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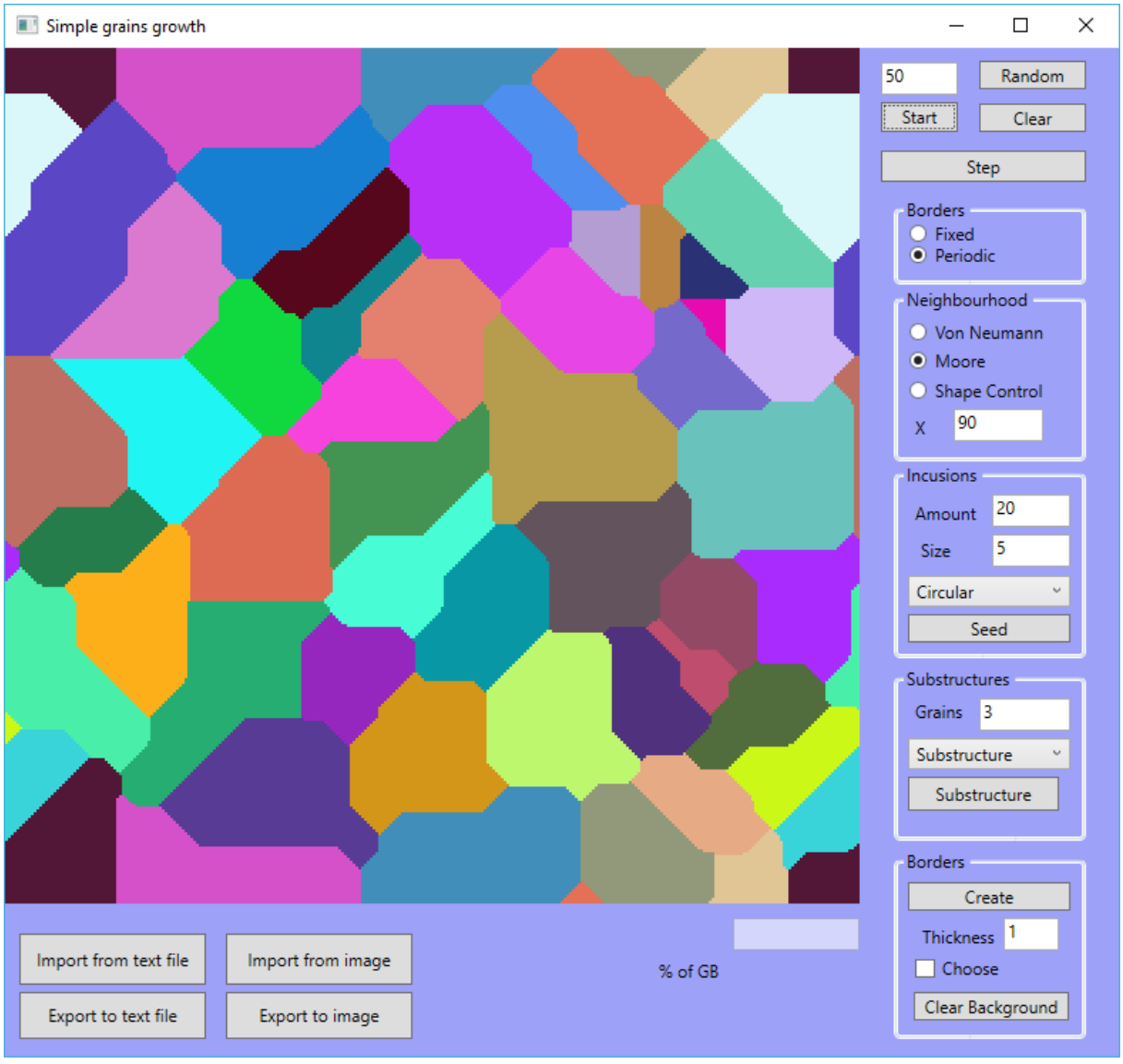
MULTISCALE MODELLING

Grain growth project report, part I

Application for simple grains growth simulation



Technologies used: .NET 4.7, WPF, C#,

Code available at: https://github.com/TMaj/MultiScaleGrainsGrowth

This program is intended to be used for simulating simple grains growth algorithm. It is based on cellular automata, and provides user with possibilities of adjusting simulation parameters such as boundaries, neighbourhood or inclusions. All features are listed below:

Application features:

1. Random nucleons seeding (User specifies the number of new nucleons):

2. Border style choice:
   - *Fixed borders*

   - *Periodic borders*

3. Simulation neighbourhood choice:

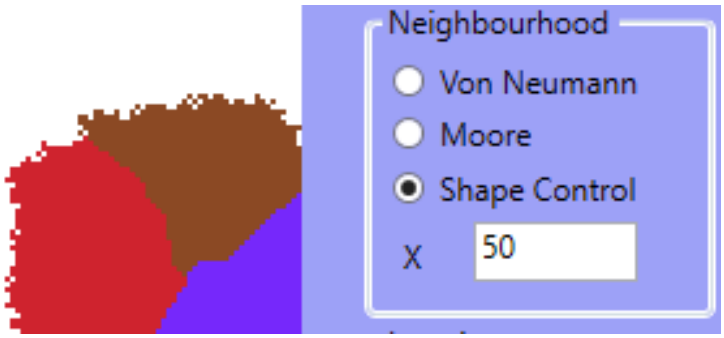
- *Von Neumann*

- *Moore*

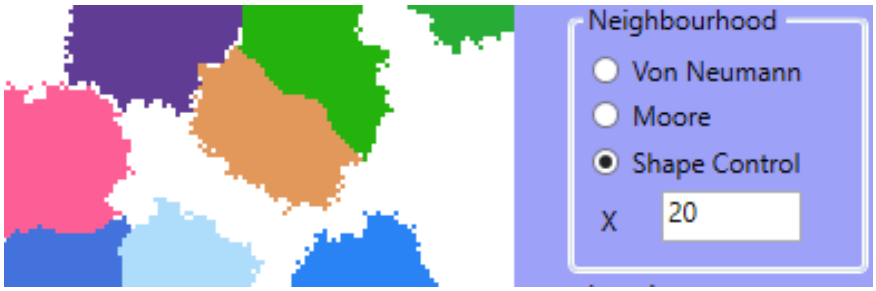
- *Extended Moore (Shape control)*

- *90%*

- *50%*



- *20%*

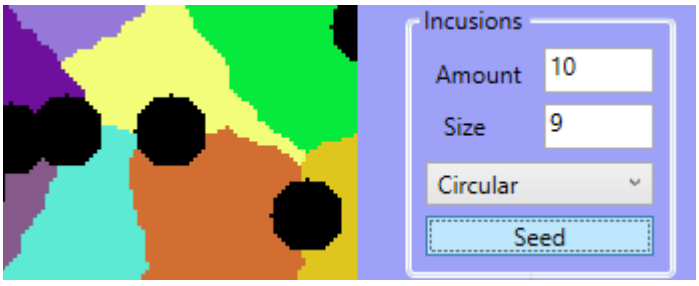


4. Inclusions (possibility to choose size, type and number of inclusions)

Inclusions are always rendered at grains borders. If no borders are present in simulation, they are rendered randomly on matrix.

- *Square inclusions*

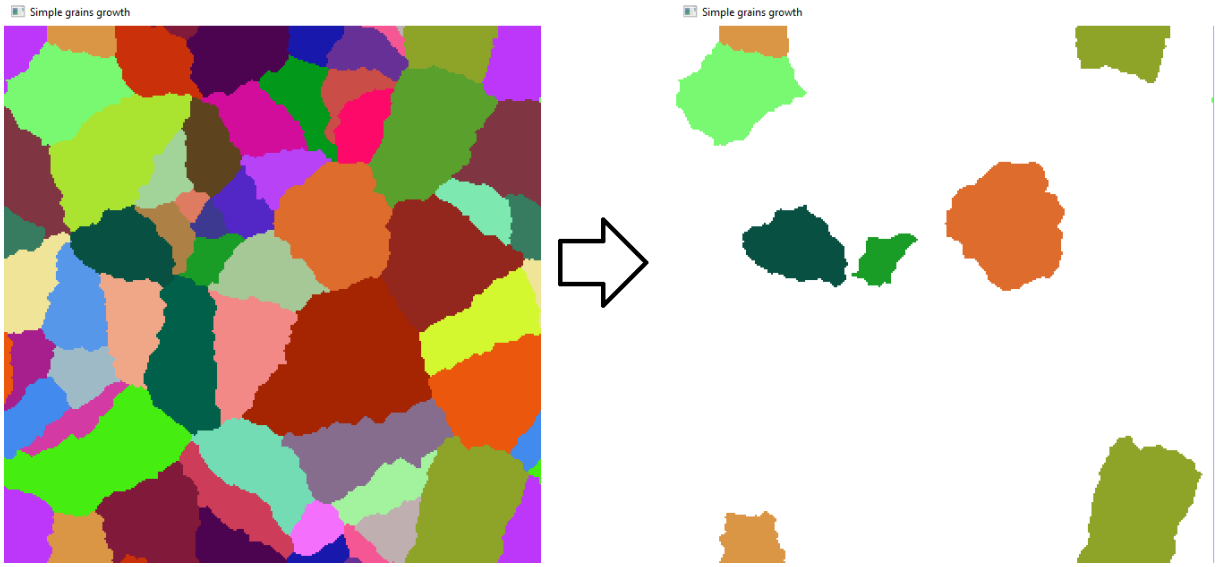
- *Circular inclusions:*



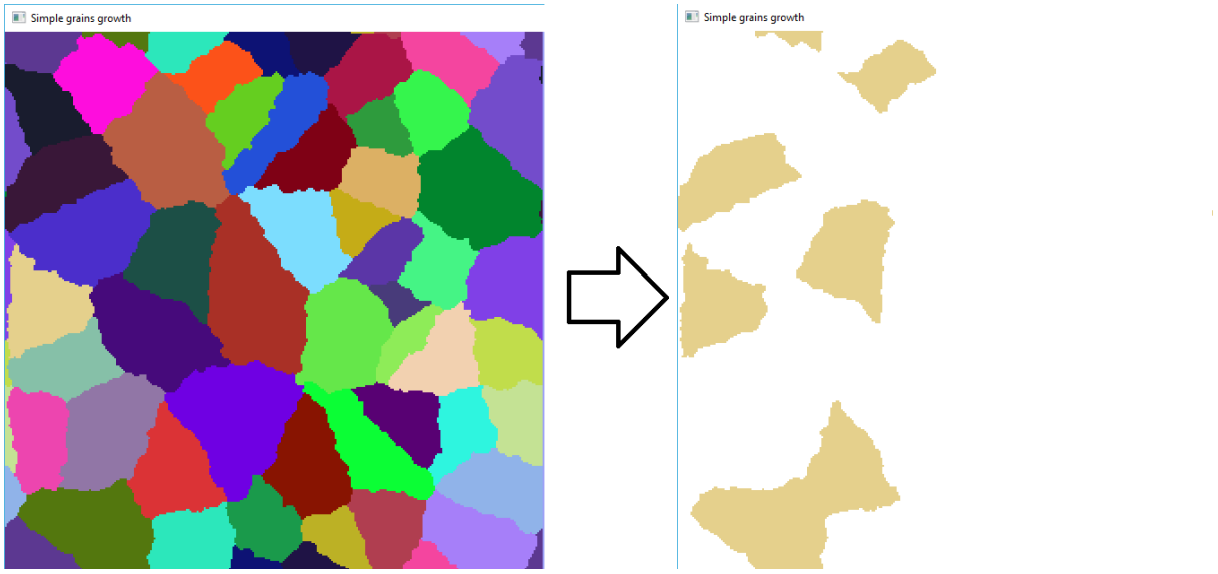
5. Substructures:

Substructures are generated by preserving specified number of random grains on simulation area and conducting new simulation.

- *Substructure:*



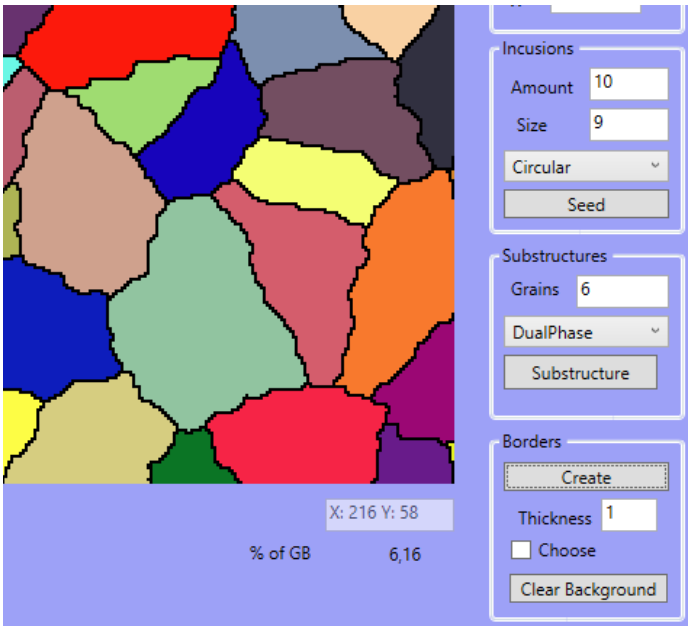
- *Dual – phase*



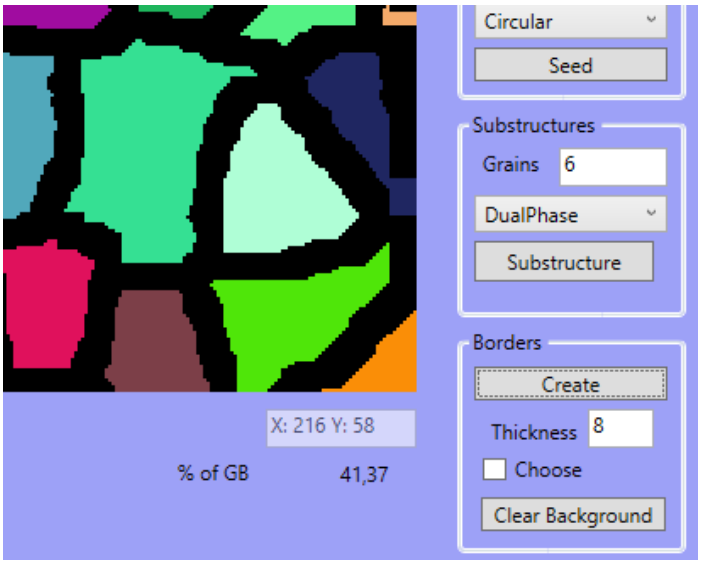
6. Borders:

User is able to generate borders between grains, and specify their thickness:

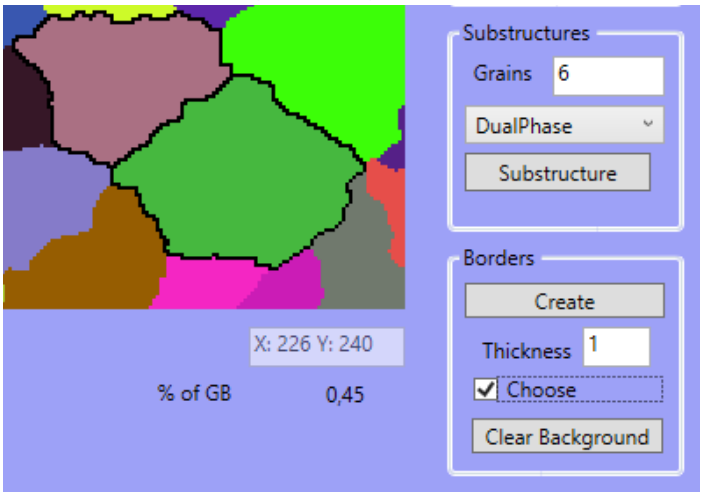
- *Thickness =1, whole area:*



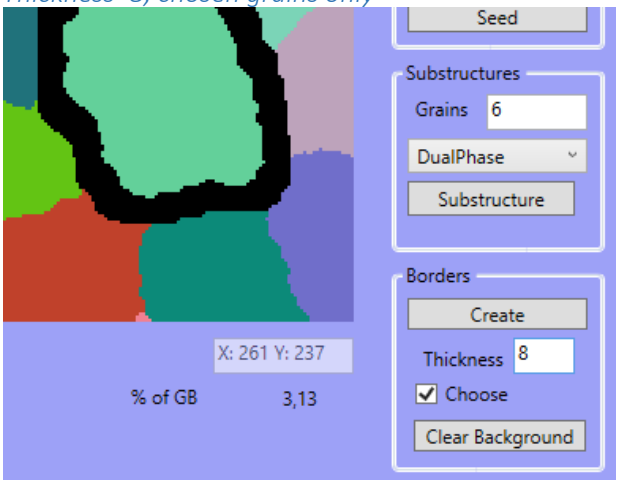
- *Thickness =8, whole area:*



- *Thickness =1, chosen grains only*

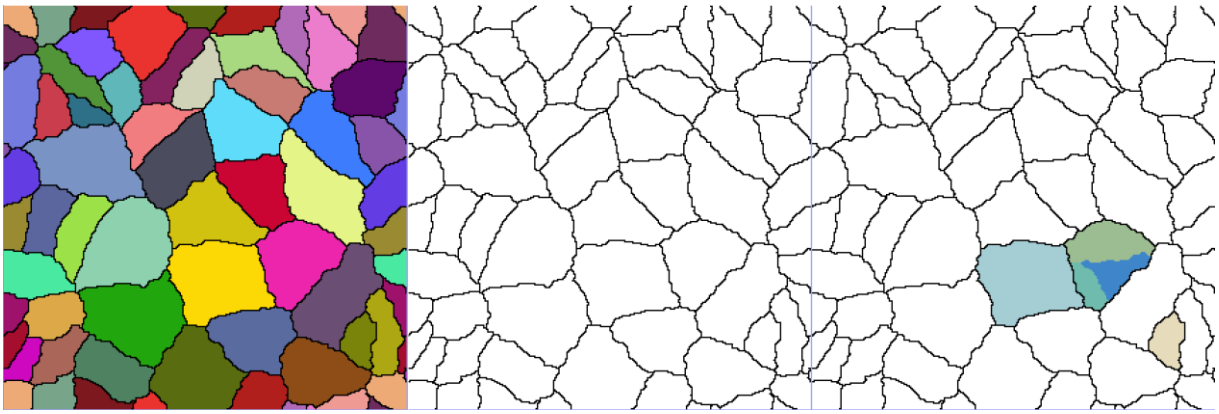


- *Thickness=8, chosen grains only*



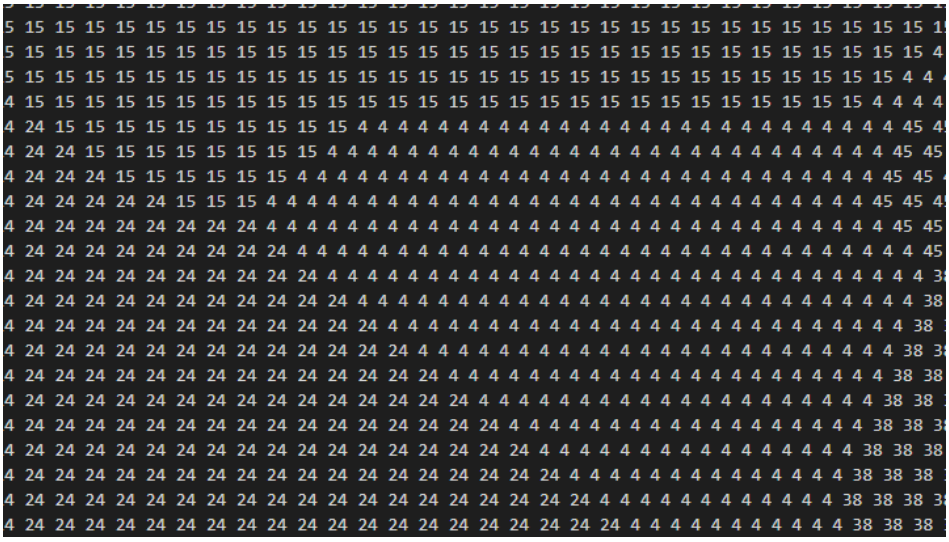
After each boundaries creation user is informed about percentage of grains boundaries in entire simulation area:

When boudaries are drawn, user can erase grains, preserve boundaries and conduct next simulation:

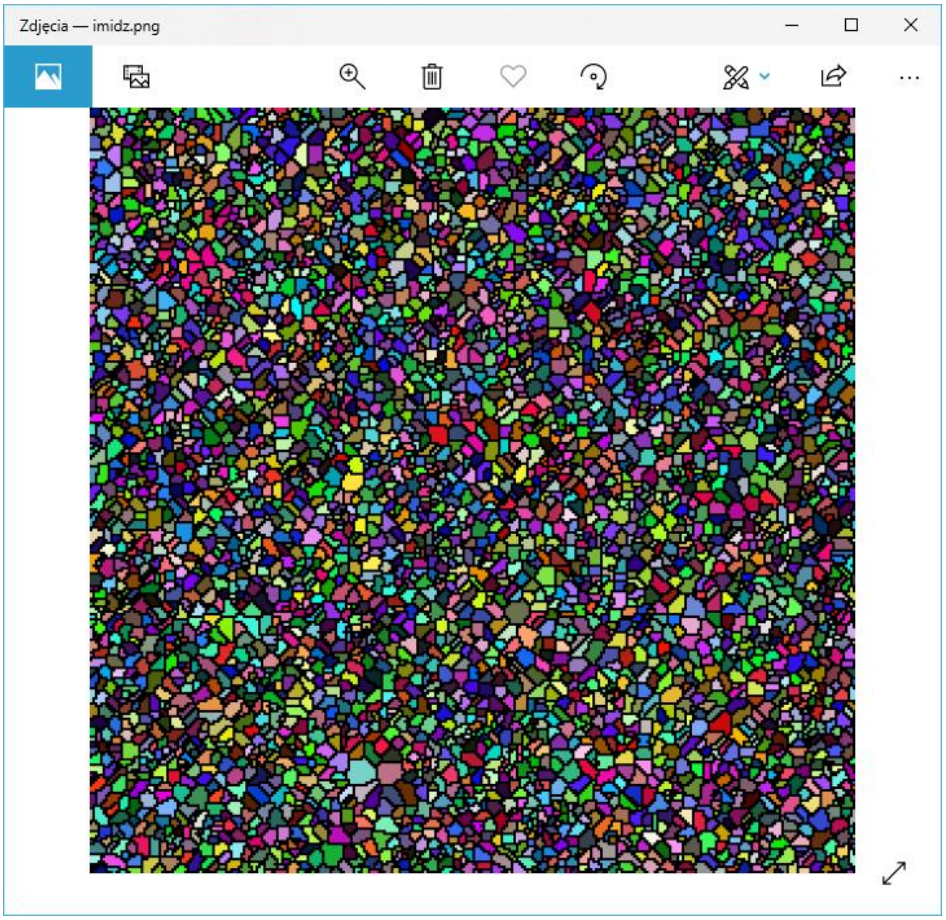


7. Simulation results import and export

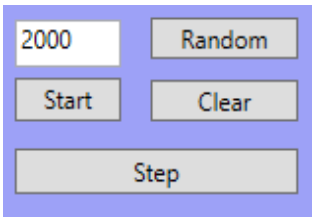
- *To text file:*



- *To png image:*



User Interface manual

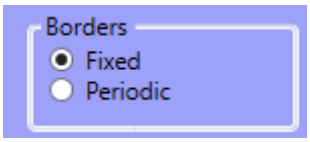


Random button renders a specified number of nucleons in random order on simulation area.

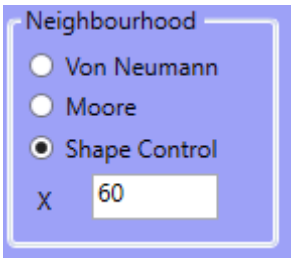
Start button starts simulation. When simulation is running, clicking on it will stop simulation.

Clear button clears entire simulation area.

Step button performs single step of simulation.

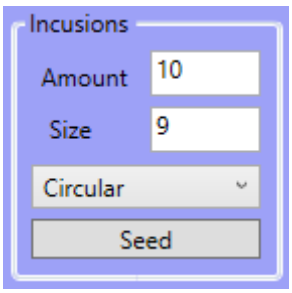


Borders group box allows to choose between ***Fixed*** or ***Periodic*** borders of simulation area.

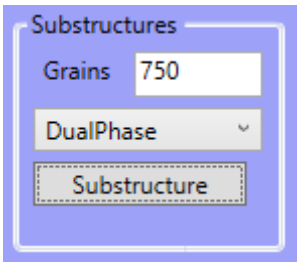


Neighbourhood group box allows to choose beetween neighbourhoods in grains growth algorithm: ***Von Neumann***, ***Moore*** or ***Shape Control*** (Extended Moore).

Shape control has text box specifying possibility parameter ***X*** used in last step of extended Moore Neighbourhood algorithm.



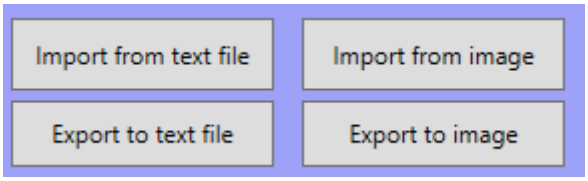
Inclusions group box determines number, size and type of inclusions. ***Seed*** button renders inclusions on simulation area.



Substructures group box specifies how many grains should be used to create substructure or dual phase (this is determined by combo box). Button ***Substructure*** generates substructure.

Borders group box contains text field for specifying border ***thickness***. Button ***Create*** generates borders between all grains present in simulation. Ticking ***Choose*** checkbox allows user to click on desired grains in order to surround them with borders. ***Clear background*** button clears all grains and preserves their boundaries.

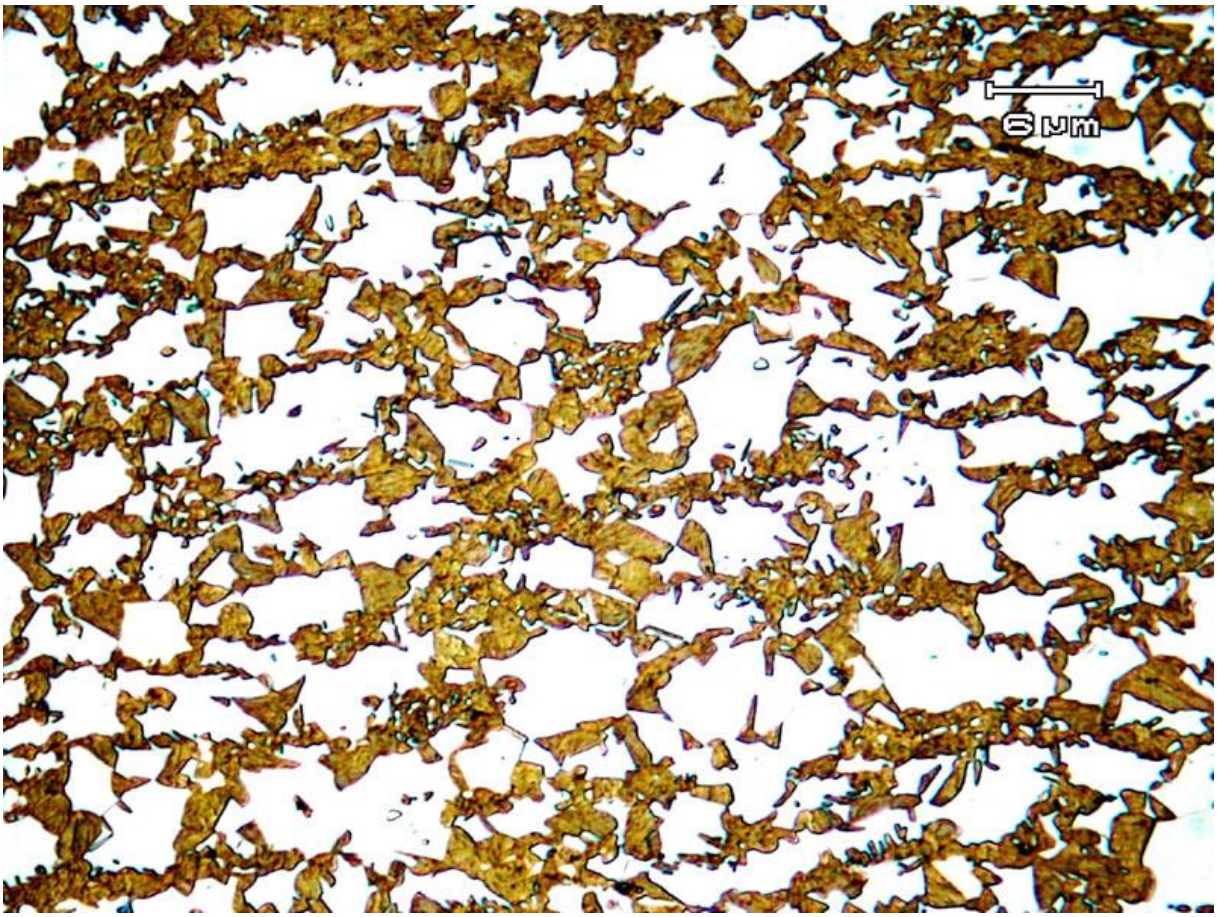
Textbox below simulation canvas displays coordinates of clicked grain. Label which is placed below indicates percentage of borders on simulation area.



Buttons for importing and exporting simulation to text/image display prompt user for selecting desired source or destination of smulaiton file.

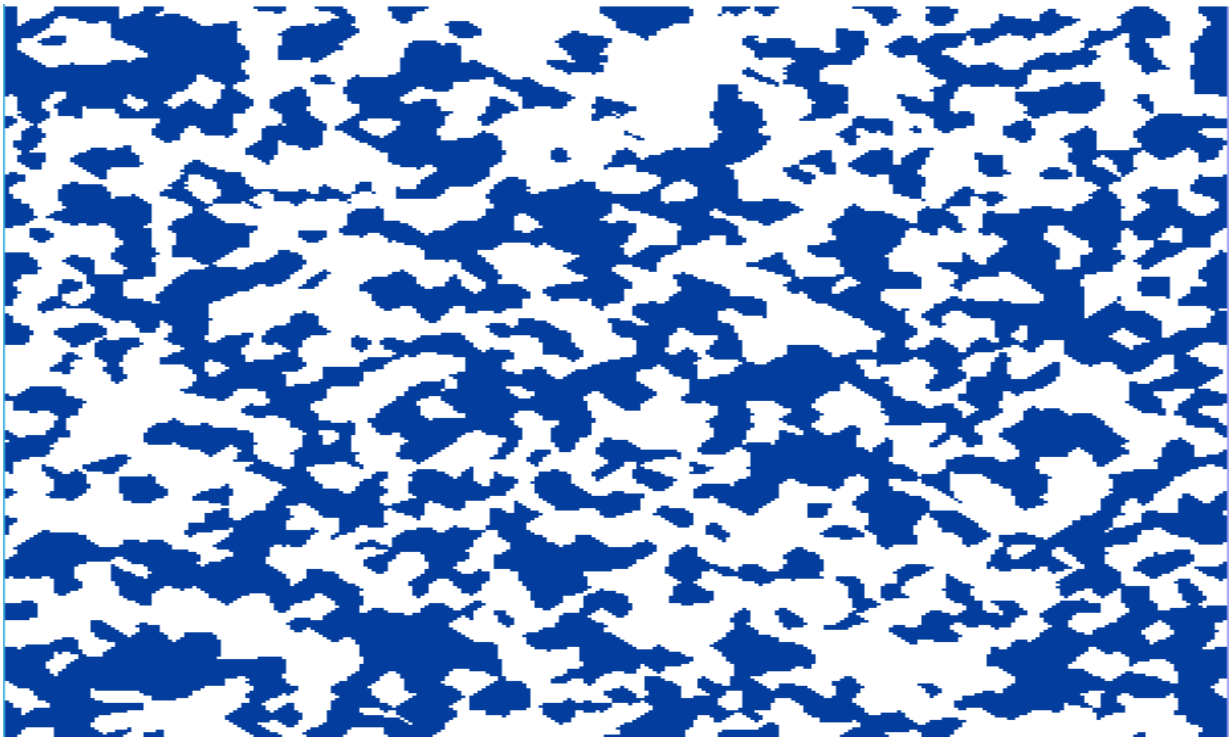
Comparison of simulation and real material

The purpose of grains growth simulation is to predict phenomenons occuring in real materials. After proper adjustment of simulation parameters, it is possible to generate structure which is quite similar to real material, for example dual-phase steel:



Rysunek 1. Dual phase steel - composition of the steels is Fe-0.15C-1.5Mn-1.5Si wt%

http://www.phase-trans.msm.cam.ac.uk/2008/dual.html



Rysunek 2. Simulation result - 2000 grain nucleons, dual-phase with 750 grains parameter