Project 1

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A cellular automaton is a discrete model studied in computer science, mathematics, physics, complexity science, theoretical biology and microstructure modeling. A cellular automaton consists of a regular grid of cells with can be in any finite number of dimensions. Main goal of this project is to implement application for grain growth simulation of steel microstructure with use of Cellular Automata methods.

First attemp

Technology: Python
Gui library: Tkinter

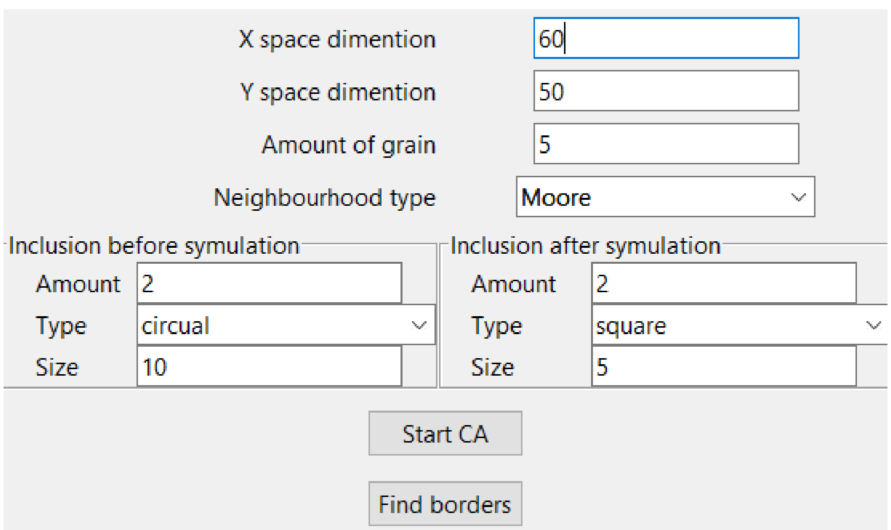


Image 1. Main menu.

User can define x space dimention, y space dimention, amount of grain and add inclusion before and after symulation.

Photo 2. Random generated microstructure

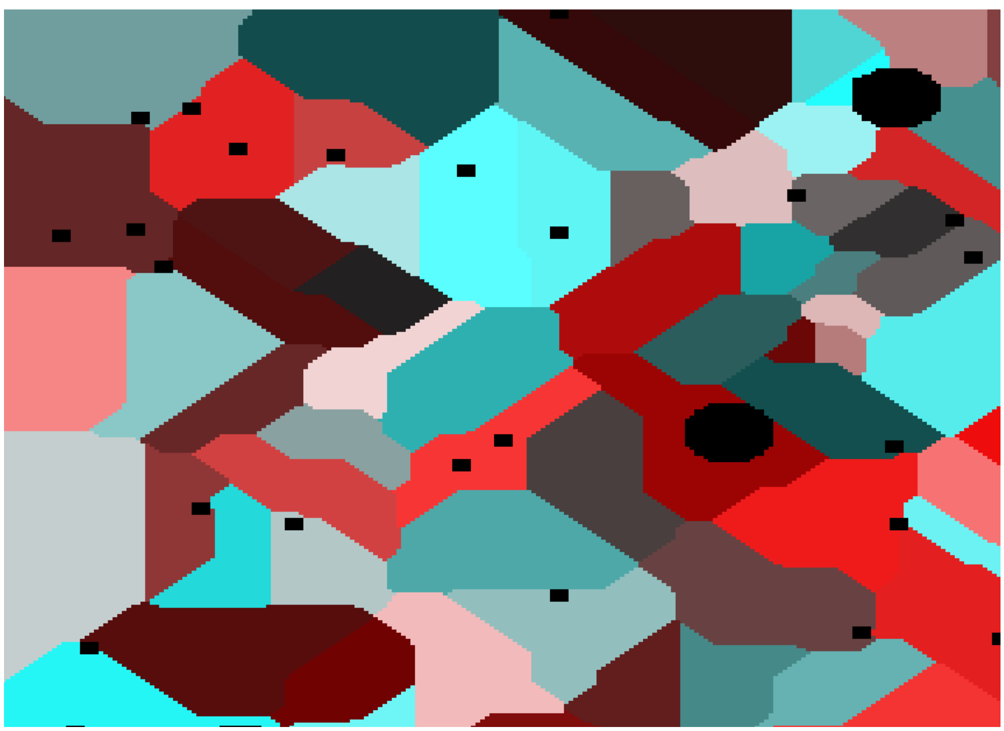


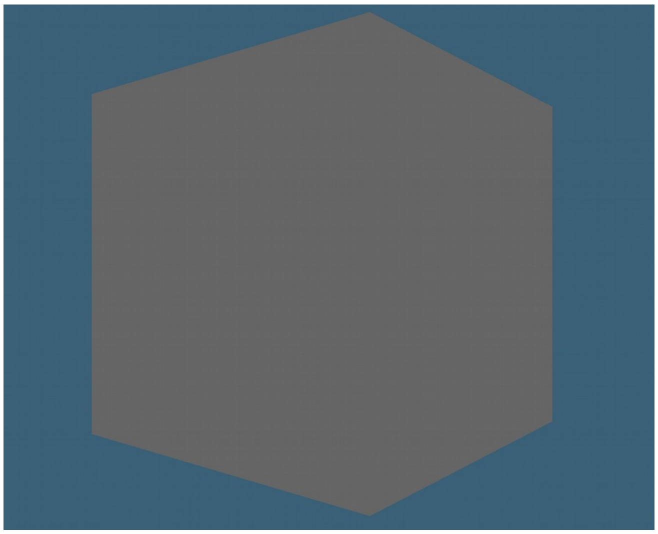
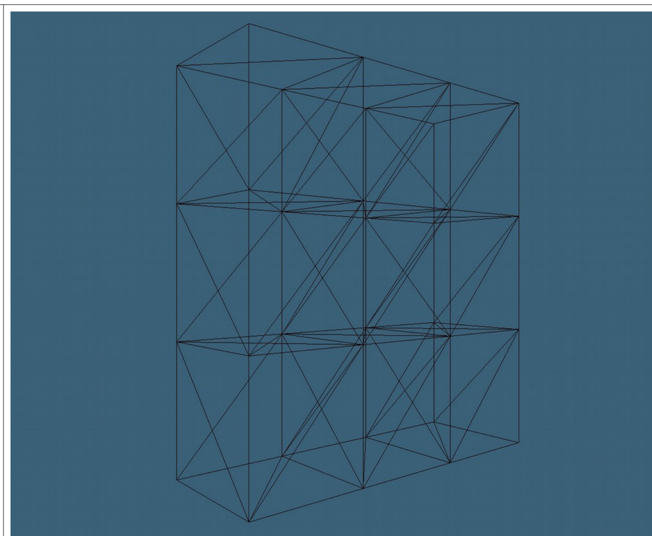
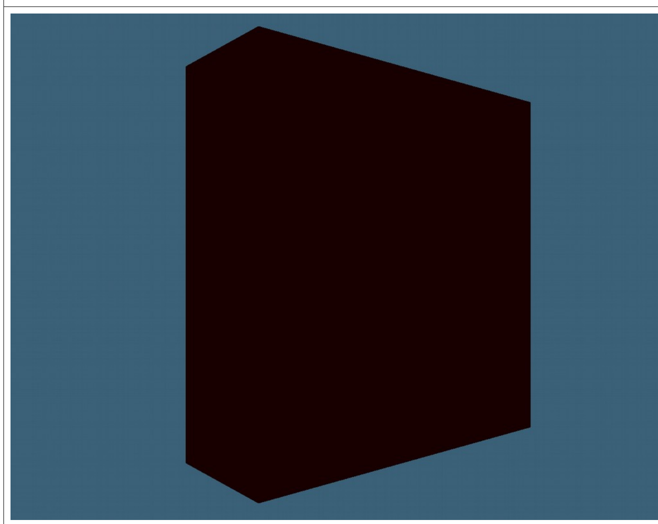
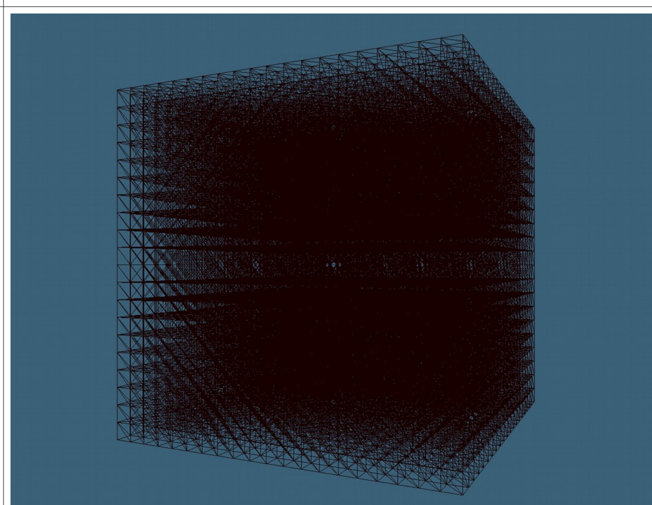
Photo 3. Random generated microstructure with added inclusion bedore and ater simulation.

Problems:
- Python is a slow language and CA simulation needs a lot of computing power.
- Way of visualisation grain structure is ineffective because of problems with tkinter canvas.

Second attemp

Project rebuild. Change 2D to 3D.
Technology: C++
Visualisation method: OpenGL

Process of creation 3D grain growth symulation.

 1. Create basic OpenGl cube.	 2. Build cube skelet wall.
 3. Add colors to skelet.	 4. Create big cube wiring net.

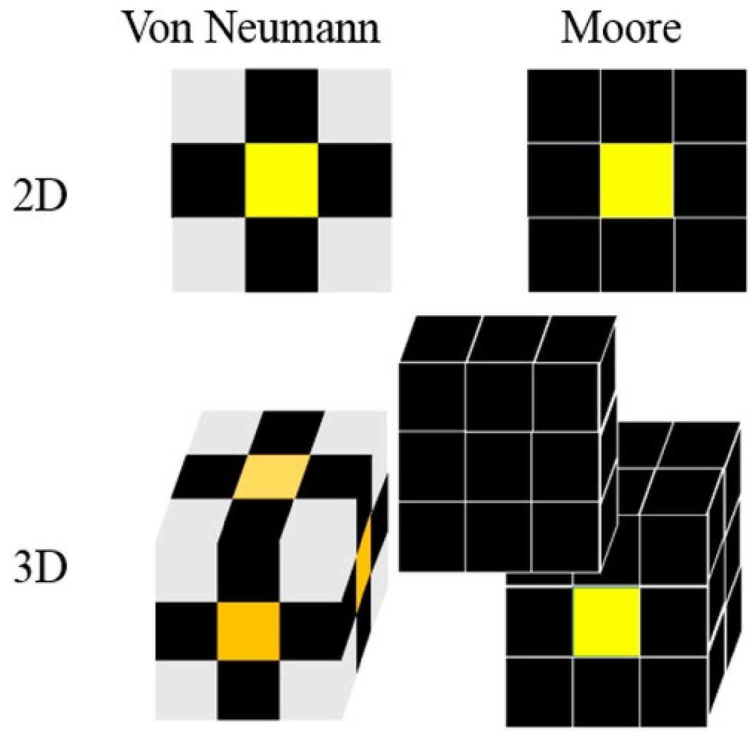


Photo 4. Neighbouthood type 2D and 3D comparation.

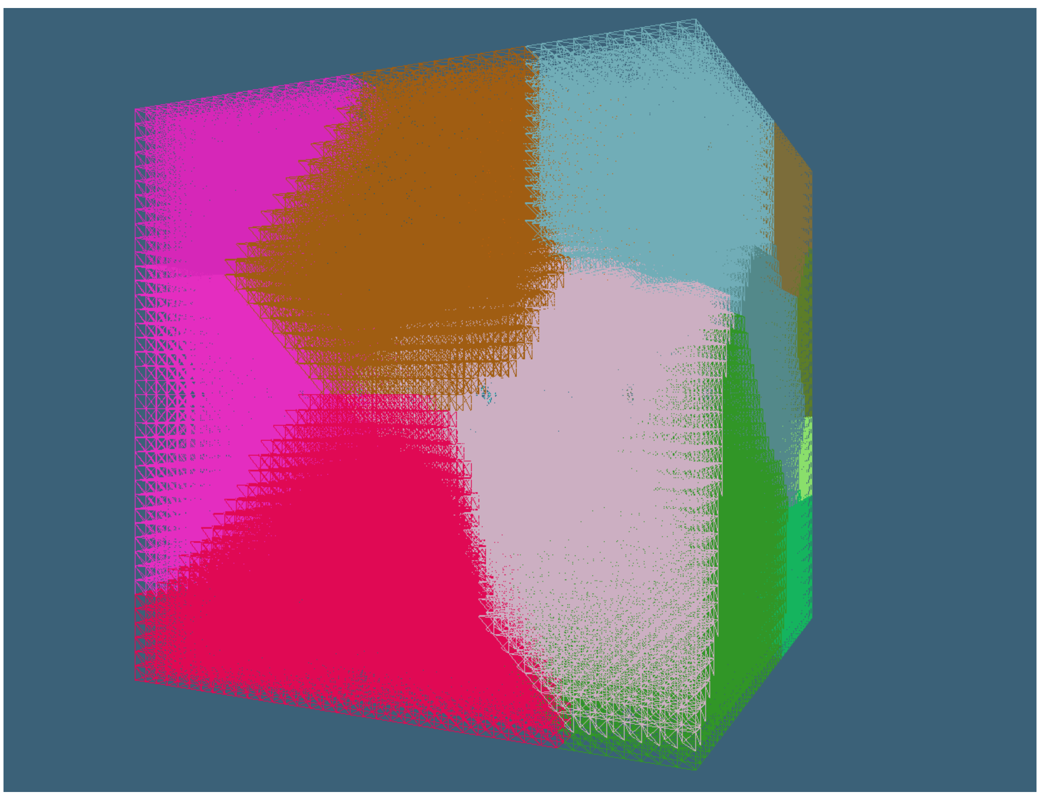


Photo 5. Creation of 40x40x40 cellular automata wire frame with contain 20 difference grains.

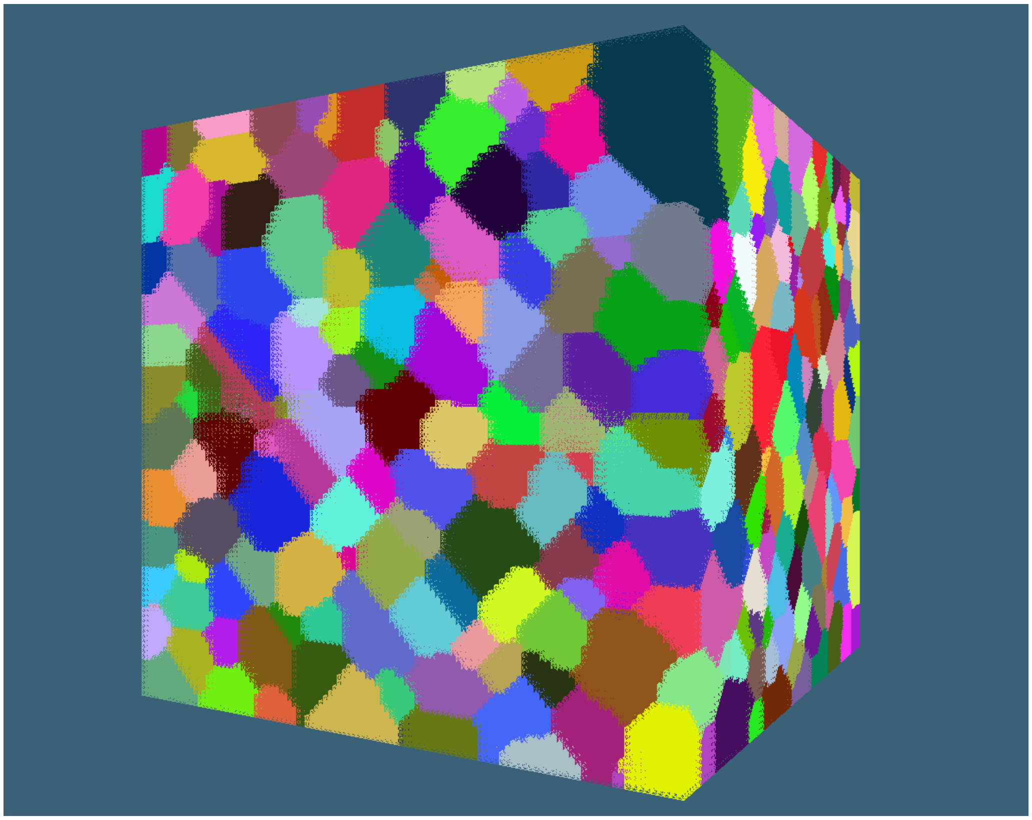


Photo 6. Creation of 120x120x120 cellular automata wire frame with contain 20 difference grains.

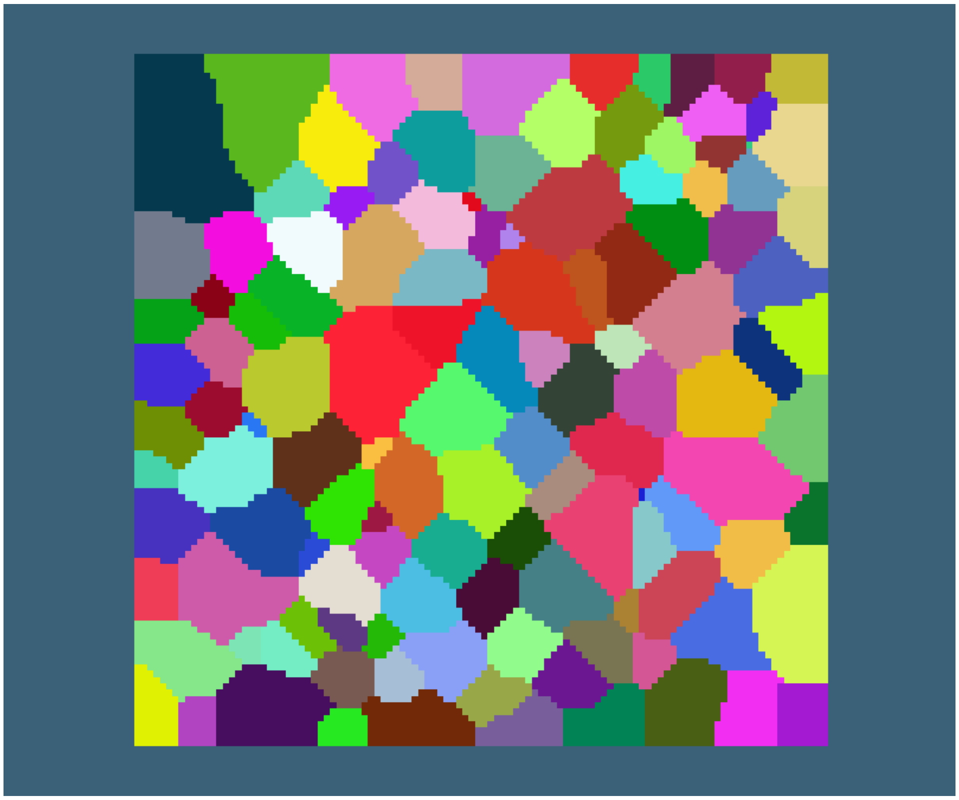


Photo 7. 2D projection of 120x120x120 grain matrix.

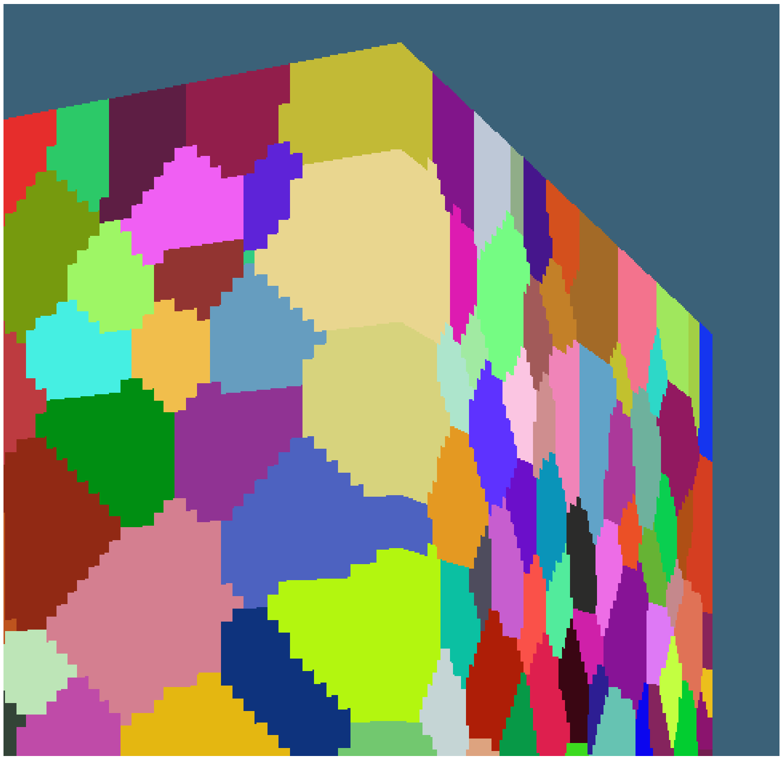


Photo 8. Corner visualisation.

Modification of CA grain growth algorithm - influence of grain curvature.

Photo 9. Probability 90%, matrix 300x300x10, 2D projection.

Photo 10. Probability 90%, matrix 300x300x10, 2D projection.

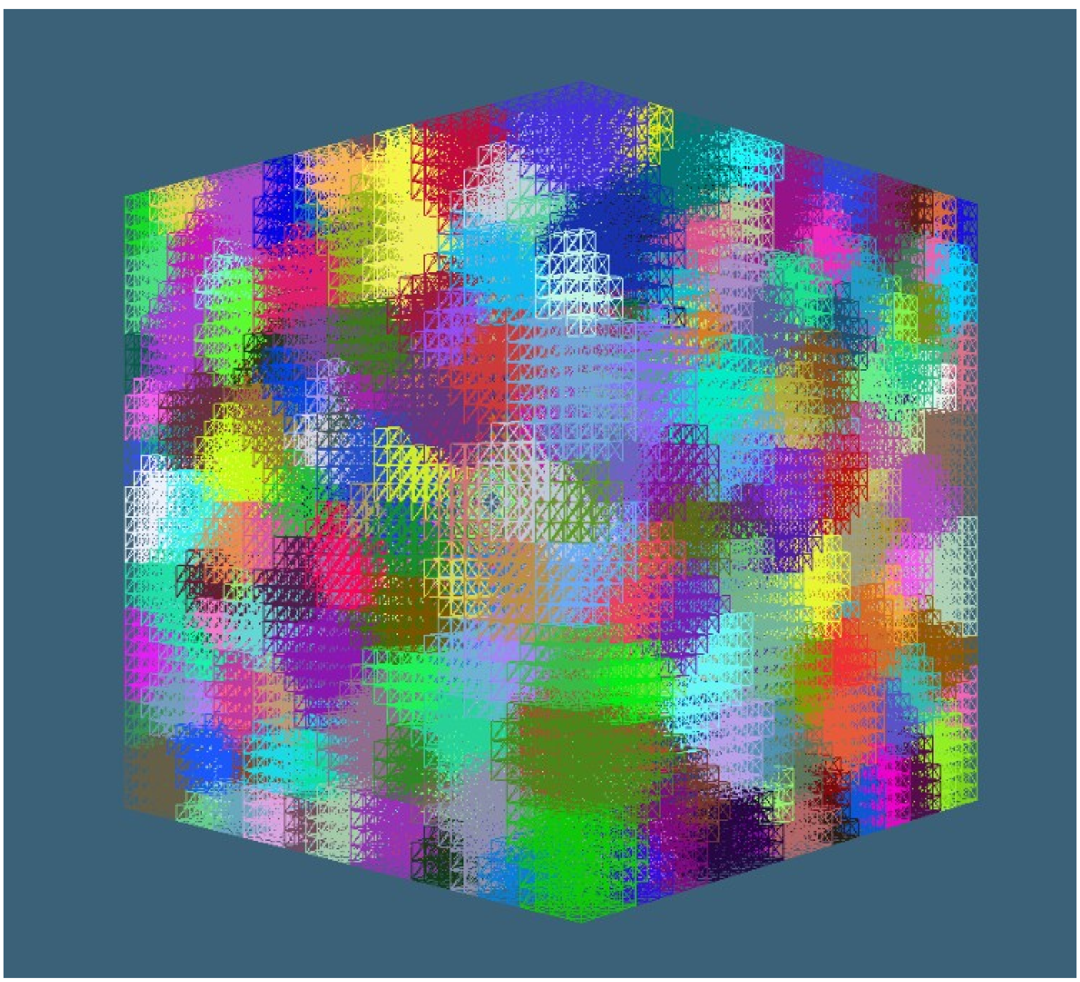
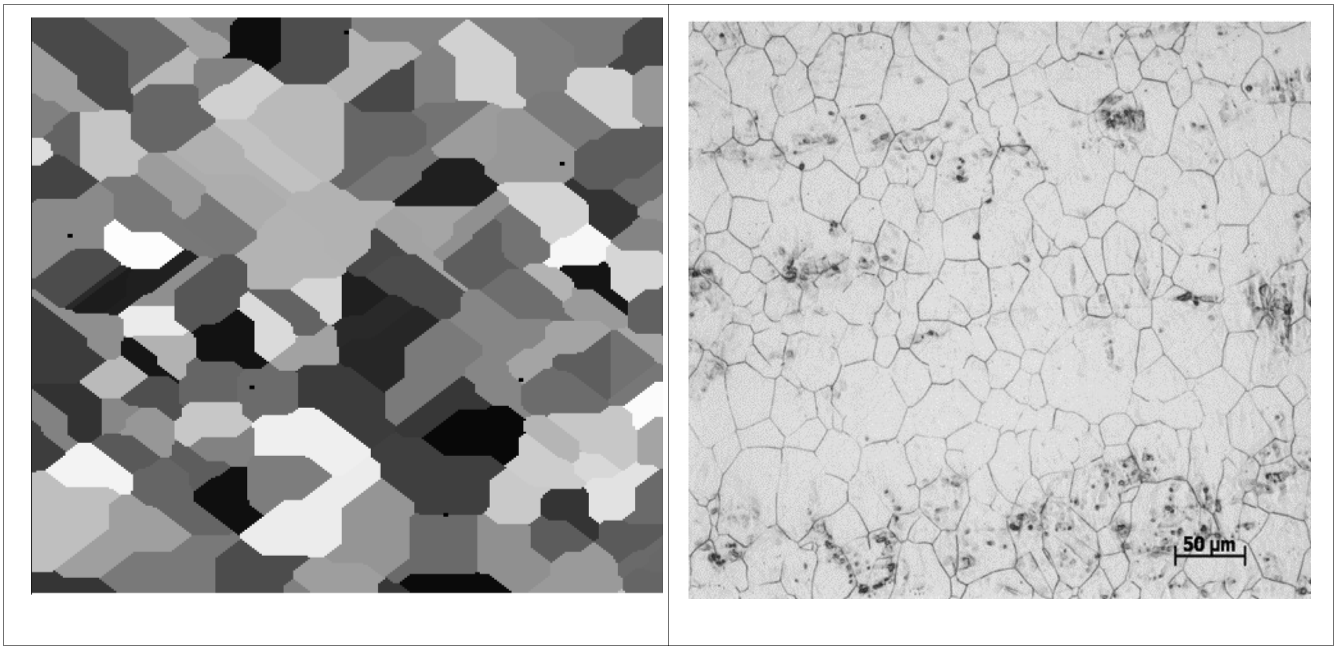
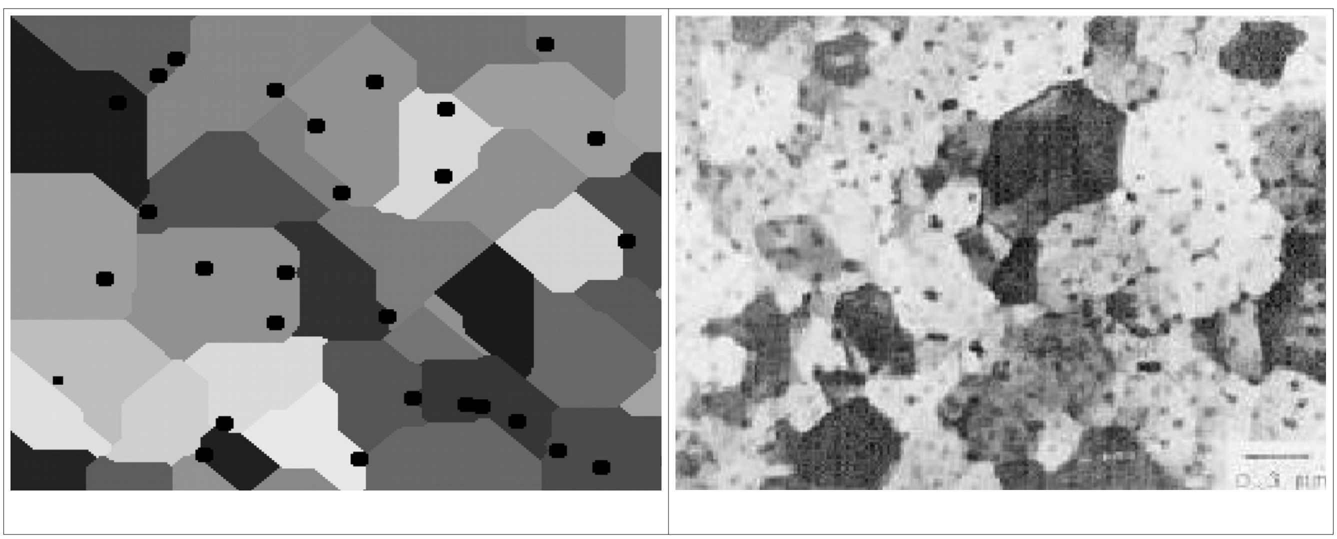


Photo 10. Influence of grain curvature in 3D model.

Real comparation



Comparison of a generated image with 304L stainless steel sample



Comparison of a generated image with real low C steel microstructure with the inclusion.

Conclusion

Microstructural evolution of metallic materials largely affects mechanical and functional properties of final products. Cellular automata approach provides a powerful tool for quantitative and explicit simulation of microstructural evolution during the hot metal forming process. A cellular automata is a collection of colored cells on a grid. The shapes of grains vary on the base of the neighbourhood and type of periodicity. Those rules are applied iteratively for as many time steps as desired to fill the whole grid. Those rules are applied iteratively for as many time steps as desired to fill the whole grid.