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Multiscale Modelling

Report 1 - CA-based grain growth simulation

Project description

Presented below user interface contains all updates performed during the whole process
of system creation. Project was created to simulate grain growth The application provides following features:
-simple grain growth algorithm with four neighborhood method
- import/export of generated microstructure from/to TXT files and from/to bitmaps
- two type microstructure generation (dual-phase and substructure)

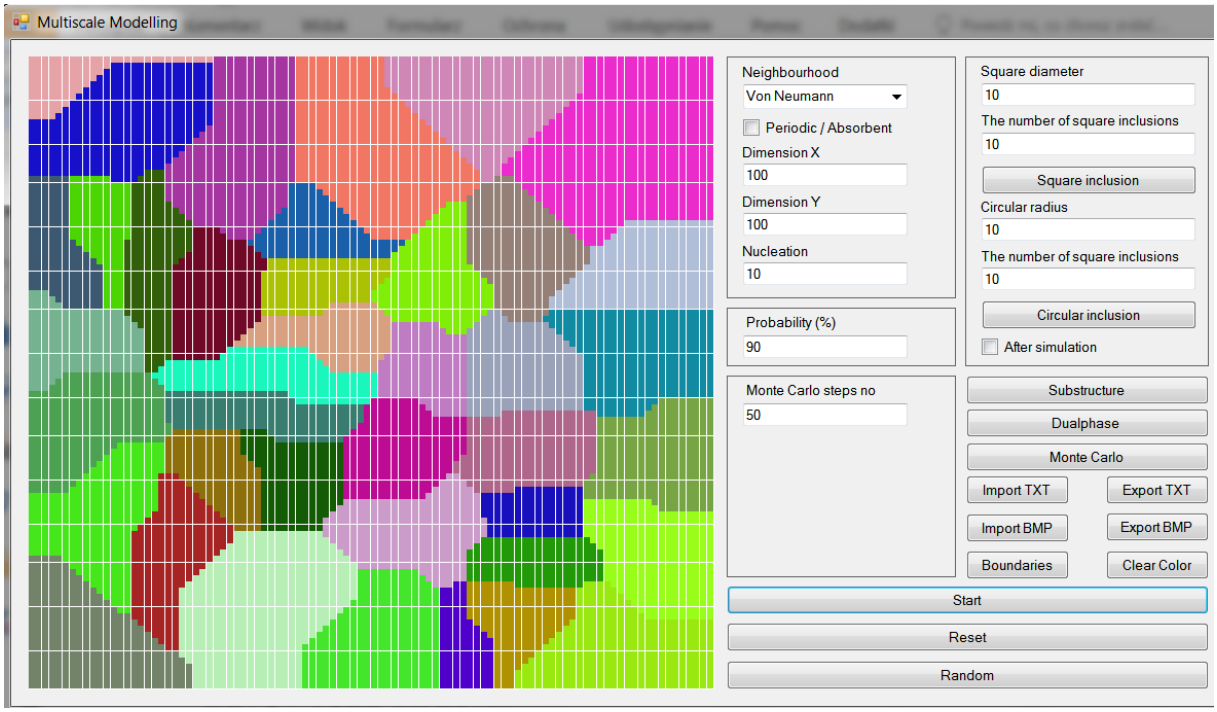
- inclusions generation before and after the simulation with two type of this (circular and square)
- draw boundaries around grains

- presented microstructure without colors of grains

Technology

For the purpose of building this application the C# programming language (.Net Technology) was used. The user interface was created based on a Win Forms. This technology allows to easily create interactive user interface and implement required function.

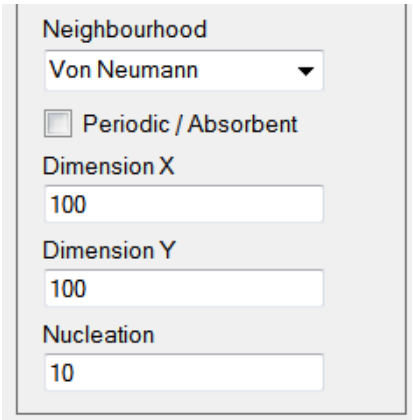
User interface



Img 1: Main app view

This image presented the main app view. On the right we can see all parameter what we set to generate microsubstructure and possibility to save/load to bmp and text format. On the left we have visualization us simulation.

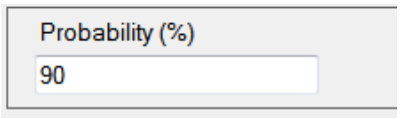
User interface - application configuration



Img 2: paramaters view in main columns

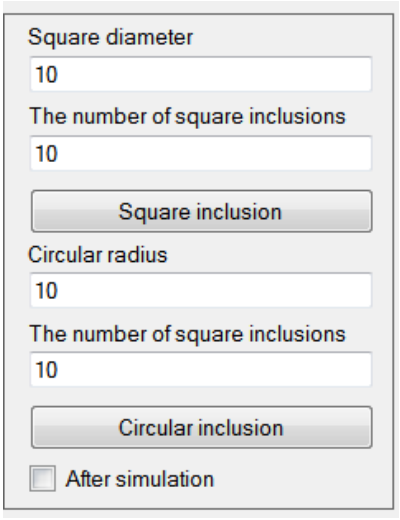
First user set neighbourhood type. This parameter defines the change in shape of each grain and describes the slosest neighbors of a particular cell. Next user can set

Periodic / Absorbent options. This parameter defines whether grains can grows without or with borders. Dimension tell about size window visualization of simulation in pixels/cells proportion . Number nucleation defines how many nucleations we can observe in the resulted structure.



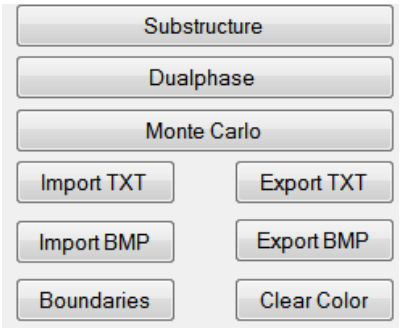
Img 3: Proballity columns for Moore Ext rule four view.

This parameter used in rule four Moore Ext method and tell about probality chance to change the particular cell.



Img 4: Inclusions column view.

In inclusions column user can generate
inclusions, set size, amount and their type (square
or circular. User can set when inclusion must be added before or after simulation inclusions.

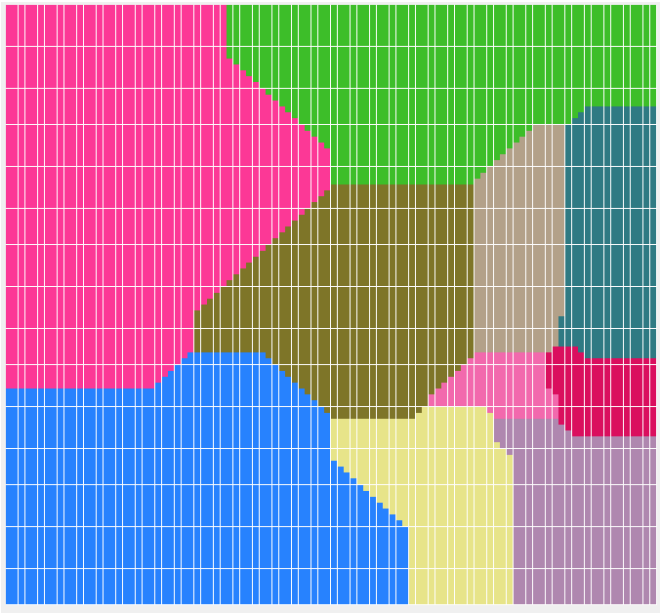


Img 5: After generation microstructure column view.

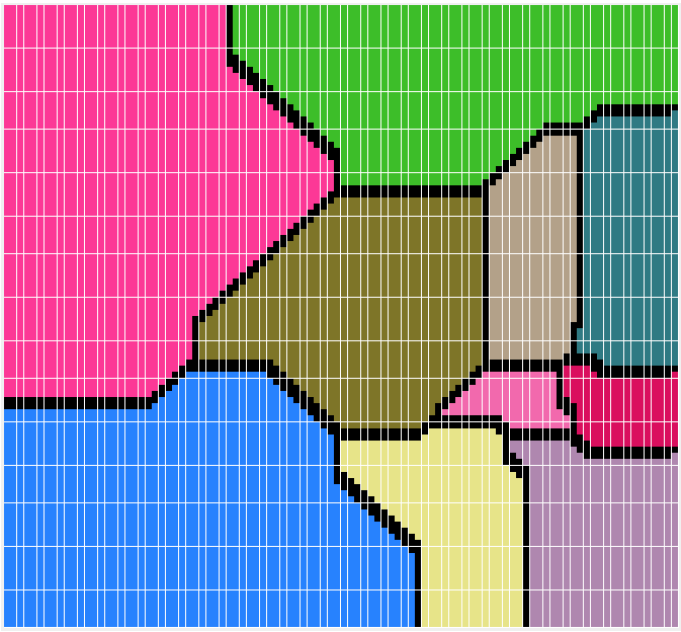
This column is about functions what we can generate after simulation. substructure makes that grains retain their IDs and color, but cannot grow.
Dual phase makes that grains cannot grow and have common ID and color assigned. After pressing *Boundaries* button on the current structure user can see black
lines of the required size which represents the grains boundaries.

After used this option user can press the *Clear color* button which will result with the white board only containing grains boundaries.

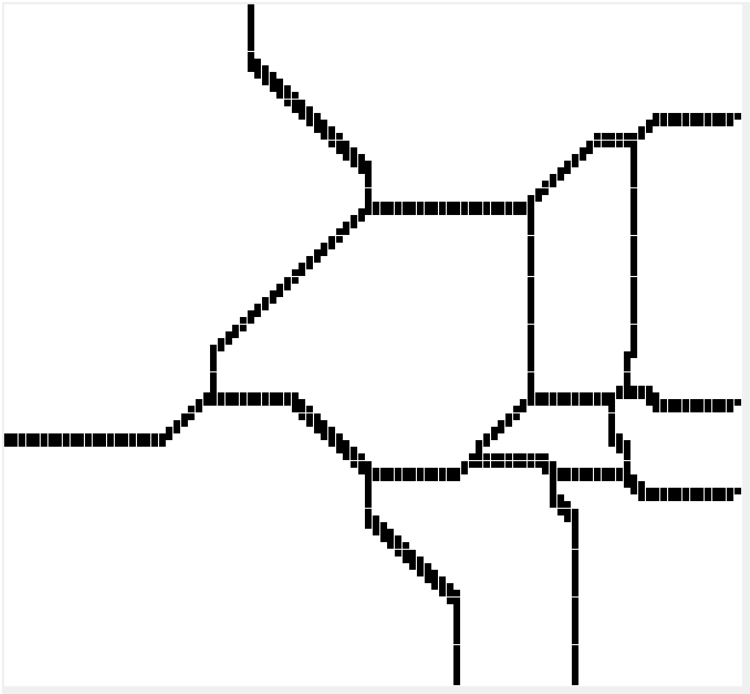
Below there is exemplary microstructure generated by application with specify parameters configuration :



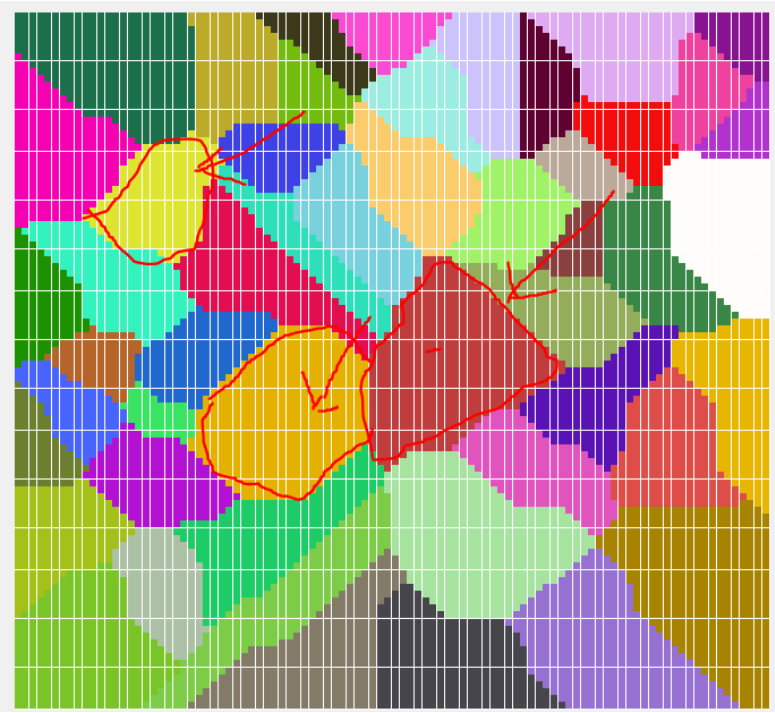
Img 6: Generated microstructure (Number of grains: 10, Type of neighborhood:Von Neumann)



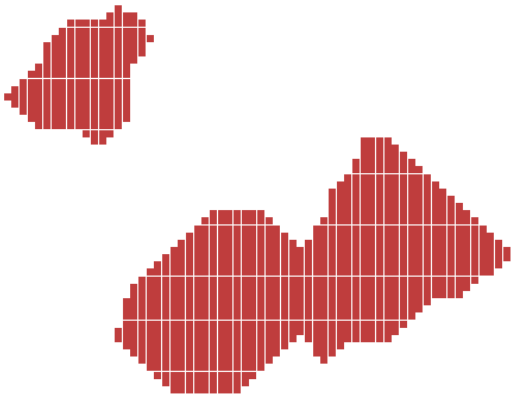
Img 7: Microstructure from img 6 with boundaries



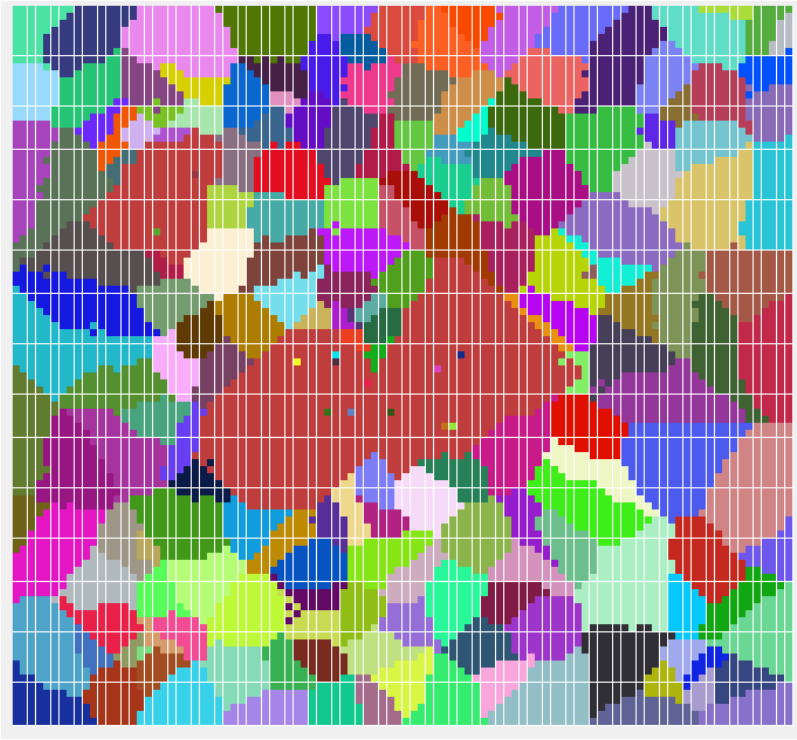
Img 8: Microstructure from img 6 with boundaries and after set functions clear color.



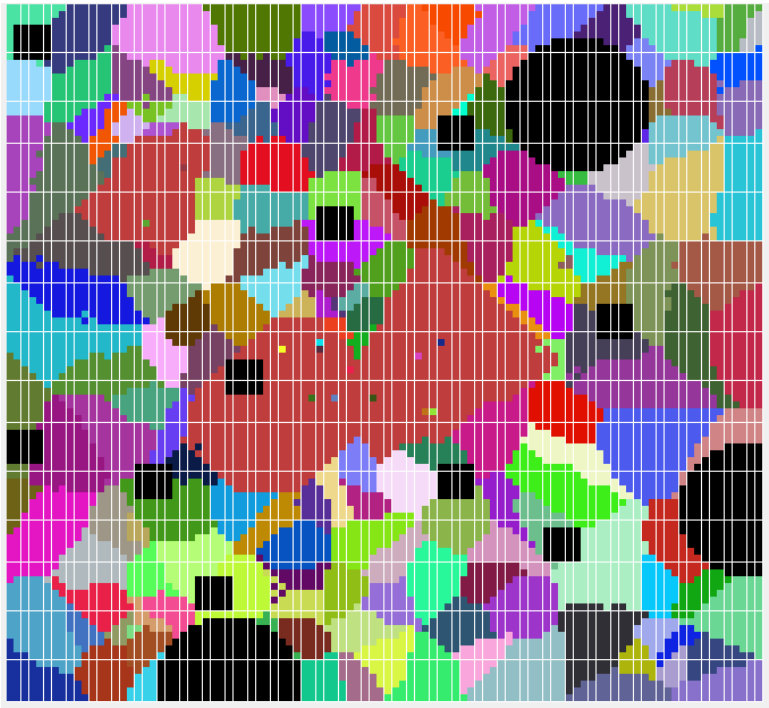
Img 9: Generated microstructure (Number of grains: 50, Type of neighborhood: Moore) and before Dual Phase for three element.



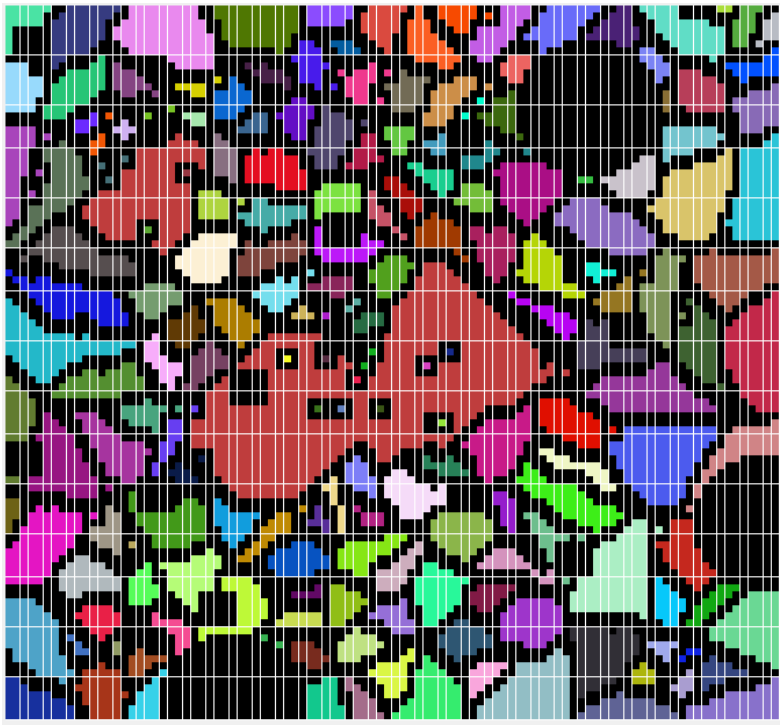
Img 10: After DualPhase



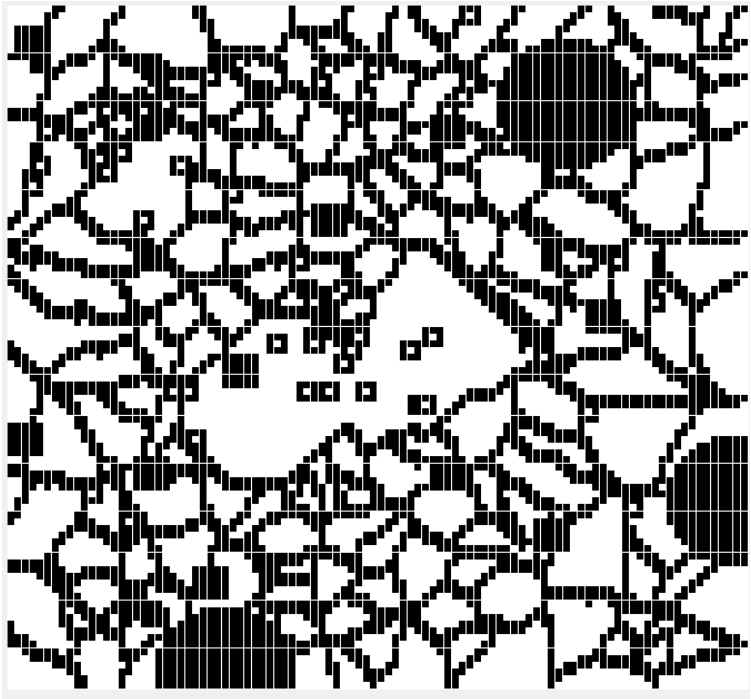
Img 11: Generate microstructure the use of dualphase grains from earlier microstructure.



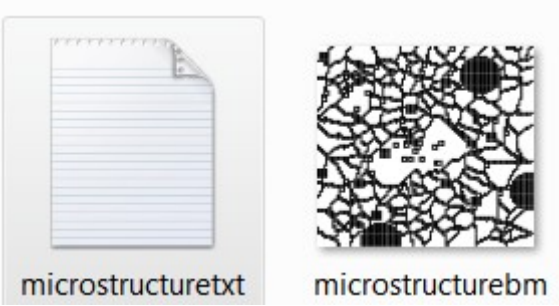
Img 12: Microstructure from img 11 with ten square inclusions of five diameter each and three circular inclusion of ten diameter each.



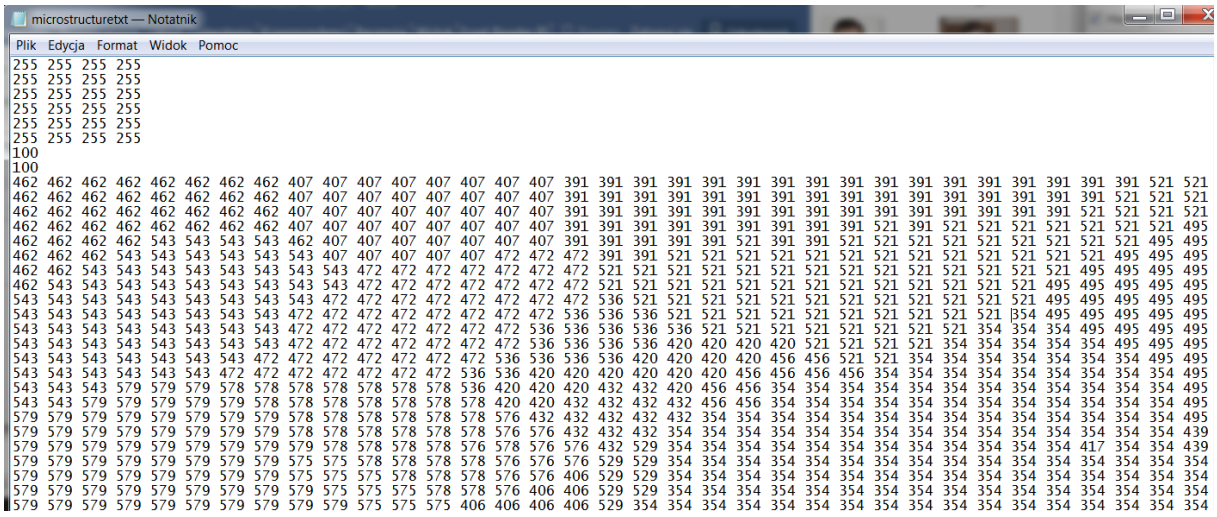
Img 13: Microstructure from img 12 with boundaries.



Img 14: Microstructure from img 12 with boundaries after set functions clear color.



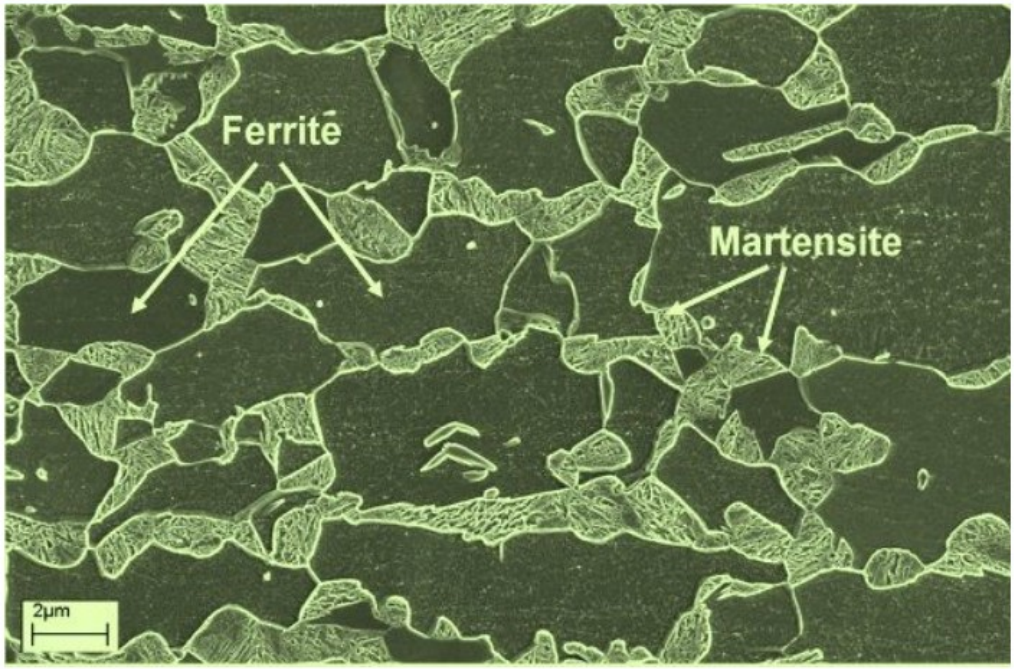
Img 15a: Microstructure from img 12 after export to txt and bmp format.



Img 15: Microstructure from img 12 after export to txt and bmp format.

Microstructure comparison

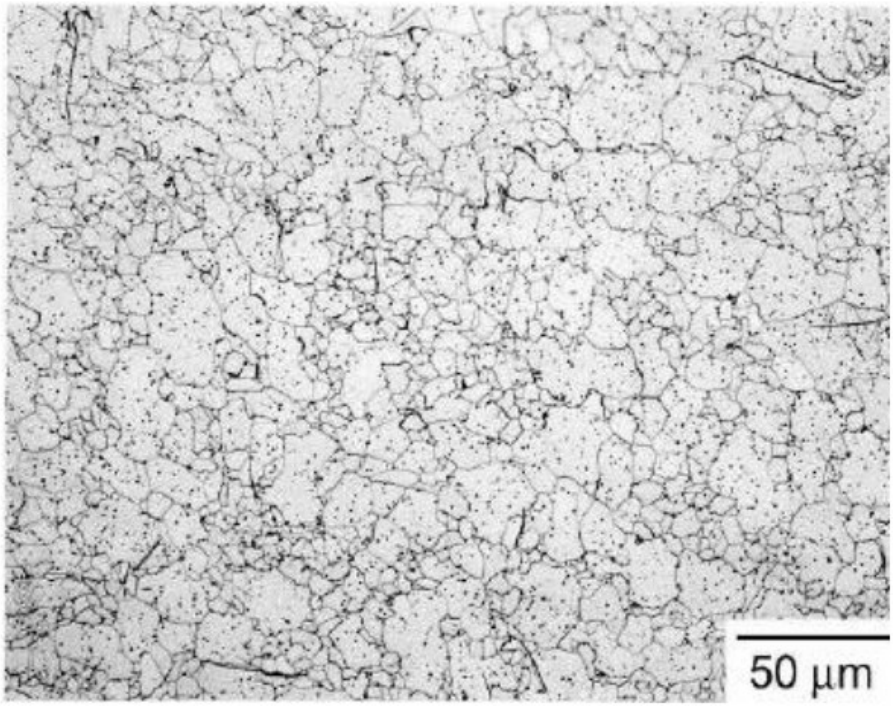
I took two microstructures to compare them. First microstructure comes from my application, second microstructure is dual phase steel. Both of them are shown below.



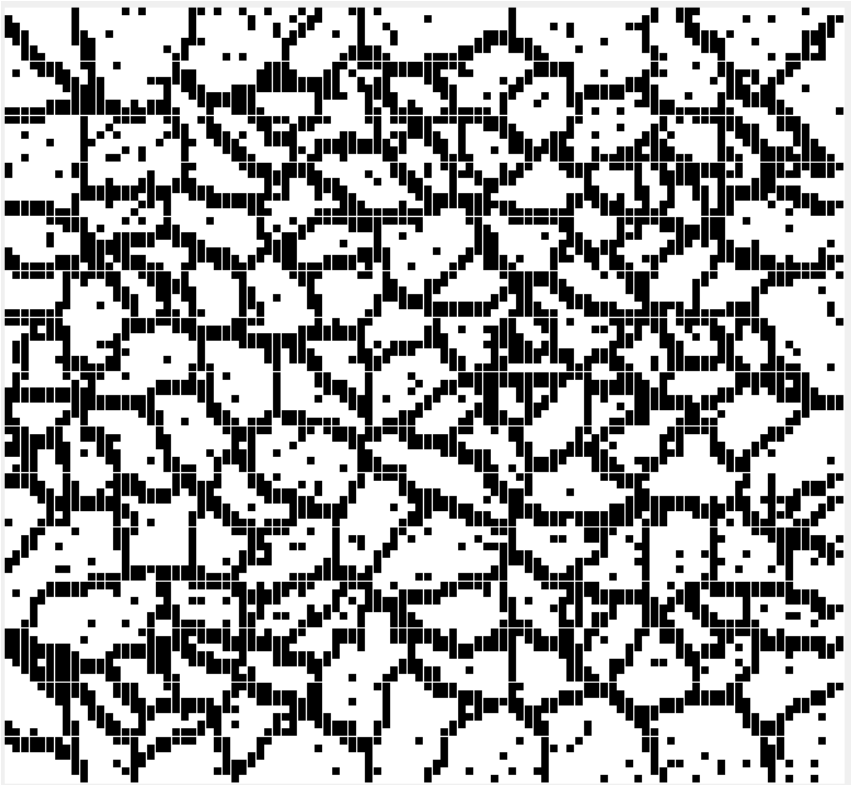
Img 16: dual phase steel with ferrite grains surrounded with martensite.

[Source: Ispat Guruwebsite]

Img 17: Similar microstructure generated with the application.



Img 18: Figure 25 – CP titanium



Img 19: Similar microstructure generated with the application.

Conclusions

-In c# technology simulate generate very quickly.

- When microstructure don’t have similar distribution grains on all area projection basic on image its very hard for satisfy result.

- When microstructure have similar distribution grains on all area projection basic on image can be close to reality.

- For education this project can understand many aspect in creation microstructure. How each factor affect on final result.

- In 17 image martensite going be easily created thanks for dualphase option. But in commercial project custom set without automatic system – (artificially intelligent) its very slow and no precise.

- Inclusion and bounderies give us very clear microstructure.

- Combination with numbers of grains and neibourhood method give us preview how microstructure can create .

https://www.researchgate.net/figure/Initial-microstructure-of-CP-titanium-longitudinal-direction_fig1_267406005,
22.11.2018