Computational Methods - Application Areas

- Computational Field Simulations
- Computational Fluid / Flow Dynamics
- Computational Chemistry
  - electron-electron interactions
  - molecular surfaces
- Computational Mechanics
  - fractures
- Computational Manufacturing
  - die-casting

Simulated flame

Thick regions in a die-cast

Shockwave

Particle density field
Computational Methods - Approach

- Start with underlying (continuous) physical model
  - Partial / ordinary differential equations (ODE / PDE)
  - Navier-Stokes equations for fluid flow
  - Schroedinger equations for waves / quantum
- In most non-trivial cases, continuous solutions do not exist
- Use numerical solutions on a discretized model
  - finite elements
  - finite differences
  - Newton
  - Runge-Kutta

Solar wind

Simulated flow around a submarine fairwater
Grid Types

- The resolution of the discretized model is usually spatially variant
  - more sample points (finer grid) in areas with more potential variation (larger derivatives)
- Example: flow around an airplane fin varies most at the curved surfaces
  → more dense and curved grid at the curved fin hull

Structured grids

addressing: cell[i, j, k] provides location of neighbors

Unstructured (irregular) grids

no addressing mechanism: adjacency list is required