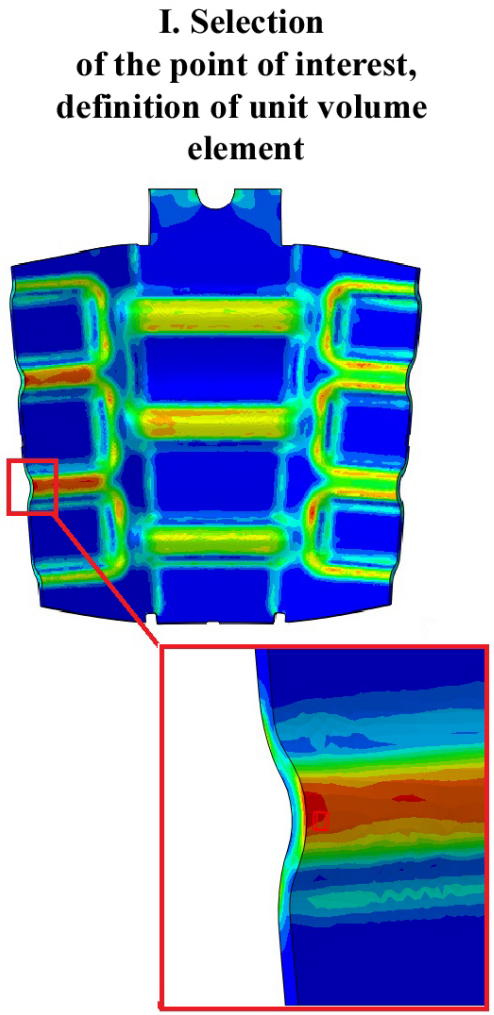
AKADEMIA GÓRNICZO-HUTNICZA
IM. STANISŁAWA STASZICA W KRAKOWIE

Three dimensional NURBS for representation of metallic material microstructures

L. Rauch, D. Bachniak, K. Bzowski

Department of Applied Computer Science and Modelling
Faculty of Metals Engineering and Industrial Computer Science

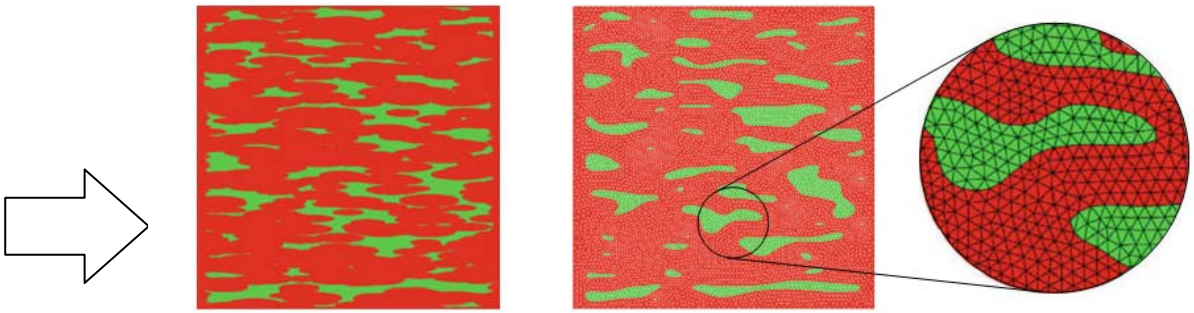
Motivation – efficient multiscale simulations



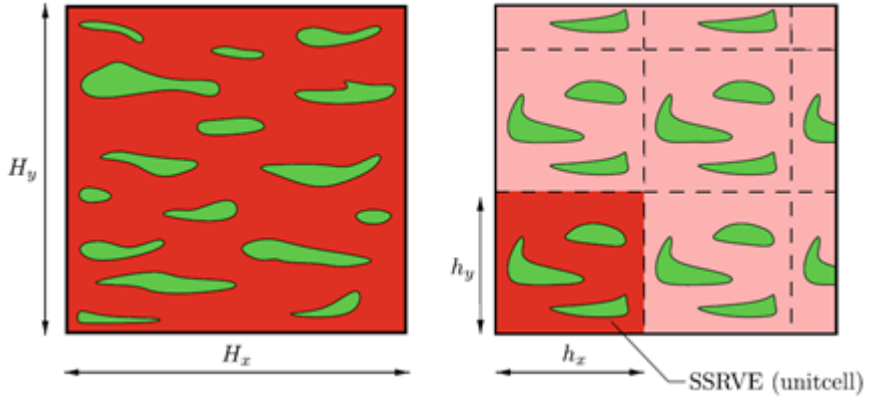
- Full representation of microstructure – mainly the case of one phase materials or RVE
- Representation of one-three grains representation – the case of SSRVE

NURBS implementation

Idea of SSRVE



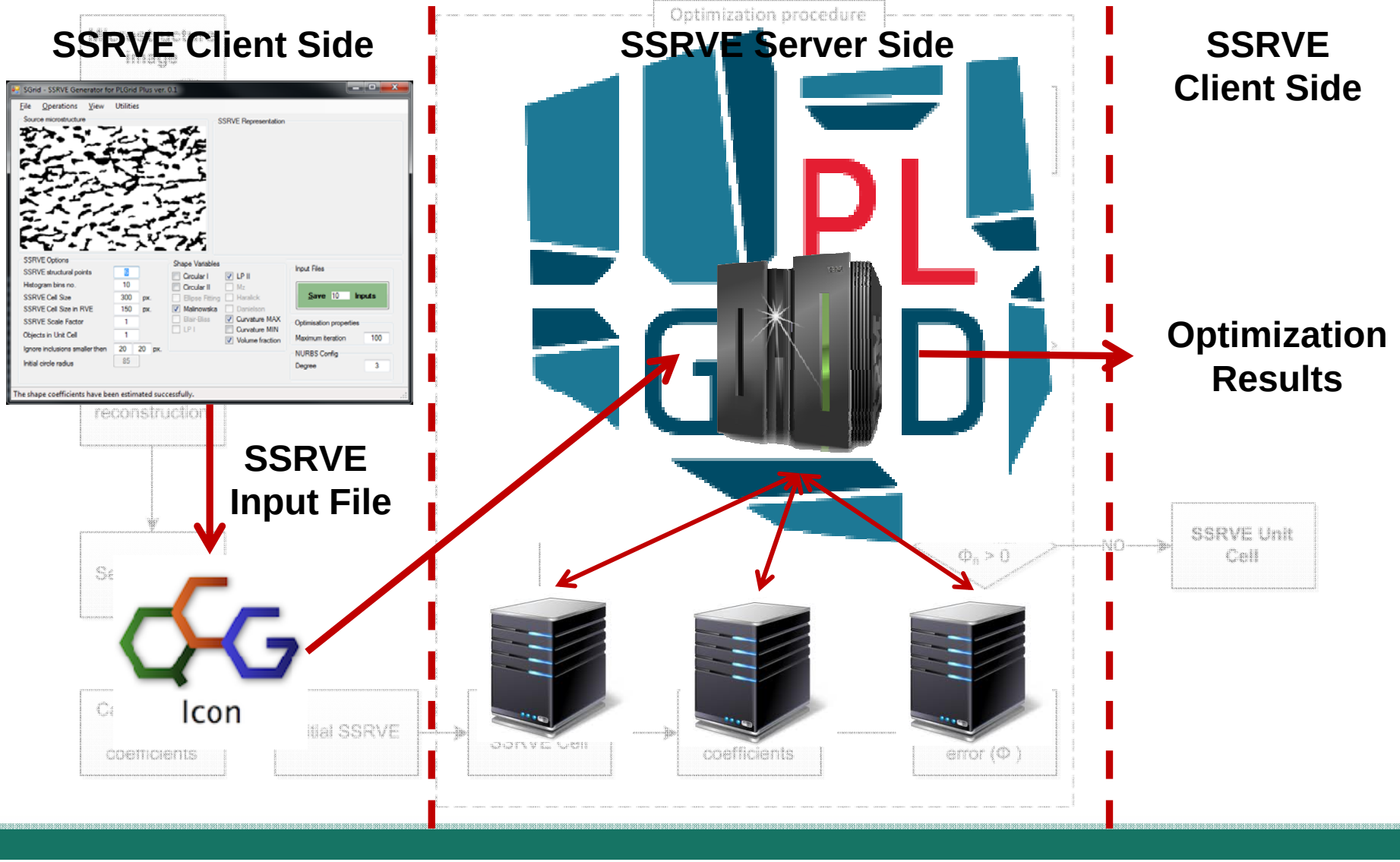
Statistically Similar Reconstruction of Dual-Phase Steel Microstructures for Engineering Applications



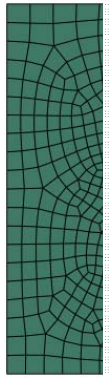
FE2-Simulation of micro heterogeneous steels based on Statistically Similar RVEs

Schroeder J., Balzani D., Brands D.: Approximation of random microstructures by periodic statistically similar representative volume elements based on lineal-path functions, Arch. Appl. Mech., 81, 2011, 975-997.

Creation of the SSRVE



Qualitative results
Examples of SSRVE for DP600 steel

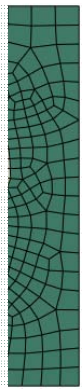


3D RESPRESENTATION!!!

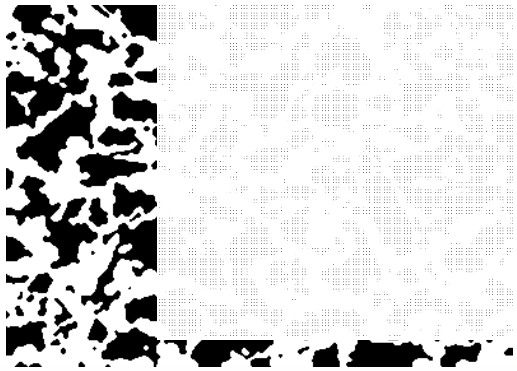
a)
89 elements

b) 8-points
1204 elements

c) 10-points
1371 elements



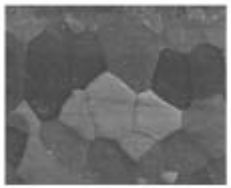
d) 16-points
1166 elements



Reconstruction idea[1]

The reconstruction is based on the following procedure:

1. Real material sample is sliced and photographed by using optical microscope.



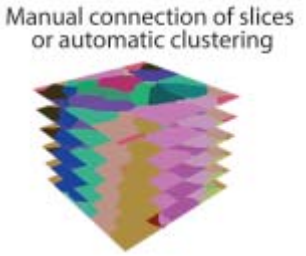
Slice through real microstructure

2. Slices are passed as input data to image analysis to obtain separated 2D grains.

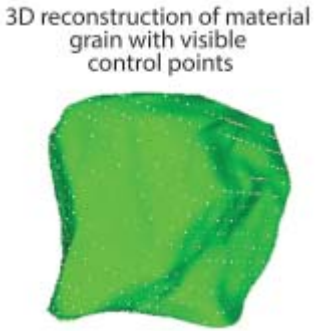
Slice after segmentation

Reconstruction idea[2]

3. Selected grains from subsequent slices are connected together manually.



4. Boundary points of each grain on connected slices are obtained from sets of 2D NURBS control points.



5. 3D NURBS, representing grains, is calculated according to the following equation:

$$S(u,v) = \sum_{i=1}^{k}\sum_{j=1}^{l} R_{i,j}(u,v)\boldsymbol{P_{i,j}} \quad \textit{where:} \quad R_{i,j}(u,v) = \frac{N_{i,n}(u)N_{j,m}(v)w_{i,j}}{\sum_{p=1}^{k}\sum_{q=1}^{l} N_{p,n}(u)N_{q,m}(v)w_{p,q}}$$

Multiscale simulations based on SSRVE