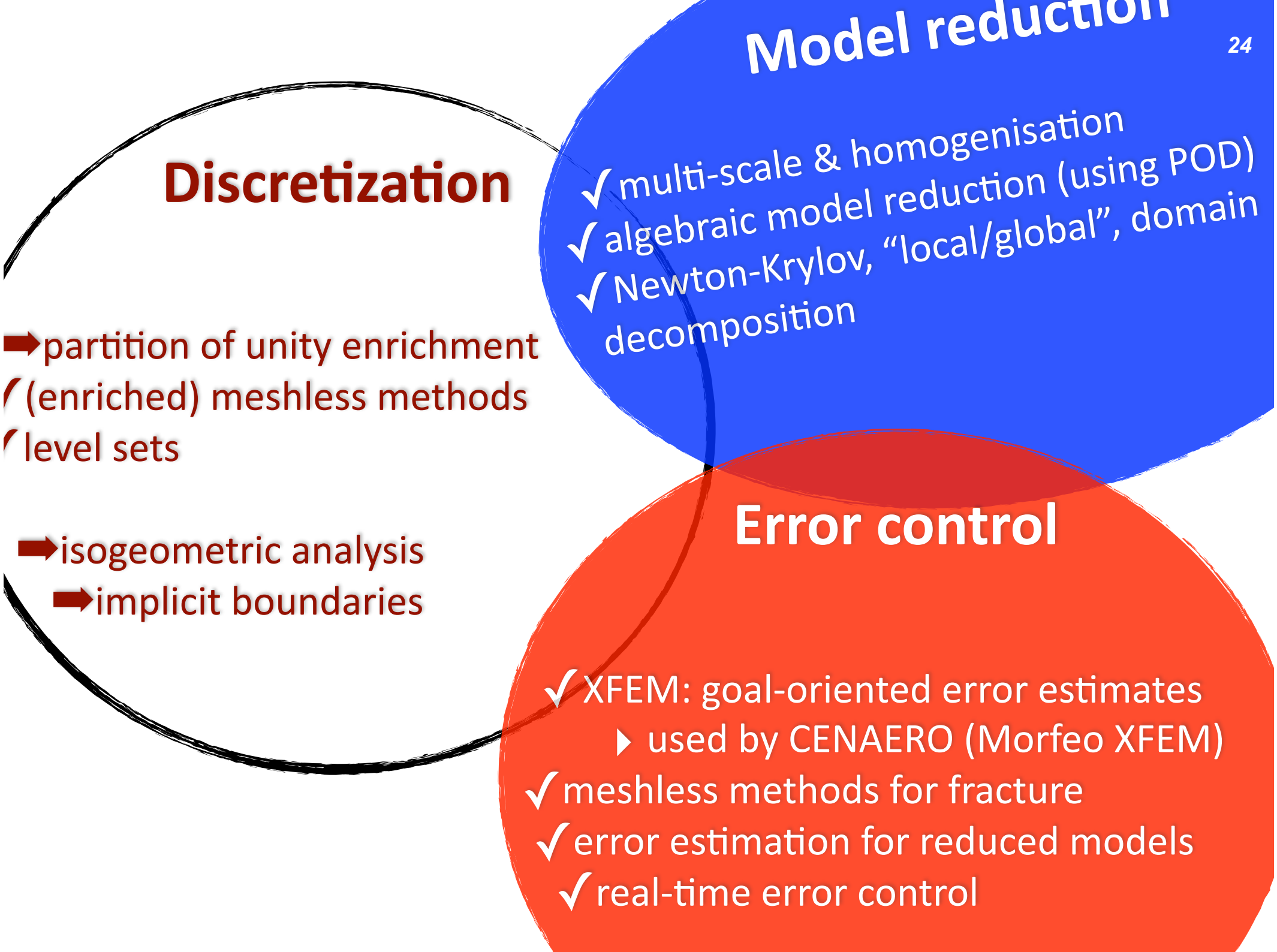
ENGINEERING

Durability & Sustainability

Energy

Aerospace

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


Model reduction
✓multi-scale & homogenisation
✓algebraic model reduction (using POD)
✓Newton-Krylov, "local/global", domain decomposition
Discretization
➡partition of unity enrichment
✓(enriched) meshless methods
✓level sets
➡isogeometric analysis
➡implicit boundaries
Error control
✓XFEM: goal-oriented error estimates
▸ used by CENAERO (Morfeo XFEM)
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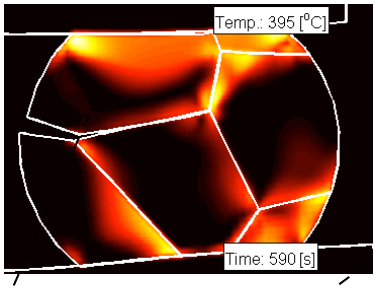

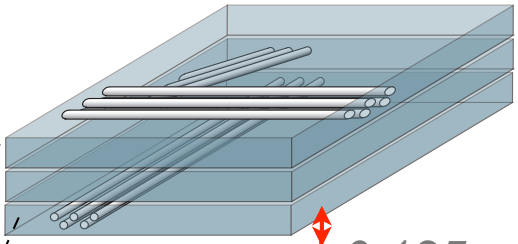

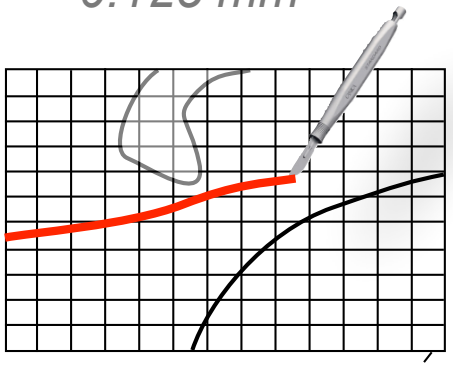

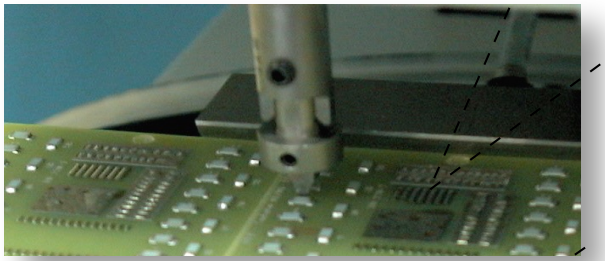

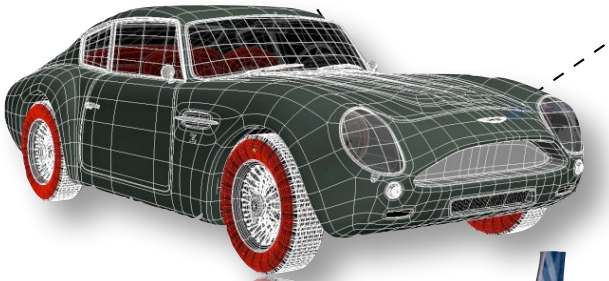

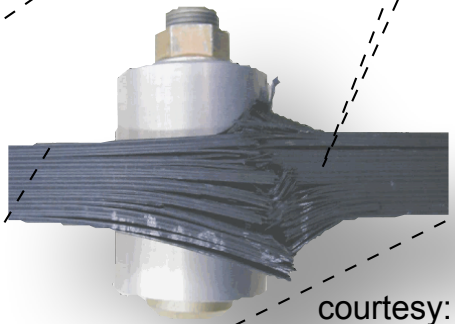

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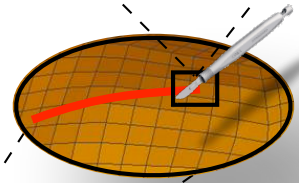

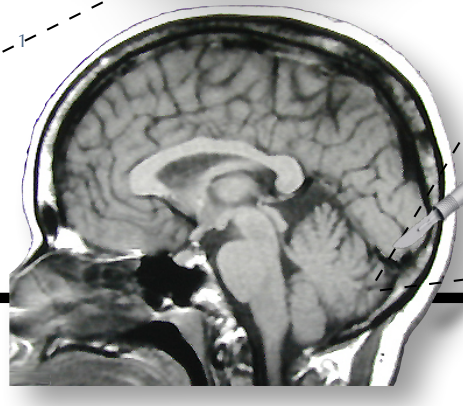

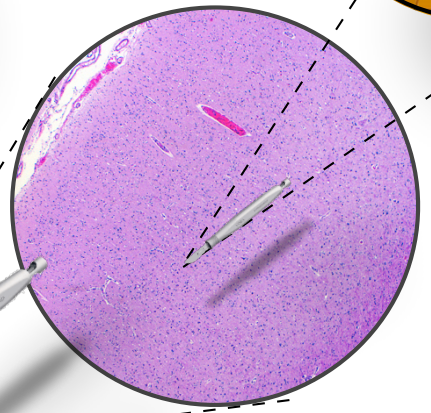

Large scale

Small scale