Virtual-power-based Quasicontinuum Methods for Discrete Dissipative Materials

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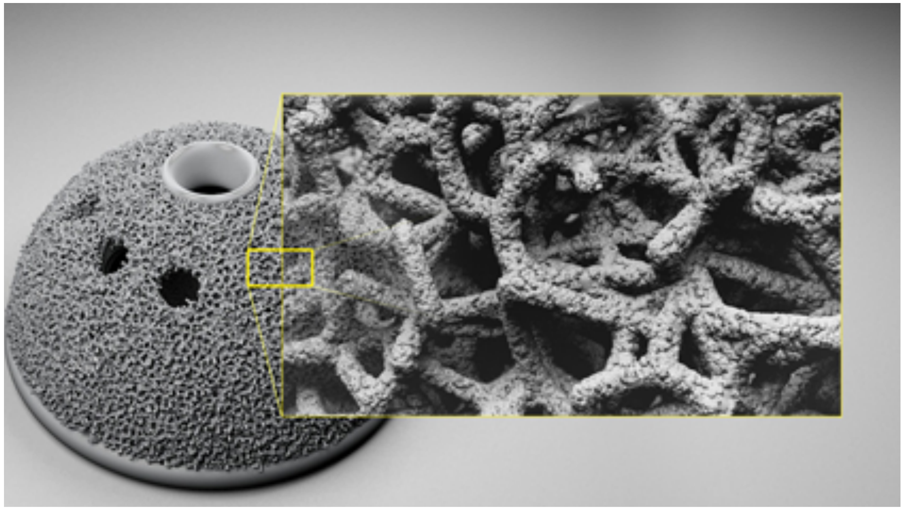
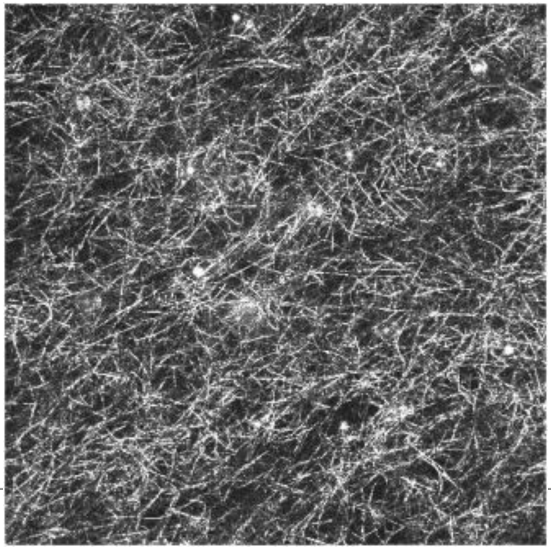
Dissipative discreteness at small scales

Foams

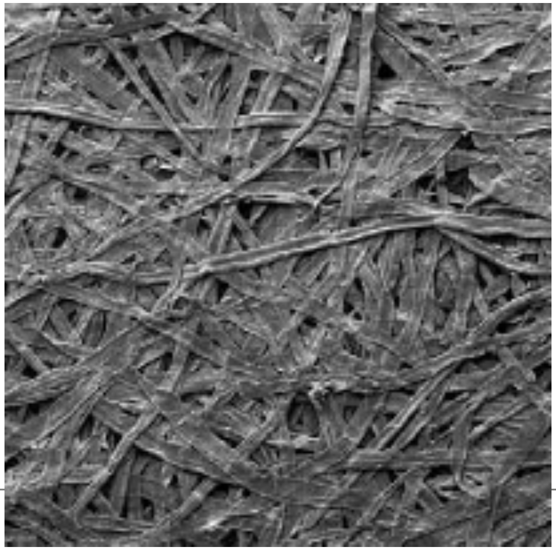


Additive manufacturing

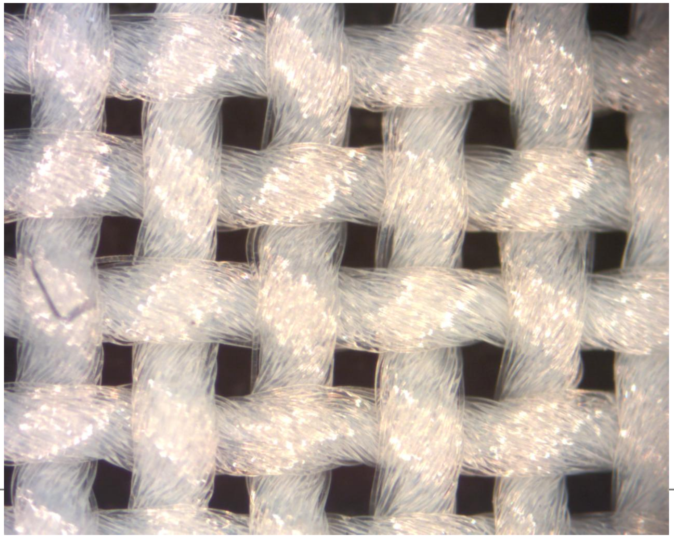
Collagen



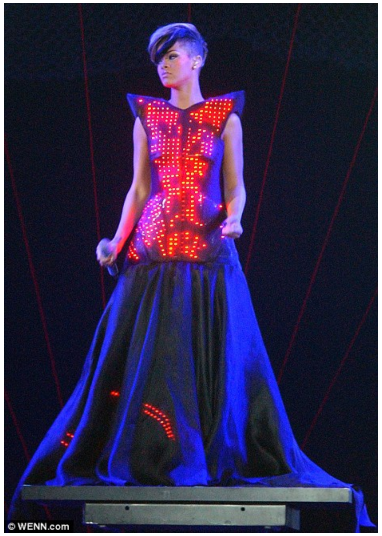
Paper/cardboard

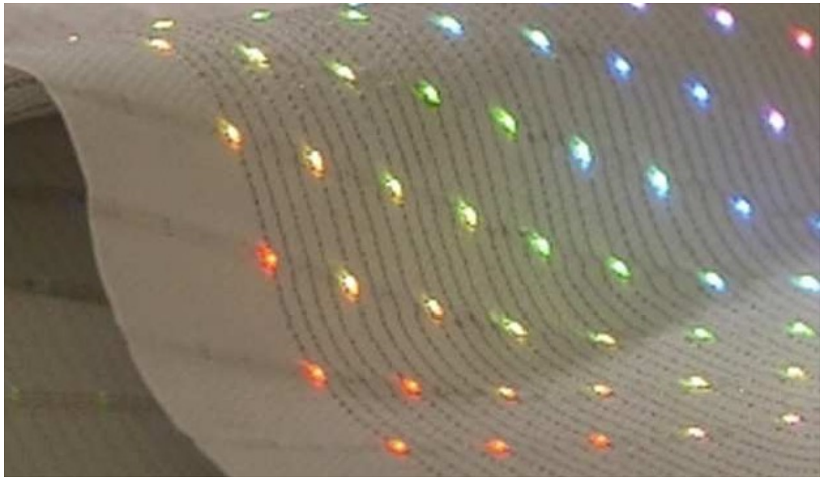


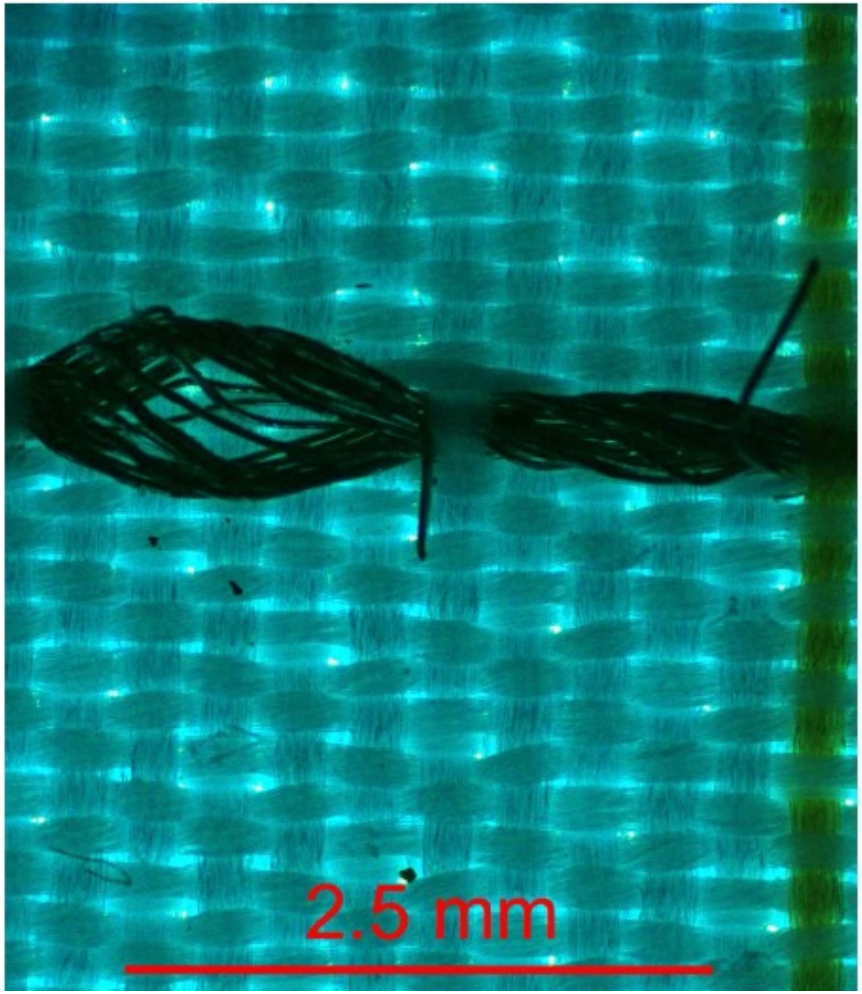
Textiles



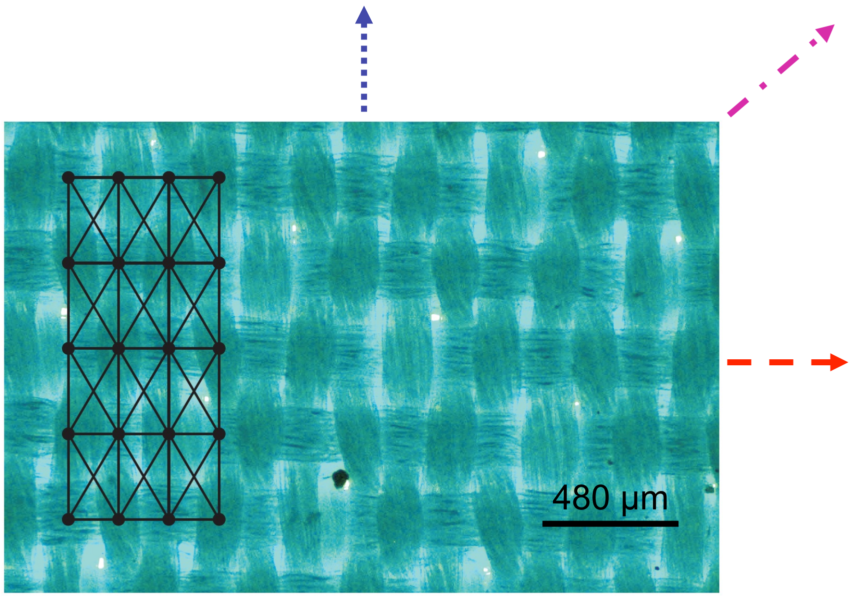
Electronic textile

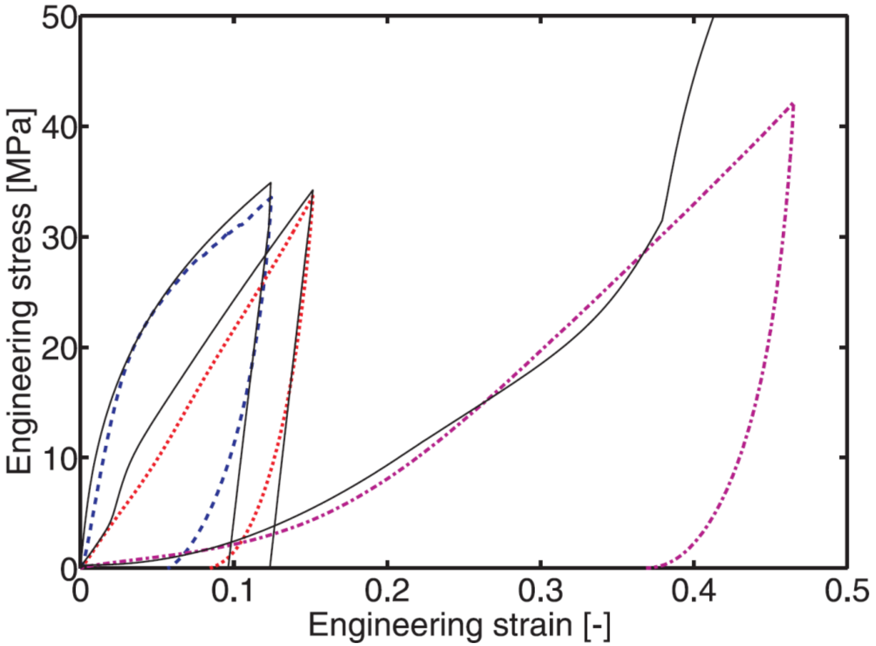




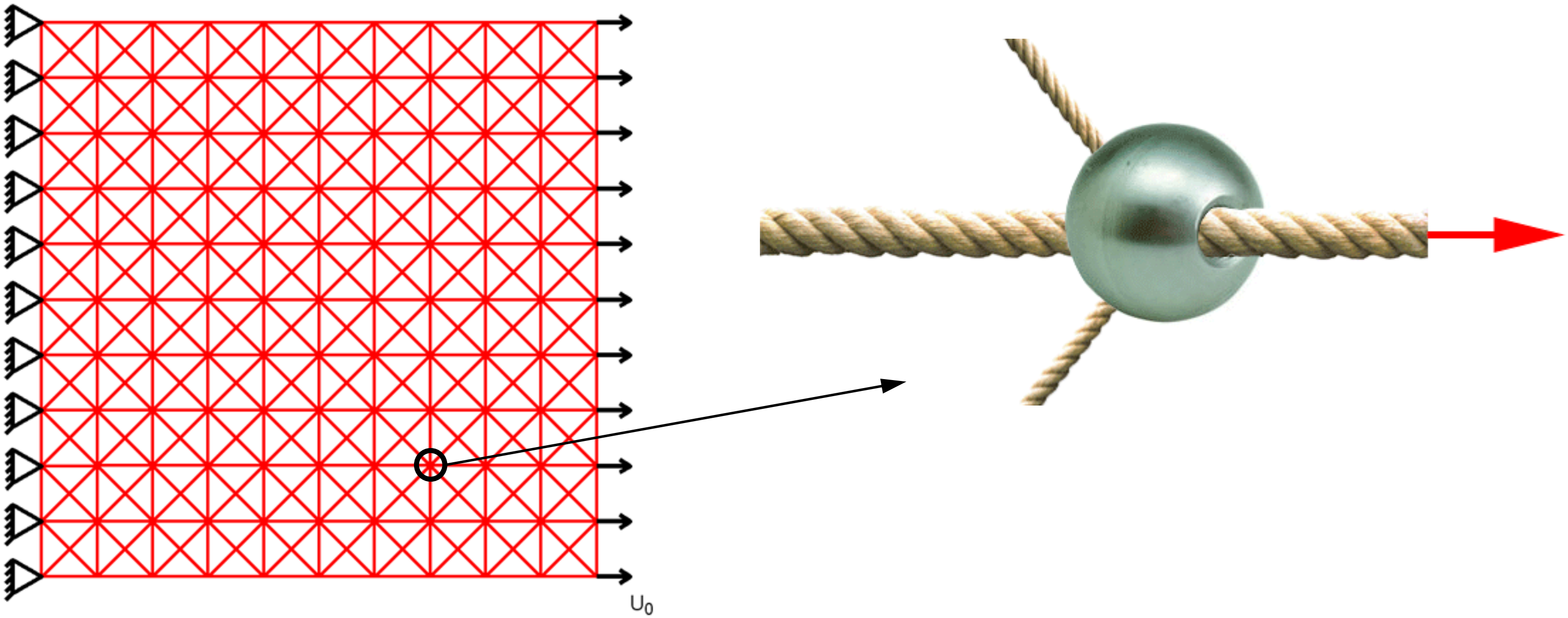


Elastoplastic spring lattice

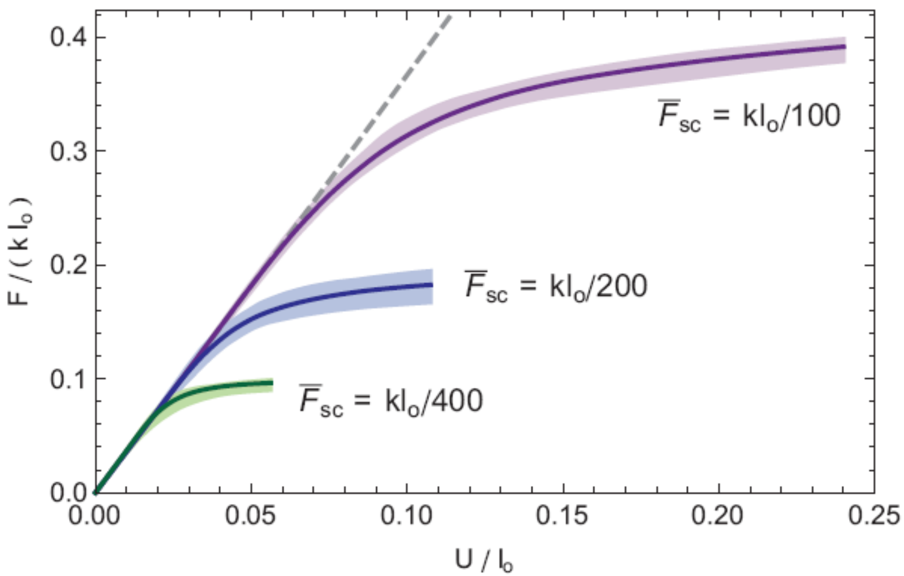


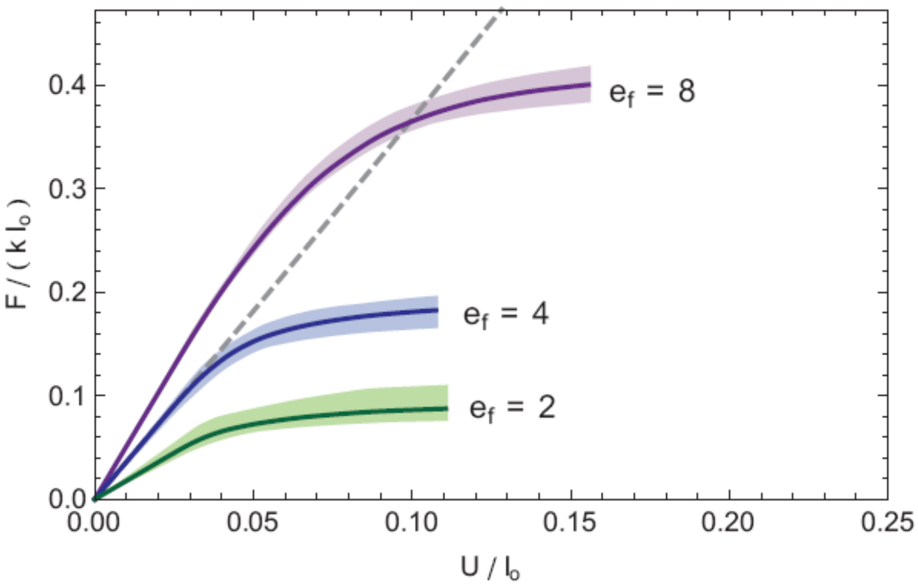


Spring lattice with nodal sliding

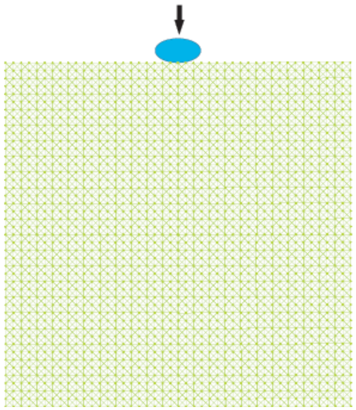


Spring lattice with nodal sliding



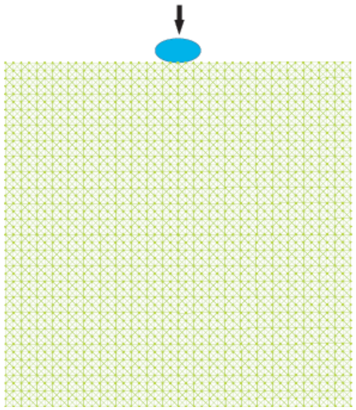


Quasicontinuum method (Tadmor et al, 1996)



$$K \cdot u = f$$

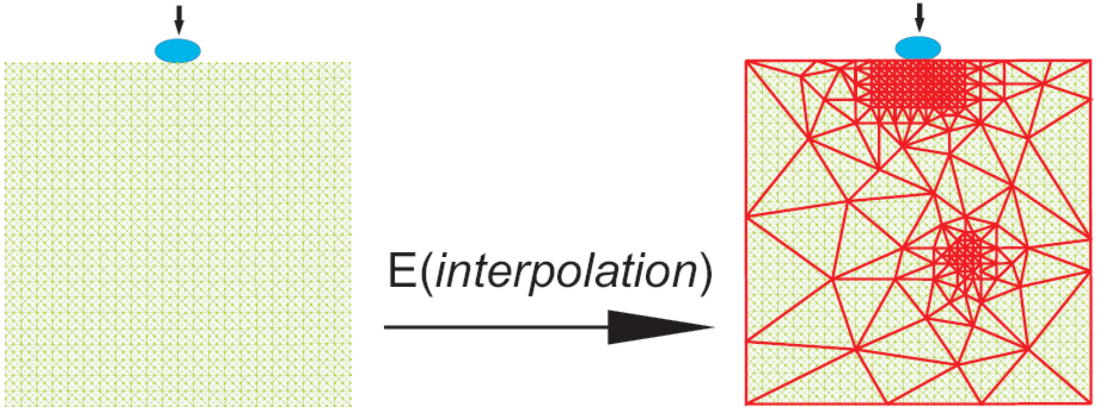
Quasicontinuum method (Tadmor et al, 1996)



$$K \cdot u = f$$

$$\sum_{i=1}^{n} K_i \cdot u = \sum_{i=1}^{n} f_i$$

Quasicontinuum method (Tadmor et al, 1996)

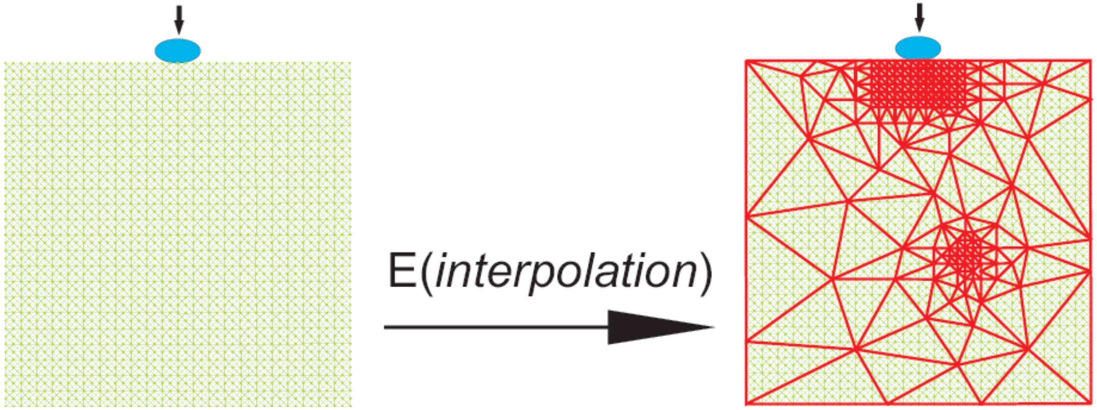


$$K \cdot u = f$$

$$N^T \cdot K \cdot N \cdot u = N^T \cdot f$$

$$\sum_{i=1}^{n} K_i \cdot u = \sum_{i=1}^{n} f_i$$

Quasicontinuum method (Tadmor et al, 1996)



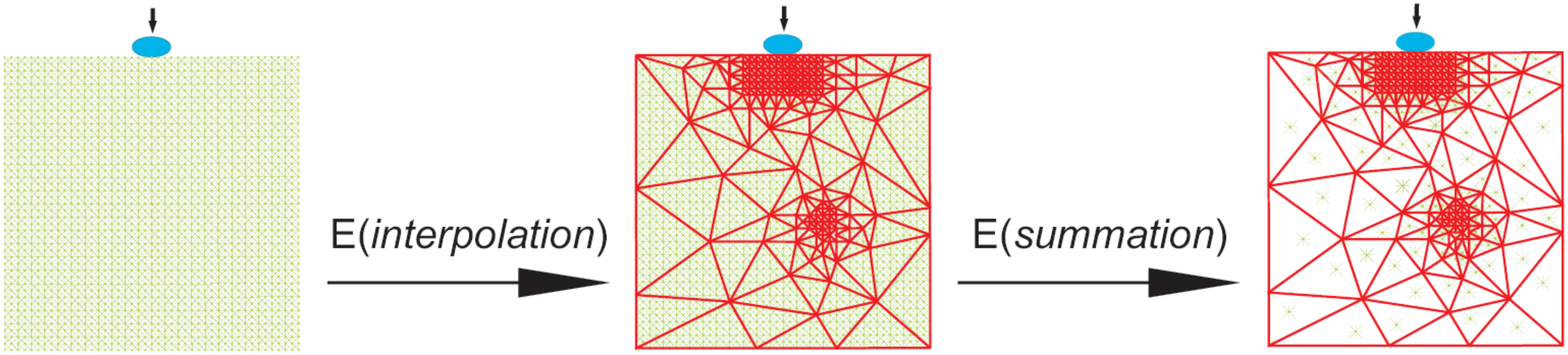
$$K \cdot u = f$$

$$N^T \cdot K \cdot N \cdot u = N^T \cdot f$$

$$\sum_{i=1}^{n} K_i \cdot u = \sum_{i=1}^{n} f_i$$

$$N^T \cdot \sum_{i=1}^{n} K_i \cdot N \cdot u = N^T \cdot \sum_{i=1}^{n} f_i$$

Quasicontinuum method (Tadmor et al, 1996)



$$K \cdot u = f$$

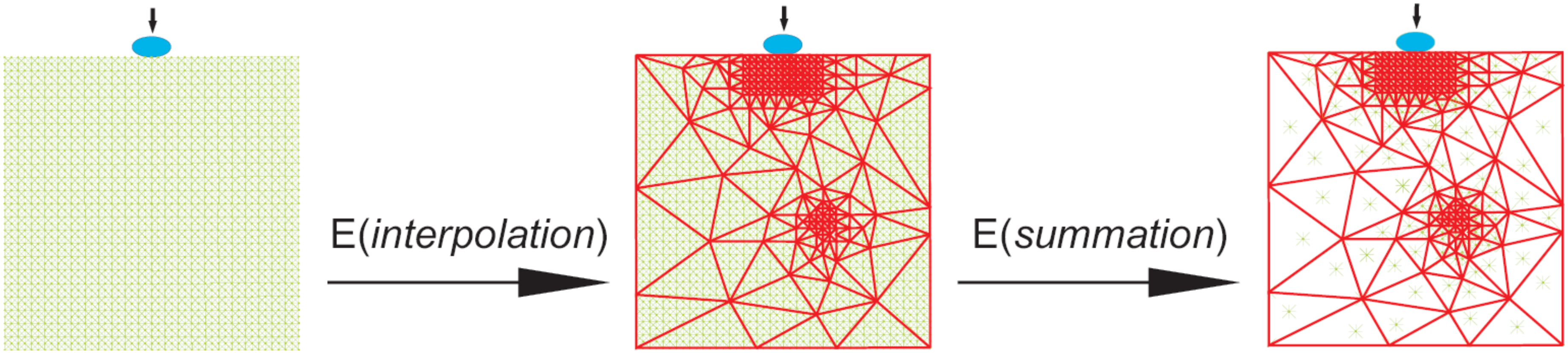
$$N^T \cdot K \cdot N \cdot u = N^T \cdot f$$

$$N^T \cdot K_r \cdot N \cdot u = N^T \cdot f_r$$

$$\sum_{i=1}^{n} K_i \cdot u = \sum_{i=1}^{n} f_i$$

$$N^T \cdot \sum_{i=1}^{n} K_i \cdot N \cdot u = N^T \cdot \sum_{i=1}^{n} f_i$$

Quasicontinuum method (Tadmor et al, 1996)



$$K \cdot u = f$$

$$\sum_{i=1}^{n} K_i \cdot u = \sum_{i=1}^{n} f_i$$

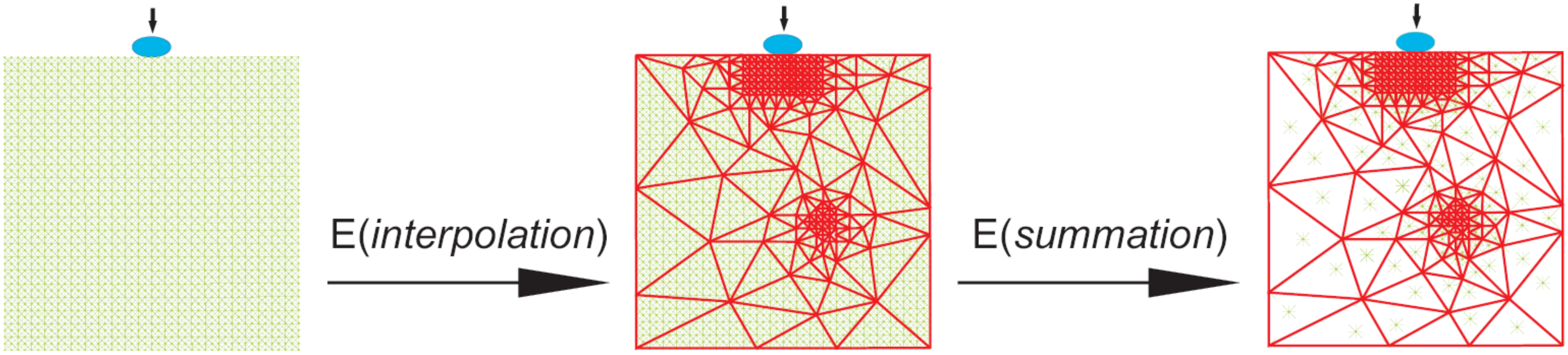
$$N^T \cdot K \cdot N \cdot u = N^T \cdot f$$

$$N^T \cdot \sum_{i=1}^{n} K_i \cdot N \cdot u = N^T \cdot \sum_{i=1}^{n} f_i$$

$$N^T \cdot K_r \cdot N \cdot u = N^T \cdot f_r$$

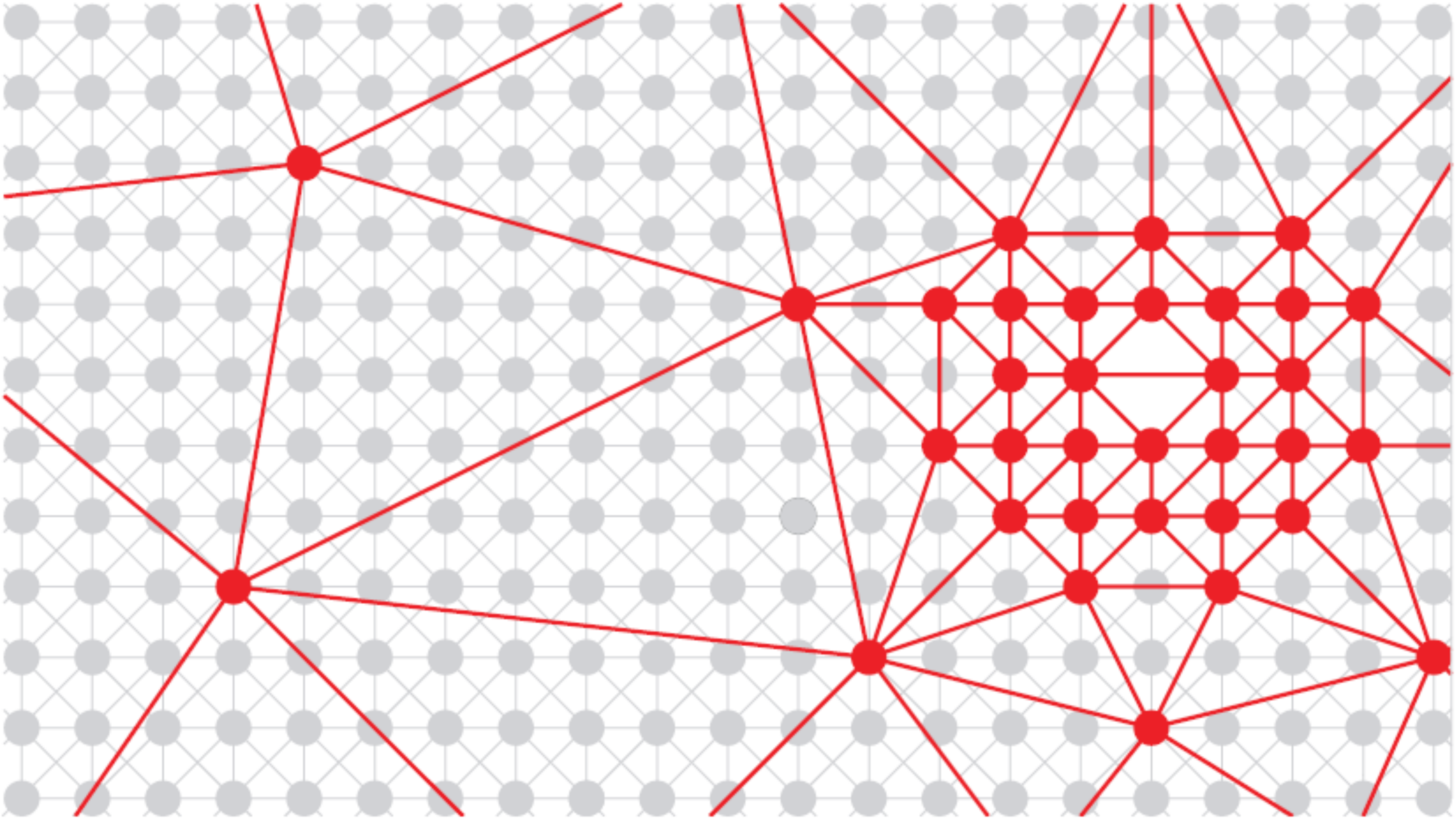
$$N^T \cdot \sum_{i=1}^{s} K_i \cdot N \cdot u = N^T \cdot \sum_{i=1}^{s} f_i$$

Quasicontinuum method (Tadmor et al, 1996)



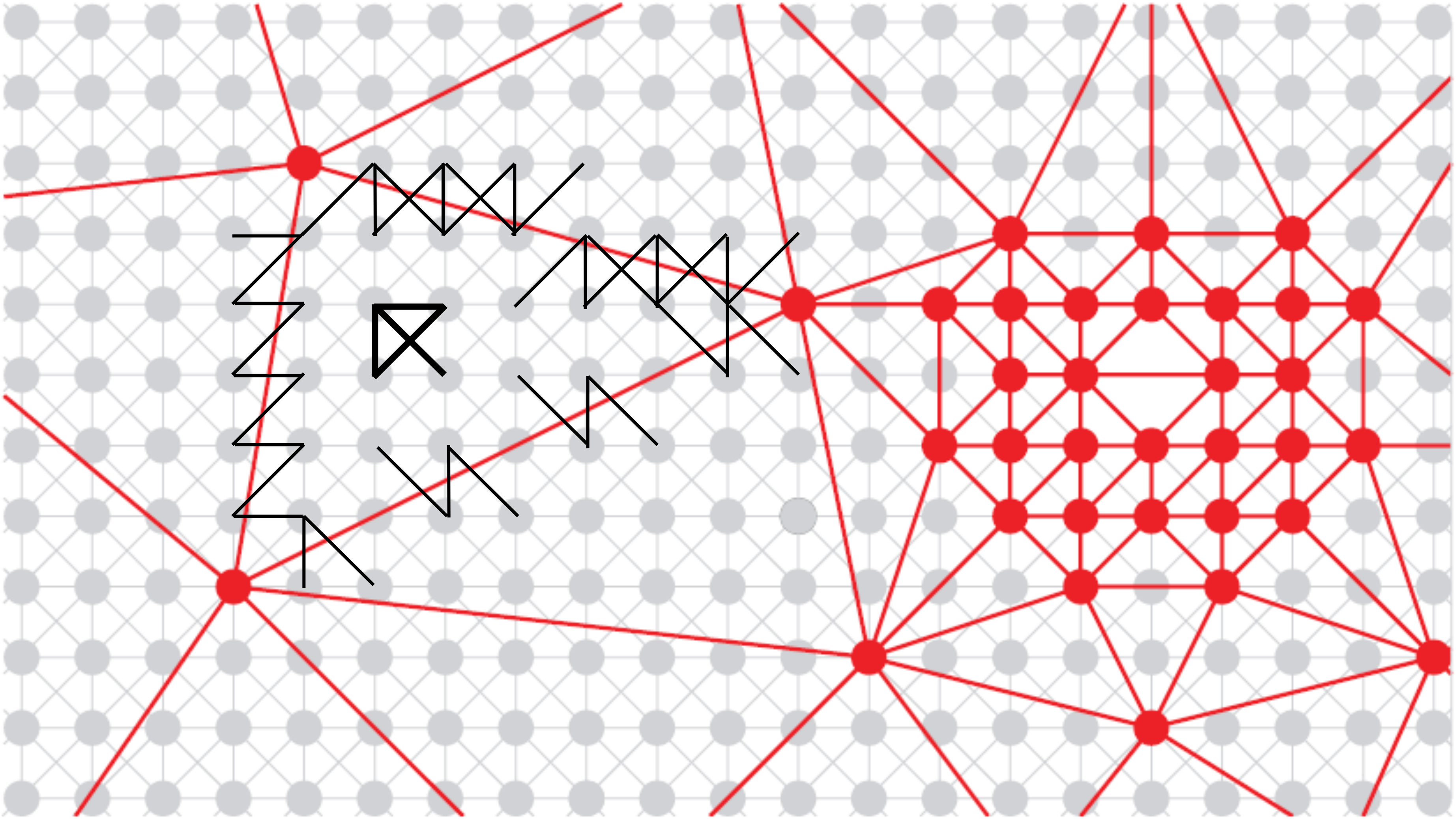
- Ideal for local events in large-scale lattice computations
- Underlying lattice fully resolved where needed
- No continuum/constitutive assumptions

Summation



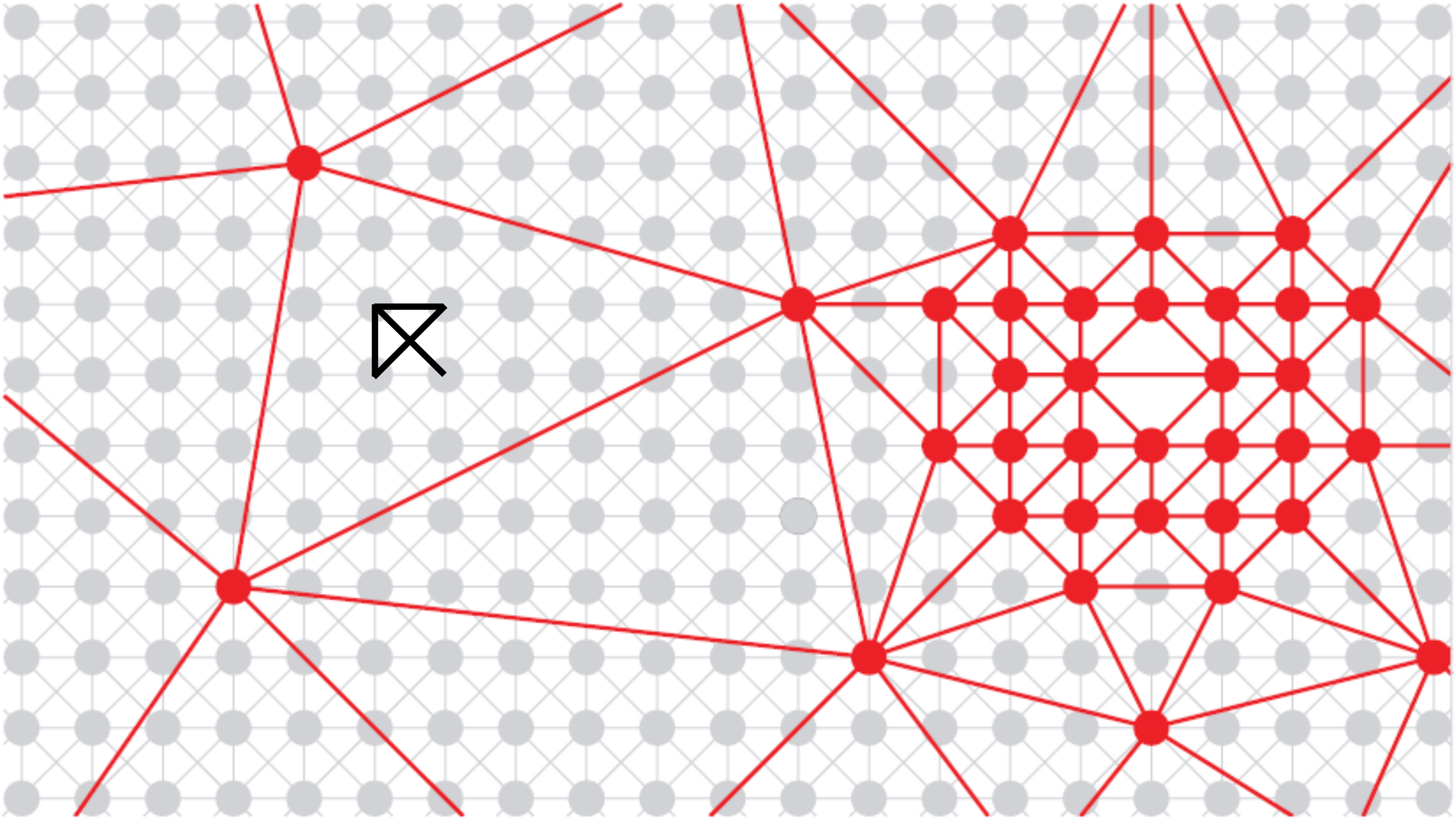
Virtual-power-based QC framework

Summation 1

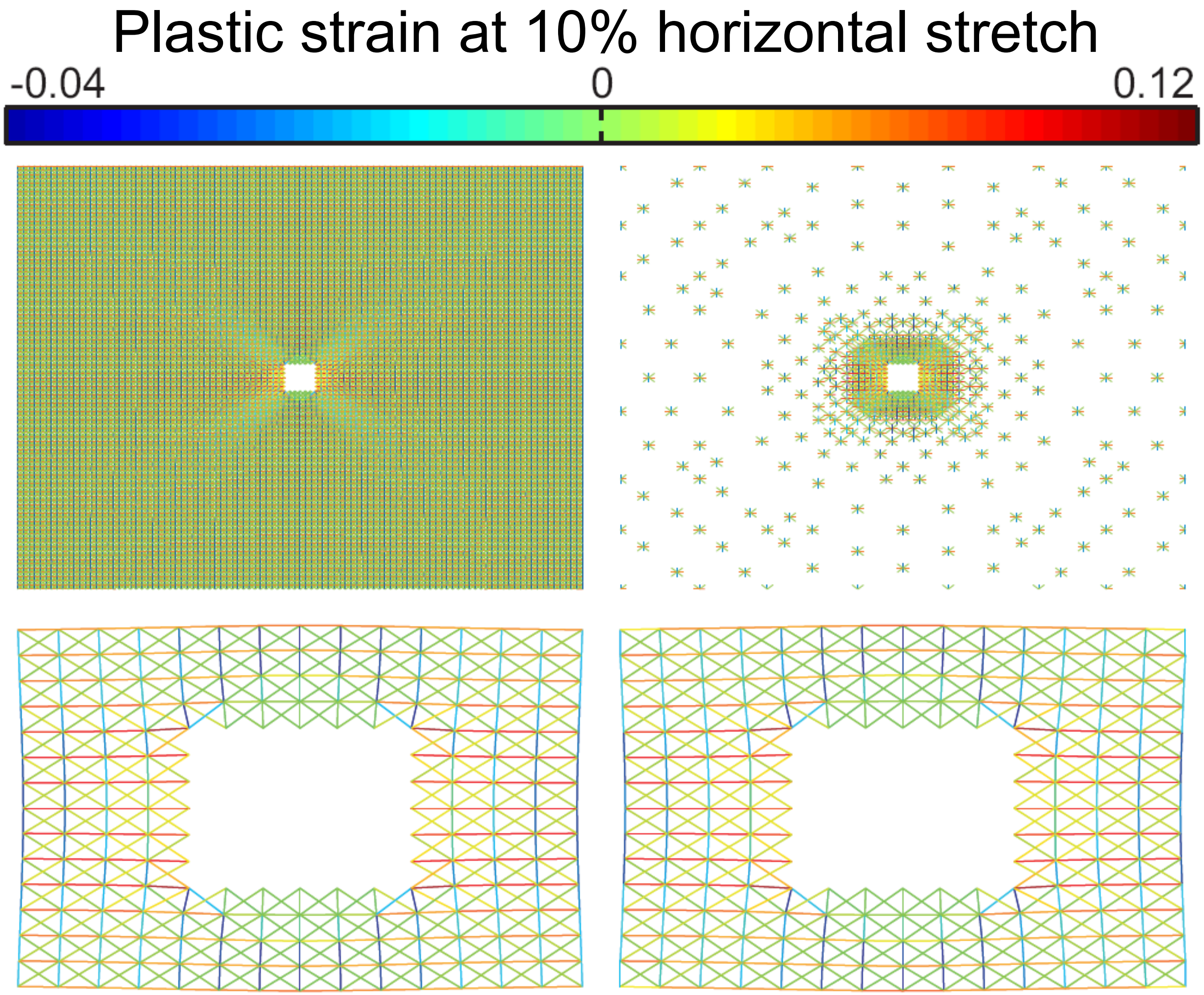


Virtual-power-based QC framework

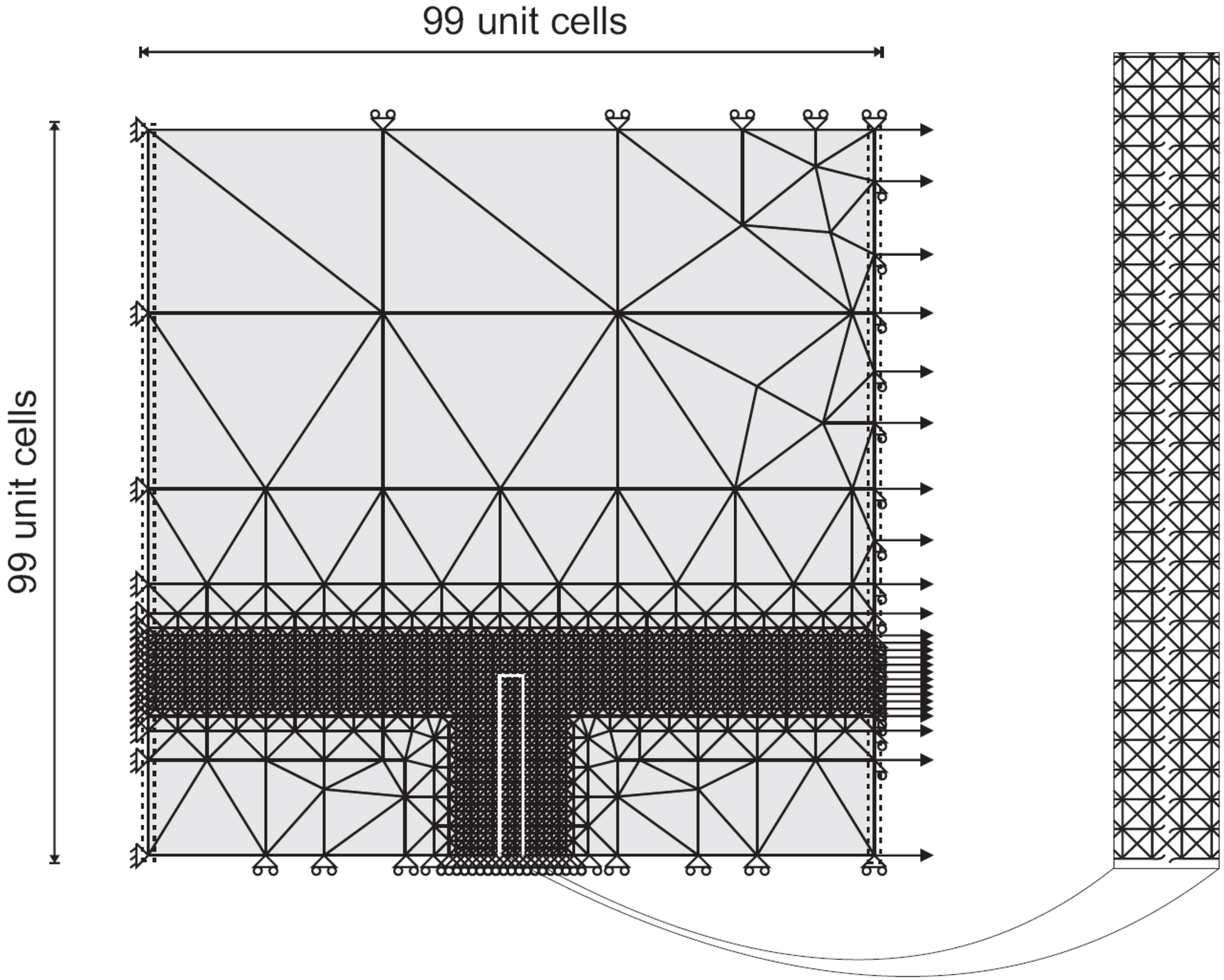
Summation 2



Accuracy and efficiency

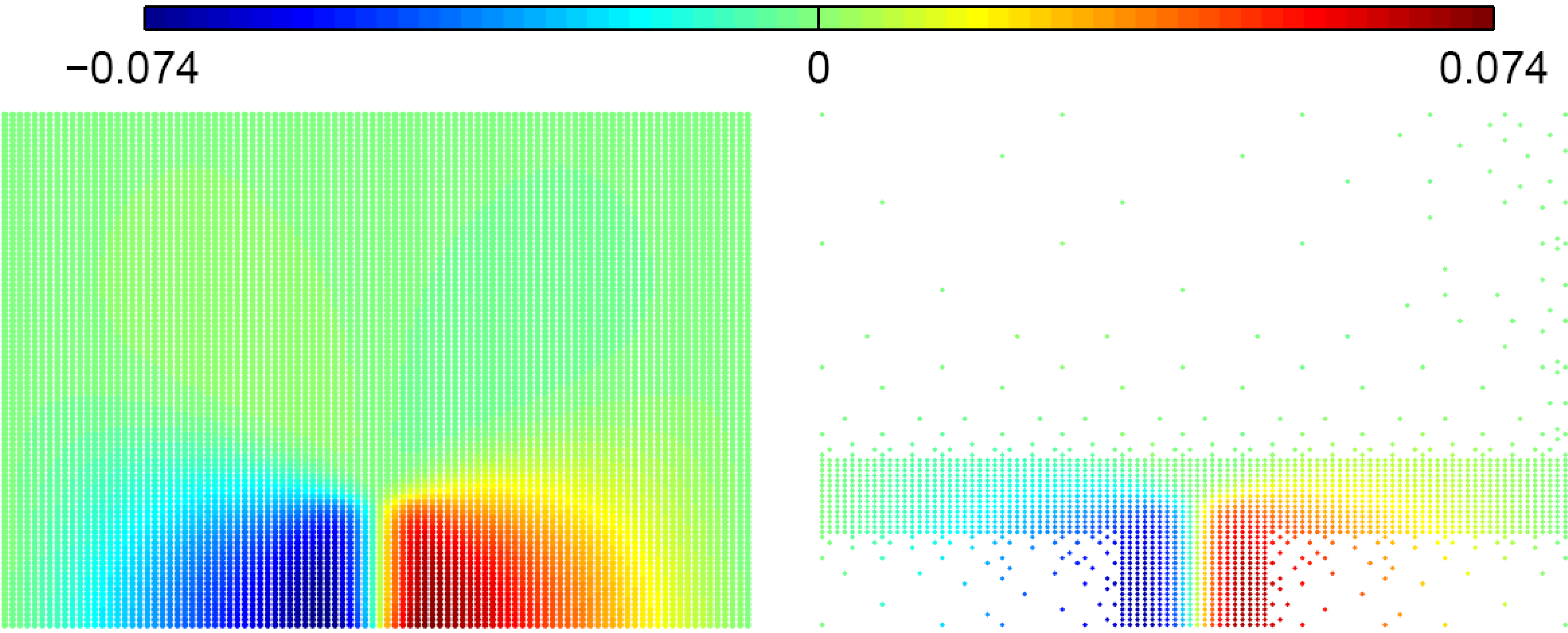


Bond failure and fiber sliding



Results: bond failure and fiber sliding

Horizontal displacement, relative to uniform displacement



Conclusions

Virtual-power-based QC methodology

Summation: 1. exact rule

2. central rule

Dissipative effects included in QC via internal variables

- for elastoplasticity at sampling spring level
- for nodal sliding interpolated due to nonlocality

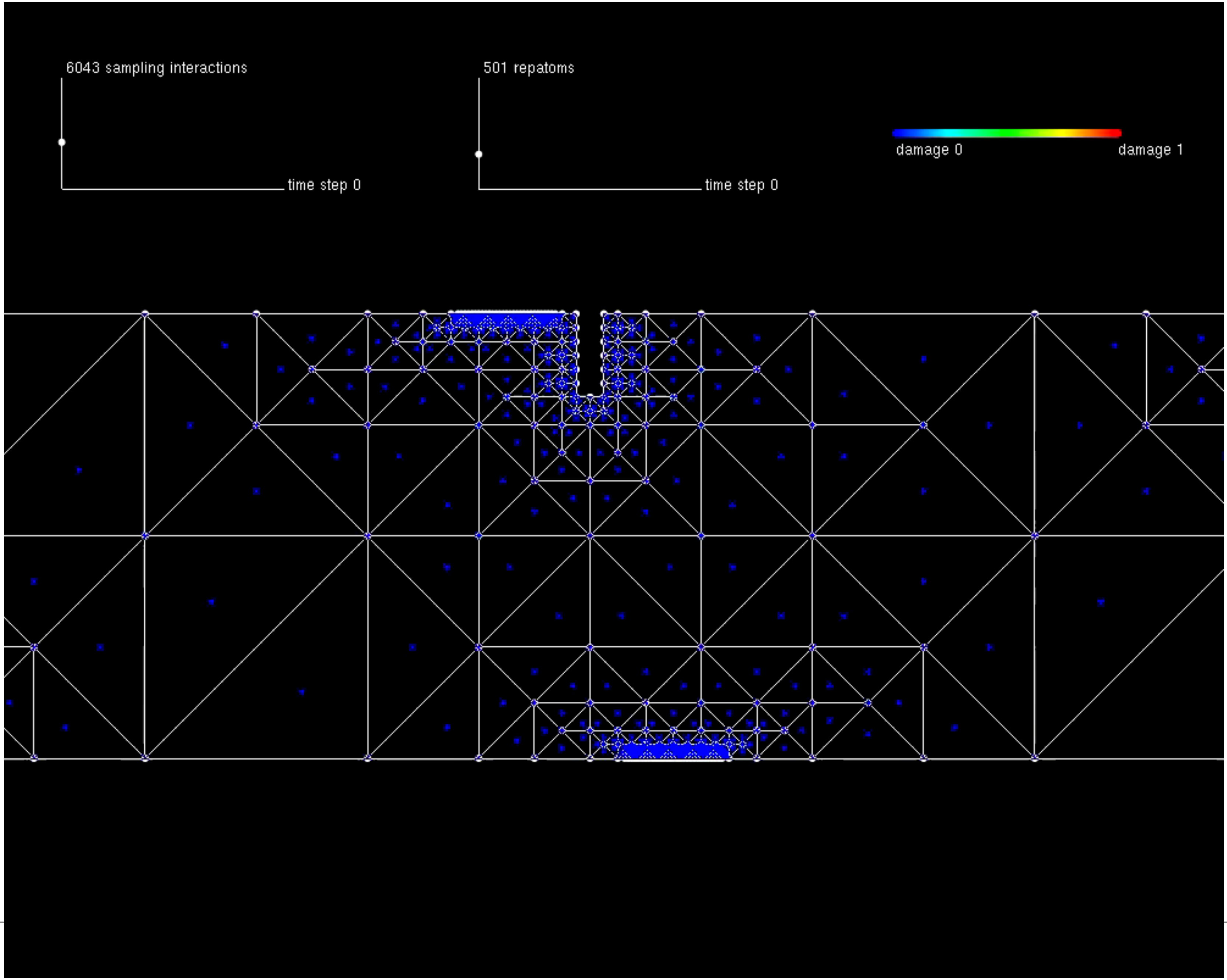
Not mentioned

QC method for beams

QC method for irregular networks

Variational QC methods + adaptivity

Ondrej Rokos & Jan Zeman


6043 sampling interactions
time step 0
501 repatoms
time step 0
damage 0
damage 1

Ongoing & future work

Applications: textiles, printed structures, foams

(goal-oriented) Adaptivity

Stochastics