The Spread of epidemics

Author: Marcin Jędrzejczyk

Supervisor: Dr hab. inż. Jarosław Wąs

Epidemic

„A widespread occurrence of an infectious disease in a community at a particular time.”[Oxford Dictionary Online]

Examples:

- 1346-1353 -„Black death”(bubonic plague) in Europe
- 1918-1919 – „Spanish Flu”

World War 1 casualities – 22 – 24 million

Spanish Flu casualities – 40 – 50 million (current estimates say 50 – 100 million)

Reasons for epidemics simulations

- To better understand how epidemic behave in time
- To predict how quickly it spreads depending on many factors (recovery rate, vaccination rate, virulence of epidemic, movement factor)
- To picture how vaccination affect disease spreading and confirms that herd immunity is important

Models

- SIR
- SIS
- SEIR
- SEIRS

- S – suspectible
- I – infected
- R – recovered
- E – exposed

$$I_{ij}^{t} = (1-\epsilon)\cdot I_{ij}^{t-1} + v\cdot S_{ij}^{t-1}\cdot I_{ij}^{t-1} + S_{ij}^{t-1}\cdot \sum_{\alpha,\beta\in V^{*}} \frac{N_{i+\alpha,j+\beta}}{N_{ij}}\cdot \mu_{\alpha\beta}^{i,j}\cdot I_{i+\alpha,j+\beta}^{t-1}$$

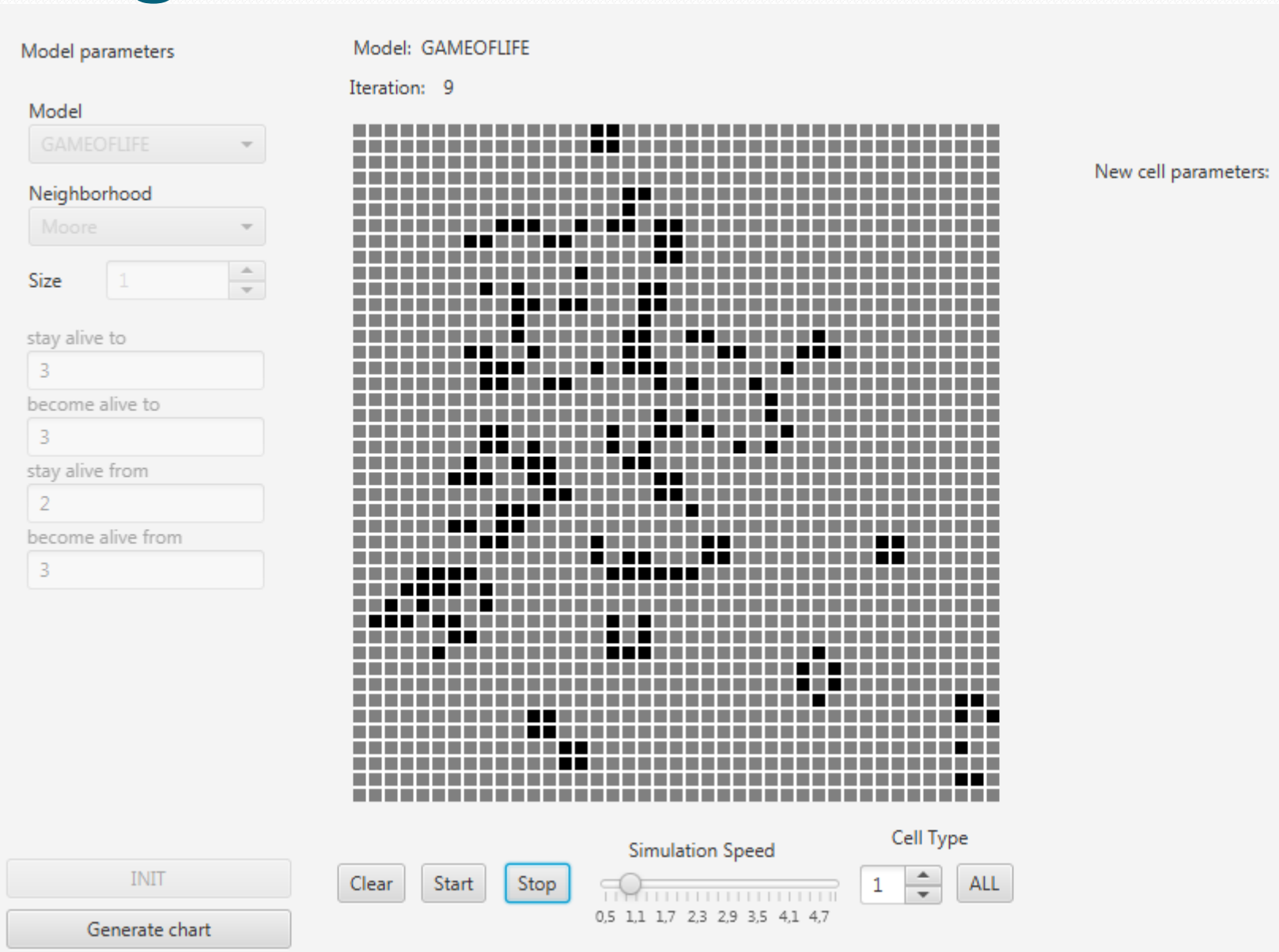
$$S_{ij}^{t} = S_{ij}^{t-1} - \omega\cdot S_{ij}^{t-1} - v\cdot S_{ij}^{t-1}\cdot I_{ij}^{t-1} - S_{ij}^{t-1}\cdot \sum_{\alpha,\beta\in V^{*}} \frac{N_{i+\alpha,j+\beta}}{N_{ij}}\cdot \mu_{\alpha\beta}^{i,j}\cdot I_{i+\alpha,j+\beta}^{t-1}$$

$$R_{ij}^{t} = R_{ij}^{t-1} + \epsilon\cdot I_{ij}^{t-1} + \omega\cdot S_{ij}^{t-1}$$

where:

$$\mu_{\alpha\beta}^{(i,j)} = c_{\alpha\beta}^{(i,j)}\cdot m_{\alpha\beta}^{(i,j)}\cdot v$$

Program


Model parameters
Model: GAMEOFLIFE
Iteration: 9
Model
GAMEOFLIFE
Neighborhood
Moore
Size
1
stay alive to
3
become alive to
3
stay alive from
2
become alive from
3
New cell parameters:
INIT
Generate chart
Clear
Start
Stop
Simulation Speed
0,5 1,1 1,7 2,3 2,9 3,5 4,1 4,7
Cell Type
1
ALL

Model parameters

Model

SIR

Neighborhood

Moore

Size 1

recovery rate

0.05

virulence of the epidemic

0.6

vaccination rate

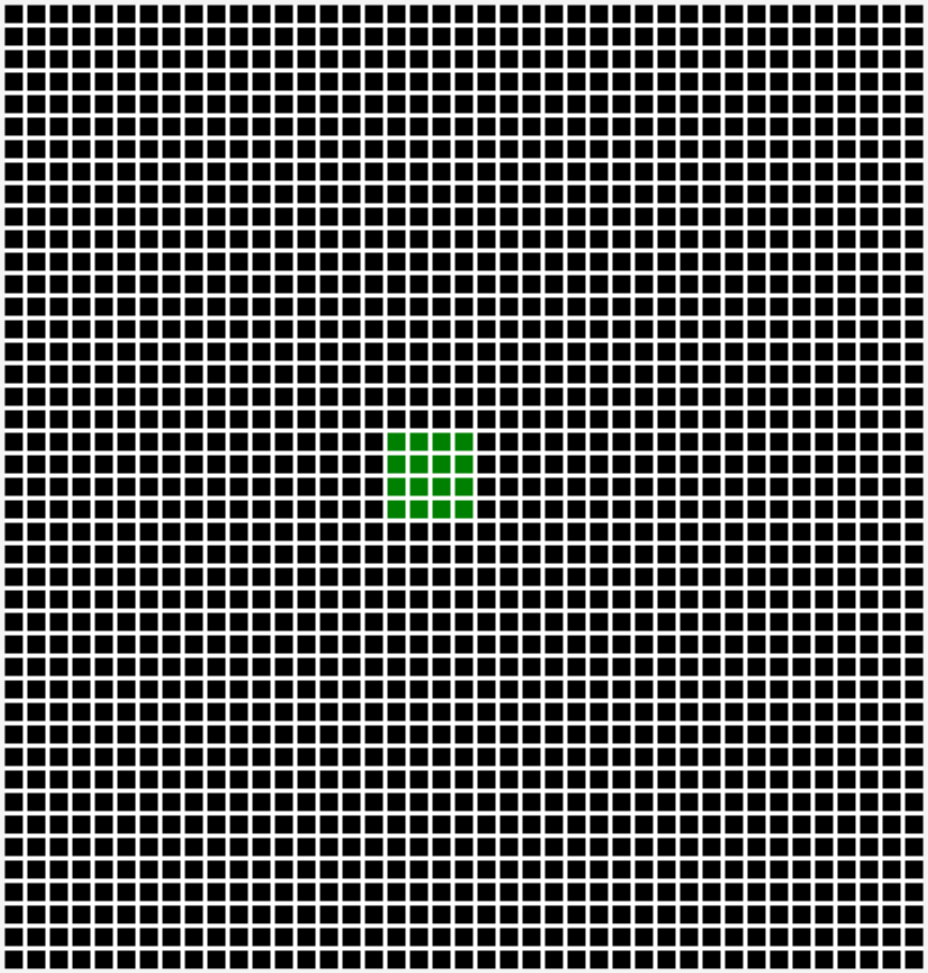
0.1

INIT

Generate chart

Model: SIR

Iteration: 0



New cell parameters:

connection factor

0.6

cell population

100

movement factor

0.6

Clear Start Stop

Simulation Speed

0,5 1,1 1,7 2,3 2,9 3,5 4,1 4,7

Cell Type

2

ALL

Model parameters

Model: SIR

Iteration: 5

Model

SIR

Neighborhood

Moore

Size 1

recovery rate

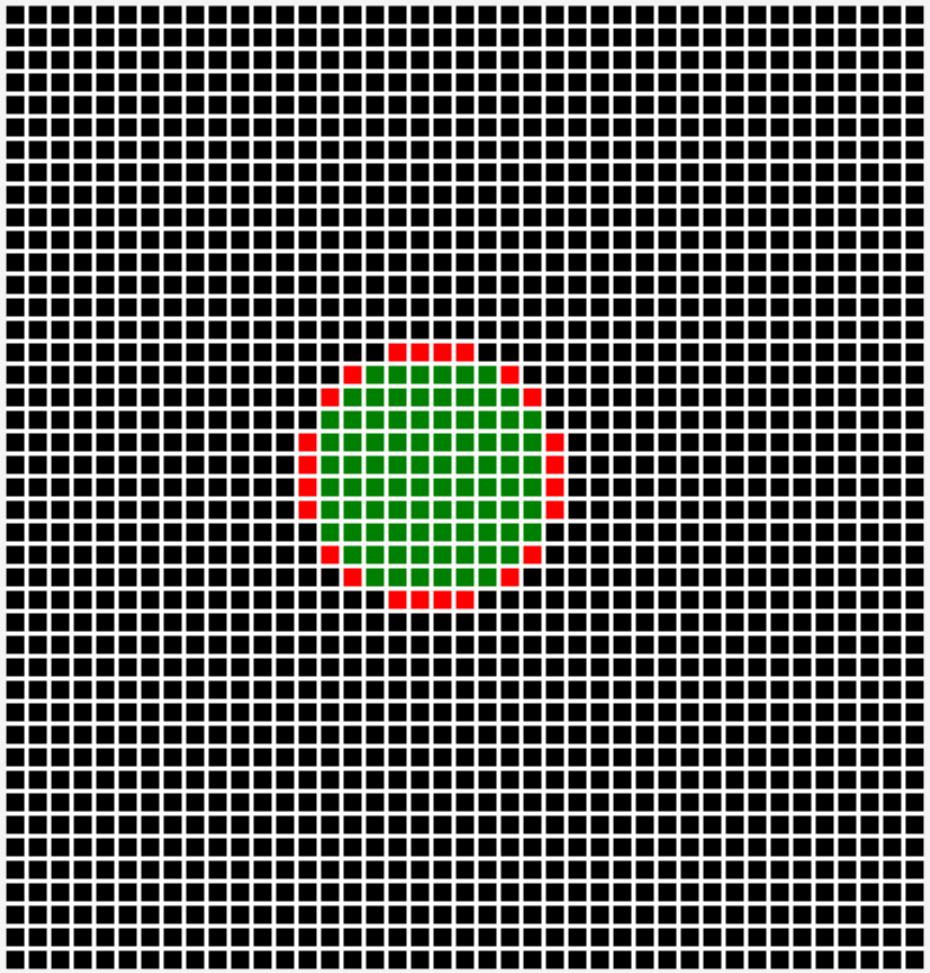
0.05

virulence of the epidemic

0.6

vaccination rate

0.1



New cell parameters:

connection factor

0.6

cell population

100

movement factor

0.6

INIT

Generate chart

Clear Start Stop

Simulation Speed

0,5 1,1 1,7 2,3 2,9 3,5 4,1 4,7

Cell Type

2 ALL

Model parameters

Model

SIR

Neighborhood

Moore

Size 1

recovery rate

0.05

virulence of the epidemic

0.6

vaccination rate

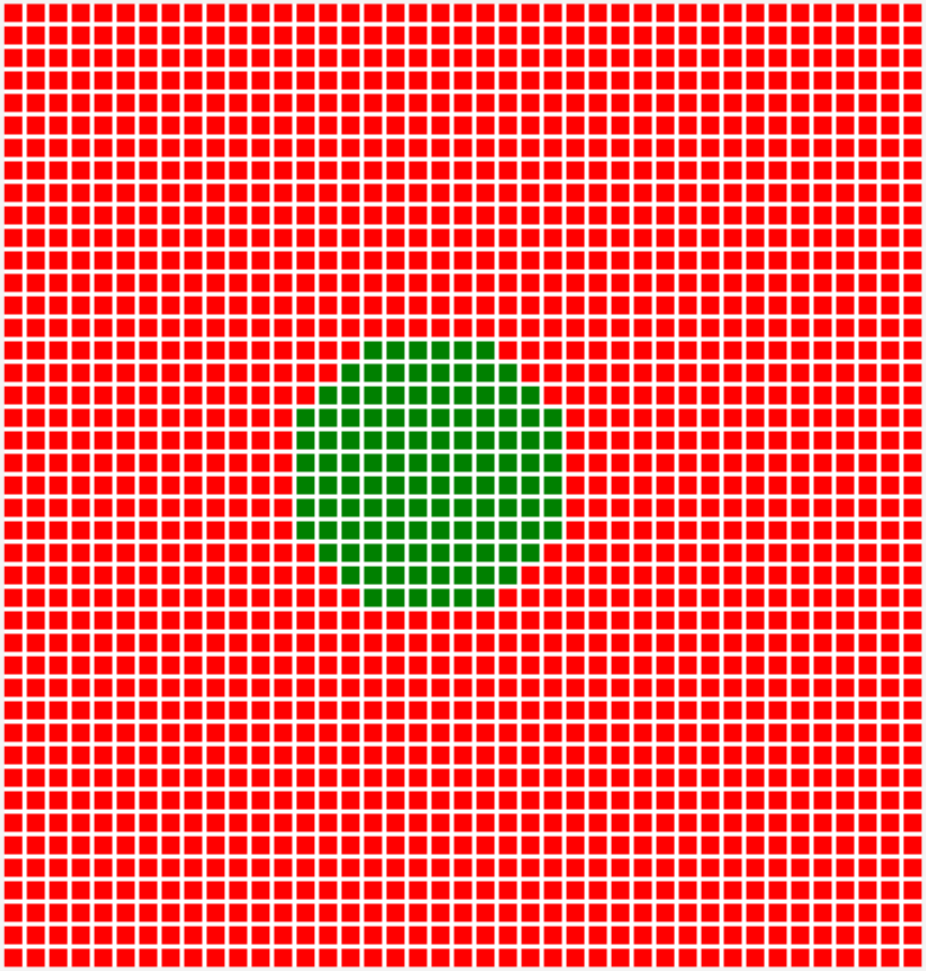
0.1

INIT

Generate chart

Model: SIR

Iteration: 7



New cell parameters:

connection factor

0.6

cell population

100

movement factor

0.6

Clear Start Stop

Simulation Speed

0,5 1,1 1,7 2,3 2,9 3,5 4,1 4,7

Cell Type

2 ALL

Model parameters

Model

SIR

Neighborhood

Moore

Size 1

recovery rate

0.05

virulence of the epidemic

0.6

vaccination rate

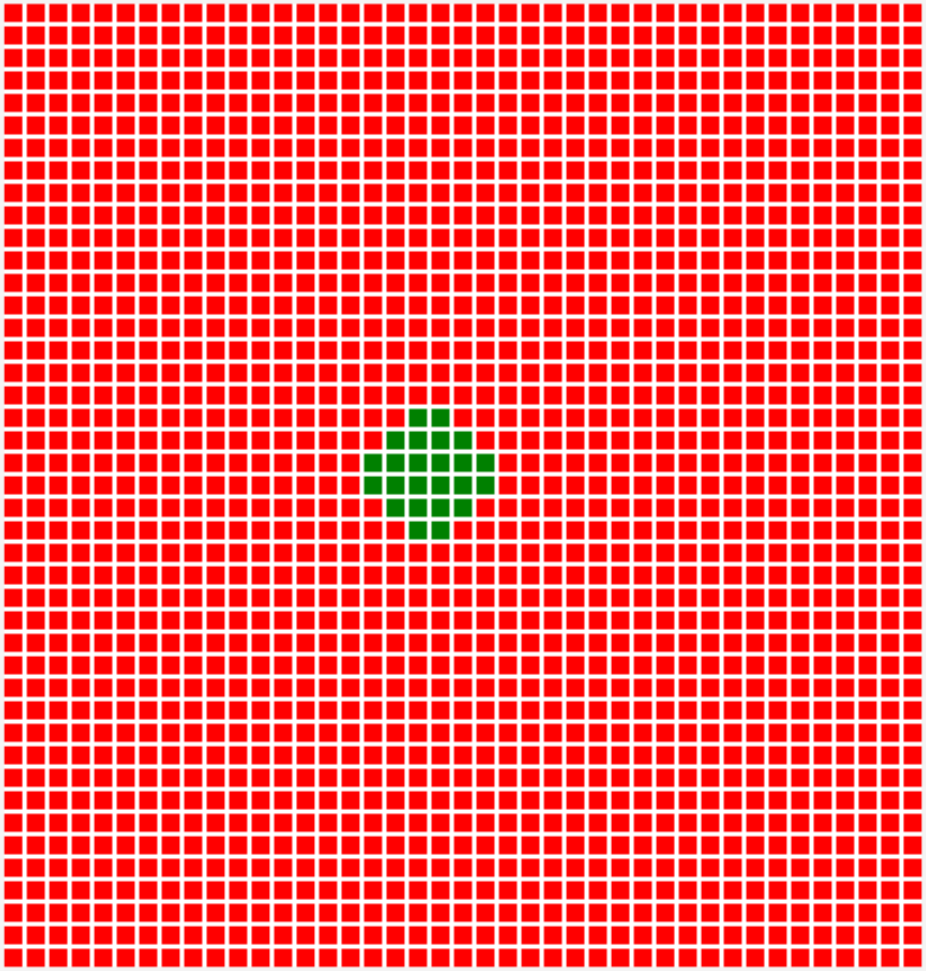
0.1

INIT

Generate chart

Model: SIR

Iteration: 12



Clear Start Stop

Simulation Speed

0,5 1,1 1,7 2,3 2,9 3,5 4,1 4,7

Cell Type

2 ALL

New cell parameters:

connection factor

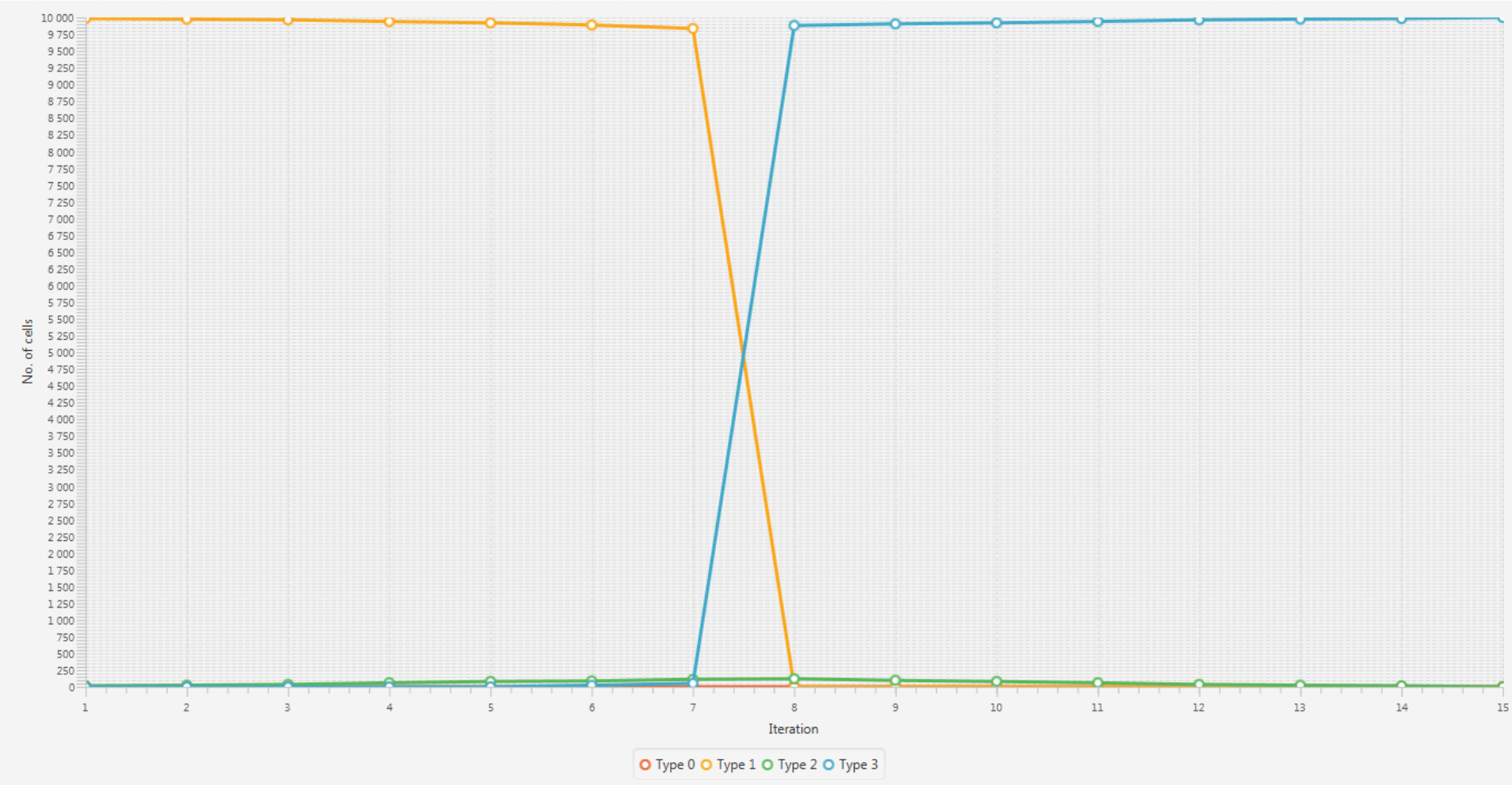
0.6

cell population

100

movement factor

0.6


No. of cells
10 000
9 750
9 500
9 250
9 000
8 750
8 500
8 250
8 000
7 750
7 500
7 250
7 000
6 750
6 500
6 250
6 000
5 750
5 500
5 250
5 000
4 750
4 500
4 250
4 000
3 750
3 500
3 250
3 000
2 750
2 500
2 250
2 000
1 750
1 500
1 250
1 000
750
500
250
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Iteration
Type 0
Type 1
Type 2
Type 3

THANK YOU FOR YOUR ATTENTION