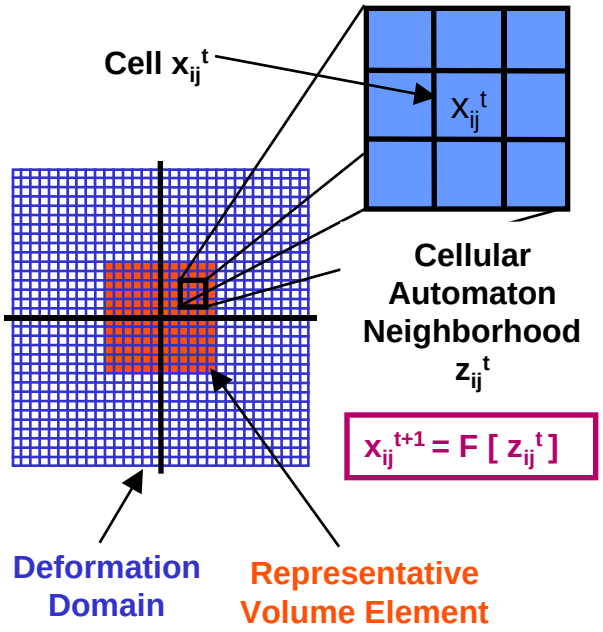
Naval Research Laboratory - Office of Naval Research
Materials Science and Technology
http://mstd.nrl.navy.mil

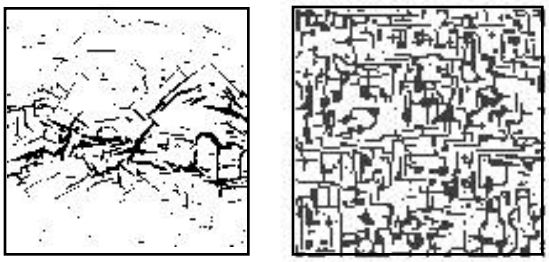
Science and Technology Success Stories

Mesoscale Material Morphology and Damage

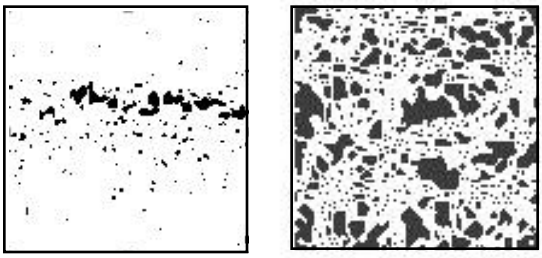
The Naval Research Laboratory (NRL), the Navy's corporate laboratory, has developed novel cellular methods to rapidly quantify initial microstructural information and simulate the evolution of material damage. These image-quality simulations are focused on mesoscale systems of microvoids and microcracks that span a wide range of engineering materials. The use of cellular automaton methods produces rapid simulations that cover the full range of damage morphologies.

With this technique, hundreds of microdamage objects can be followed from initiation through propagation and coalesence. A complementary effort has formulated the transition of microfracture to macrofracture in terms of connectivity and percolation of these events across the mesoscale. These geometrically based approaches capture the heterogeneous response patterns in materials and quantitative statistical parameters for constitutive modeling, damage surfaces (analogous to yield surfaces) and iterative inverse solution procedures for cellular automaton parameters based on experimental data.





Cast iron spall morphology and simulation



Ductile iron spall morphology and simulation

Mesoscale Material Morphology and Damage

Military Impact

- **Image-Quality Simulation Methods to Predict, Quantify and Characterize Progressive Damage in Materials**

- **Improved Predictive Capability for:**
  - **Structure Response Simulation**
  - **Damage Tolerance (Survivability)**
  - **Lethality**

Potential Civilian Spin-offs

- **Simulation Capabilities for:**
  - **Aerospace Structures**
  - **Automotive Structures**
  - **Manufacturing Processes**

Point of Contact

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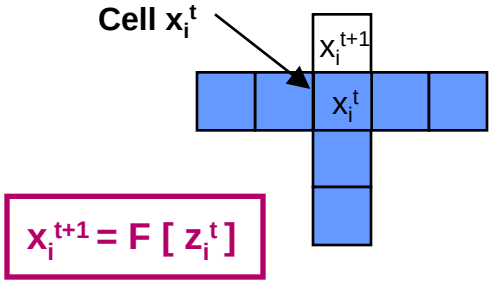
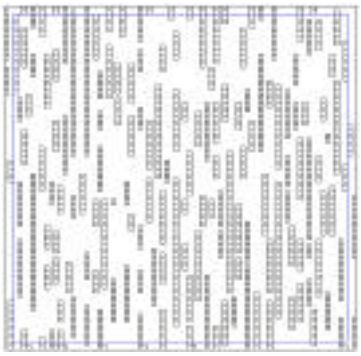
Cellular automaton model of cast gasar porous copper morphology and the effects of pore nucleation and extinction model parameters

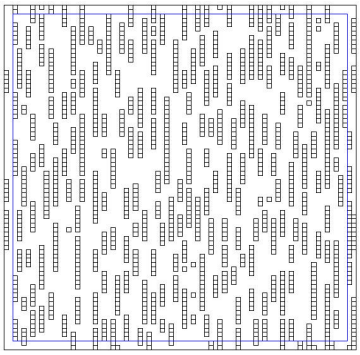


$$x_i^{t+1} = F[z_i^t]$$

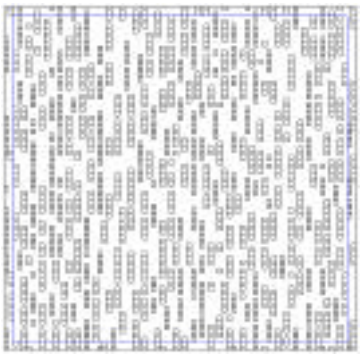
Cellular Automaton Neighborhood z_i^t



Low Nucleation/ Low Extinction



Medium Nucleation/ Medium Extinction



High Nucleation/ High Extinction