WIMiIP, IS, st. II, rok 2	MULTISCALE MODELING	07.11.2019
Wojciech Jarosz	1st application report	

1. Graphic user interface:

Graphic user interface is shown on *Figure 1*. Application window is divided into two parts: on left microstructures are drawn and on the right part main menu can be found. There is also menu bar when export/import functionalities buttons are placed.

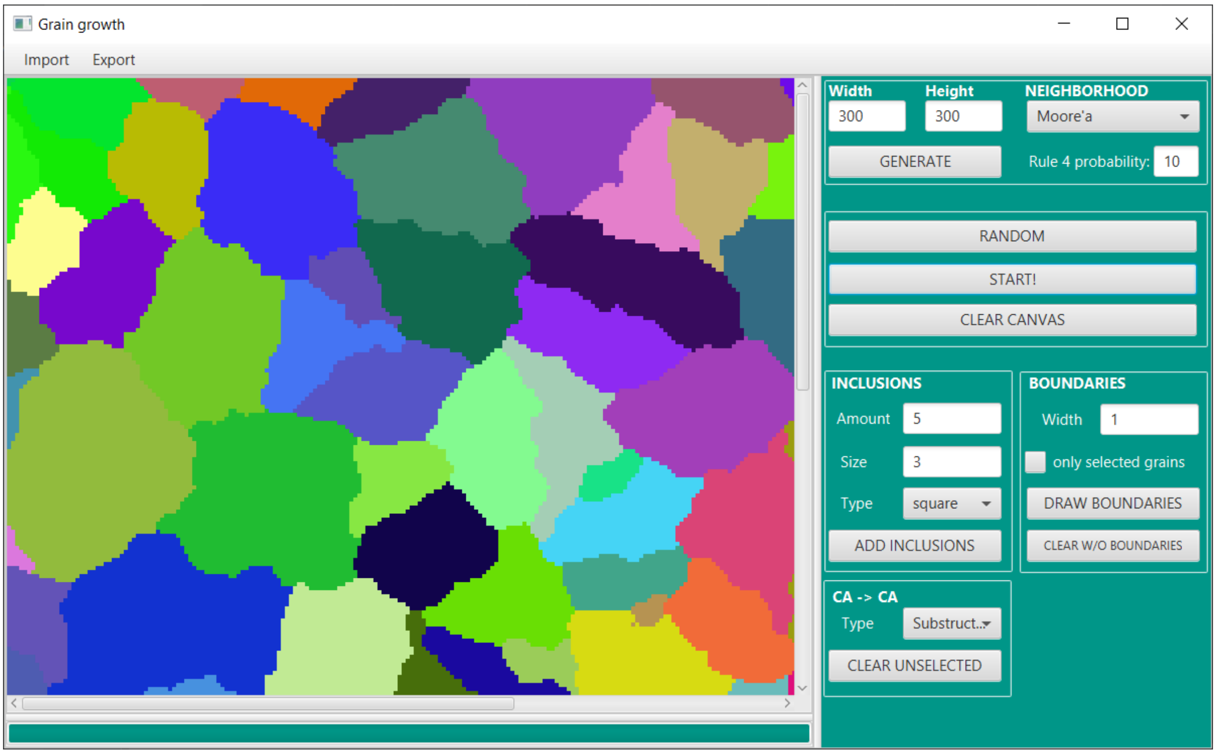

Figure 1. User intarface

2. Functionalities:

Simple grain growth

User is able to choose the size of microstructure, the neighborhood type: von Neuman or Moore. In case of Moore neighborhood, it is possible to input the percent probability of rule 4. After changing any of those data, user must generate the microstructure. Button “RANDOM” randomly choose nucleation of grains. To start or stop process user may click the “START!”/”STOP!” button. By pressing “Clear canvas” button, microstructure is reset to initial state.

Microstructure import/export:

To make e.g. different tests on the same microstructure it is possible to import and export it to/from bitmap and text file.

Inclusions

Inclusions can be added to microstructure in two ways. Firstly, you can add inclusion before grain growth and secondly inclusions can be added after grain growth but in this case, only on grain boundaries. Inclusion can have square and circular shapes. Both of them are shown on *Figure 2.*

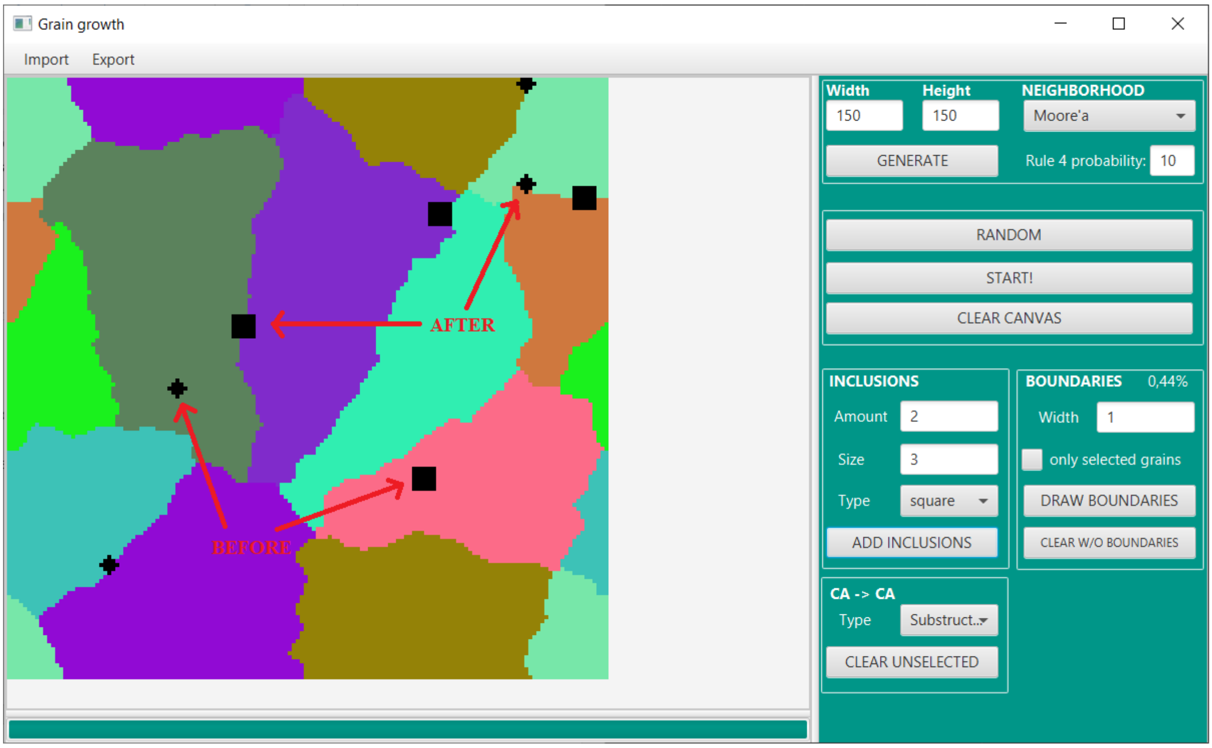

Figure 2. Microstructure with inclusion added before and after grain growth

Control of grain boundary shape

To control grain shape, user can choose Moore neighborhood with 4 rules of grain growth control. Fourth rule probability can be chosen on user interface. The bigger percent is inputted, the more straight grain boundaries are (*Figure 3).*

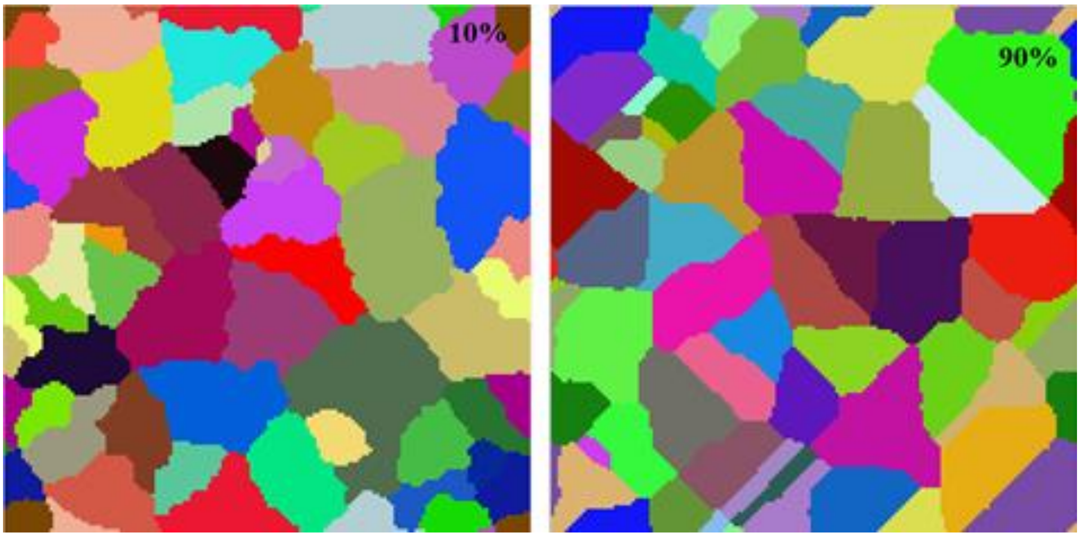

Figure 3. Microstructure with 10% and 90% probabilities of rule 4

Different microstructure type: – substructure – dual phase (CA -> CA).

In order to make specific microstructures with different types of grains which may differ from each other with size of grains or with phase. In one grain growth both substructure and dual phase grains can be added. Grain can be chosen with mouse click. After finishing this step, all grains apart from “substructure” and “dual phase” can be cleared to start next grain growth (Figure 4).

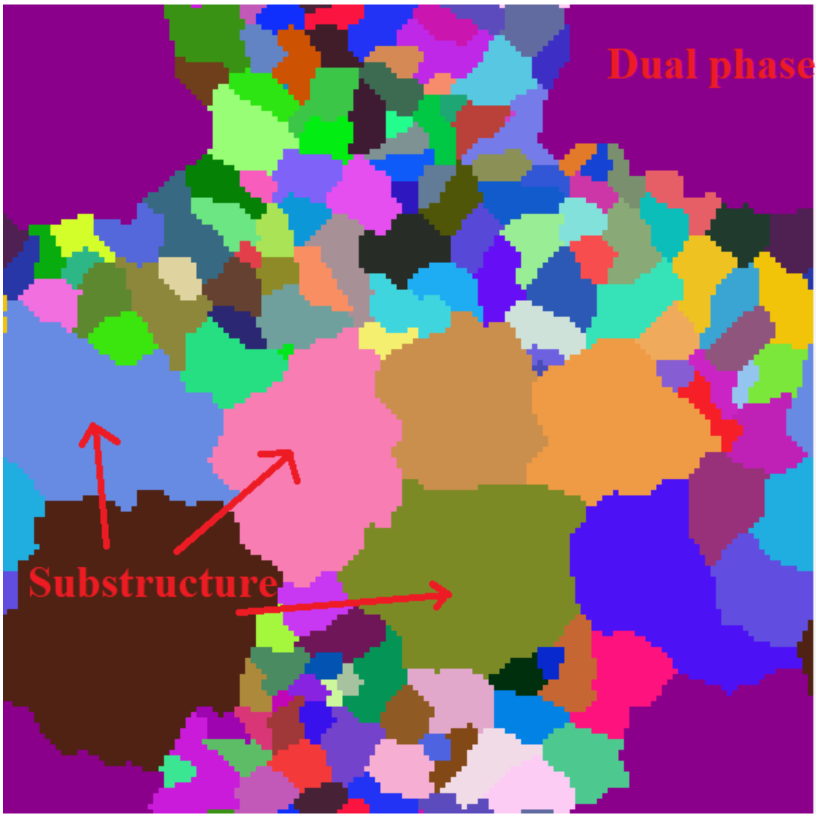

Figure 4. Microstructure with substructure and dual phase grains

Grain boundaries selection

Possibility of generating boundaries of given width. Boundaries can be generated on whole microstructure or only around the selected grains. After that microstructure, apart from boundaries, can be returned to initial state and next grain growth can be started. Left part of *Figure 5* shows only a few boundaries of selected grains, while right part shows result of next grain growth after clearing microstructures without boundaries.

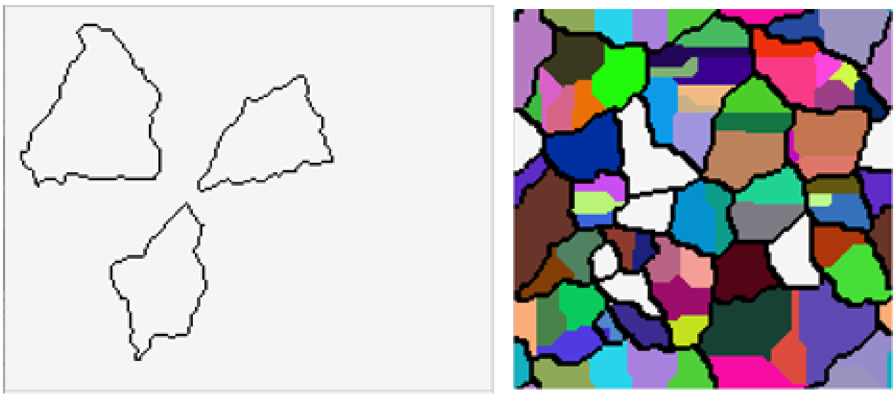

Figure 5. Boundaries of only selected grains and of whole microstructure with next grain growth

The percent of boundaries is shown in top-right corner of “Boundaries” section (Figure 6).

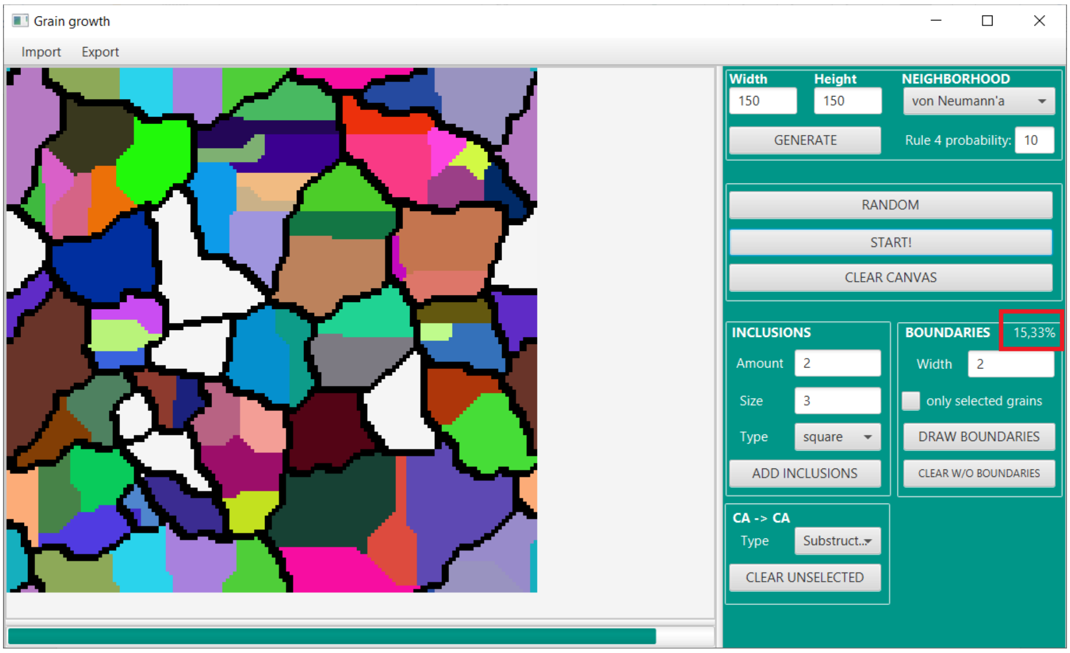

Figure 6. Percent of boundaries in microstructure

3. Technology

   Following technologies was used in project:

   - Java

     Java was chosen because it is object-oriented language, which allows you to create modular programs and reusable code.

     Java is platform-independent, so its ability to move easily from one computer system to another is one of the main advantages.

   - JavaFX

     The biggest advantage of this solution is the ability to create GUI in the MVC Model-View-Controller model. This ensures the purity of the code and the ability to divide the work into creating the view and the controller in which the action is created by associating it with the controls using annotations. Another important advantage of JavaFX is the ability to use CSS files to create a view. There is also a convenient SceneBuilder *drag and drop* tool for generating XML.

4. Microstructures comparison

Figure 7 shows a microstructure of the hot-forged 18CrNiMo7-6 steel. It is possible to see layouts of bigger and smaller grains as well as some of inclusions both on generated and real microstructures.

To achieve effect, following steps were performed:

- Grain growth with Moore neighborhood type
- Selection layouts of grains
- Clearing of unselected grains
- Second grain growth with Moore neighborhood type
- Adding inclusions

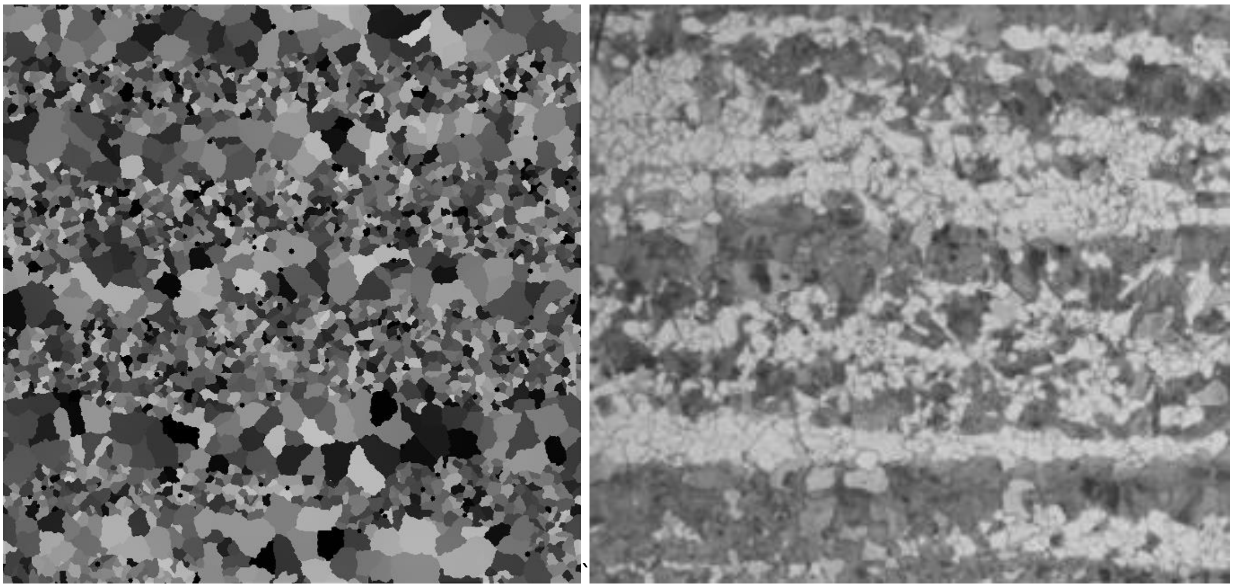

Figure 7. Generated and real microstructures of hot forged steel

Figure 8 shows stainless steel. Boundaries are more straight grain boundaries. Grains looks like plates. In some area grains are very long and thick and together with other grains create layouts.

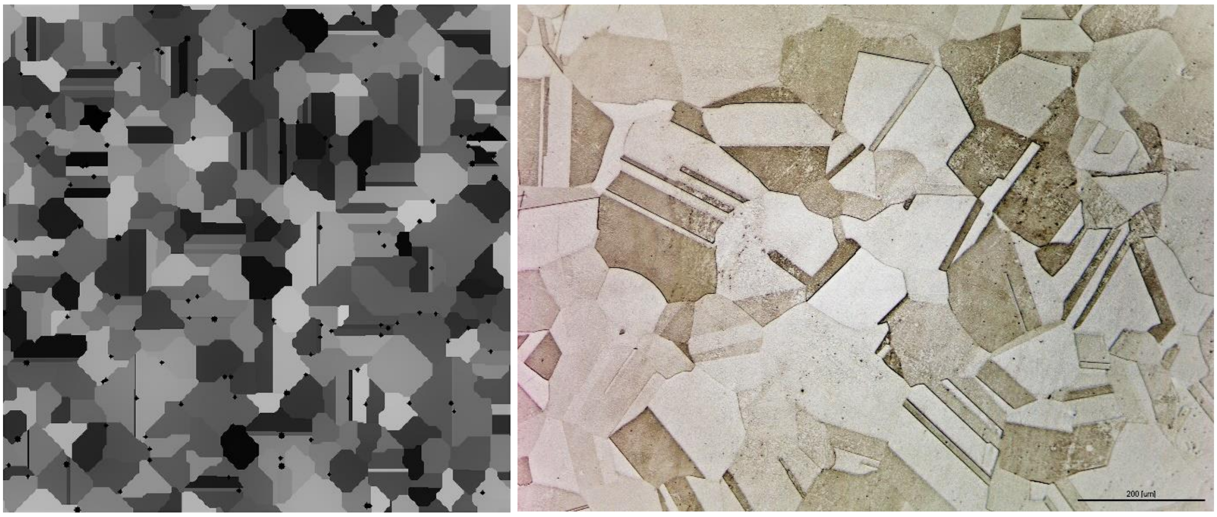

Figure 8. Generated and real microstructures of stainless steel

To achieve effect, following steps were performed:

- Grain growth with von Neuman neighborhood type
- Selection of some grains
- Clearing of unselected grains
- Choosing of nucleons with mouse click in order to create layouts of grains inside previous bigger grain
- Adding inclusions

Sources:

1. https://www.researchgate.net/figure/Microstructure-of-the-hot-forged-18CrNiMo7-6-steel-6_fig2_241698682
2. https://fr.wikipedia.org/wiki/M%C3%A9tallographie#/media/Fichier:Microstructure_of_a_stainless_steel.jpg