Opdracht 4 Natural Computing

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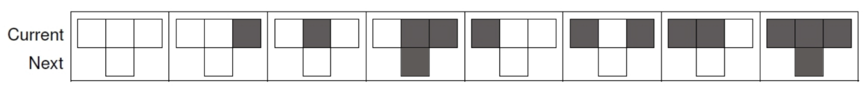


Figure 1: Rule set 1

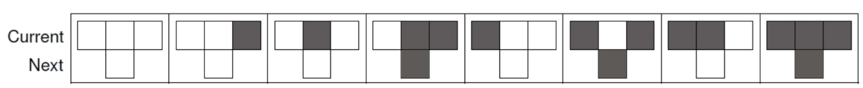


Figure 2: Rule set 2

2

For the described property to be present in $rule30$ - with two states C and D that only differ in one position i, and after one update the position $i+1$ in both resulting states differ - there are only so many cells that influence the color of the cell at $i+1$ in the resulting state.

In fact, it's only the cell itself and it's neighbours. The cells $i-1$ and lower and $i+3$ are higher do not influence $i+1$. This allows us to simply enumerate the possible combinations of 3 (relevant) cells with $i+1$ in the center, and i being different in the original states, and then compare the cell $i+1$ after one update in both patterns.

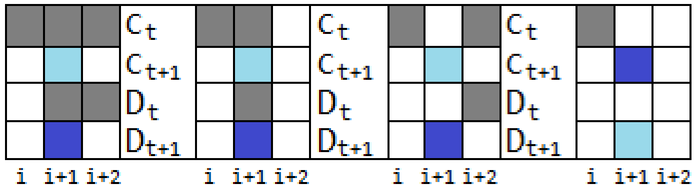


Figure 3

Note that in the above figure 3 only the cell at i+1 was computed in C_{t+1} and D_{t+1}, where light blue is 0 or empty, and dark blue is 1 or black. One can see that in all of these configuration C and D the cell at $i+1$ indeed differs after one update.

3

Four shapes exist, for each of the colored cells there are exactly two neighbours, which means the cell stays alive. As there are no more than 3 or less than 2 neighbors, these cells don't 'die'.

None of the empty cells inside and around the shapes have exactly 3 colored neighbours (which is the requirement of new life), which means no new cells get colored.

4

4.1 Relationship average fitness of individuals as a function of mutation rate

Hypothesis A greater mutation rate leads to a faster increasing average fitness of individuals.

Null hypothesis A greater mutation rate does not lead to a faster increasing average fitness of individuals.

Motivation The fitness values are determined by the computation of complex functions, and we think an organism can get stuck in some local optima where it is unlikely that it will develop a more complex function. An increased mutation rate may increase the probability of an organism making such a leap.

4.2 Relationship of population size as a function of mutation rate

Hypothesis A greater mutation rate leads to fluctuations in population size.

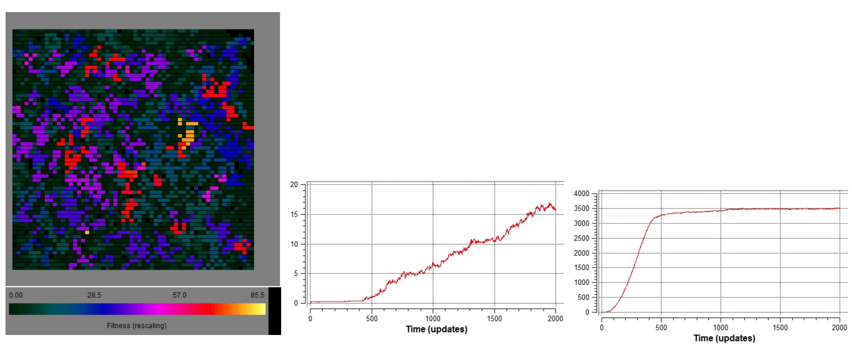
Null hypothesis A greater mutation rate has no effect on the population size.

Motivation With a high mutation rate, it is more likely that a 'good' mutation will occur, resulting in an organism with a high fitness that can reproduce more, creating fit offspring that also reproduces rapidly. At the same time, it is more likely that a 'bad' mutation can occur, resulting in weak offspring that will die off. Thus populations with a high mutation rate will be less stable compared to populations with a low mutation rate.

5 Observations (Data)

Mutation rate 1%

1. Avg. Fitness at update 2000: 15.7
2. Pop. size at update 2000: 3524
3. Graph of avg. fitness as function of update: see figure 4b
4. Picture of your plate: see figure 4a
5. Description of your plate: There a a few islands of individuals with a high fitness. These islands seem to have developed independently (as they are not connected).



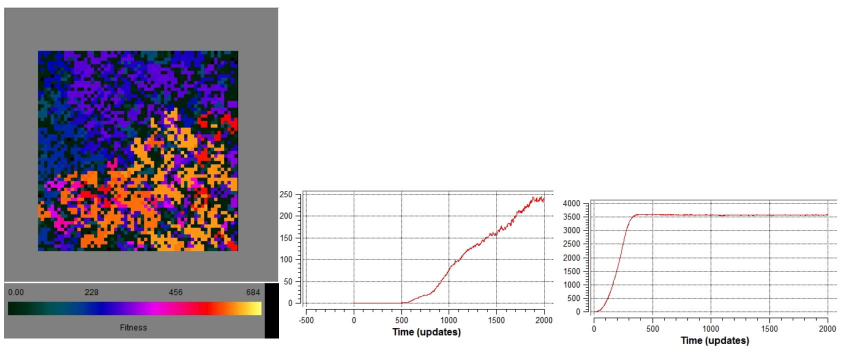
(a) Petri dish (b) Average fitness (c) Population size

Figure 4: Mutation rate 1%

Mutation rate 5%

1. Avg. Fitness at update 2000: 242
2. Pop. size at update 2000: 3576

3. Graph of avg. fitness as function of update: see figure 5b
4. Picture of your plate: see figure 5a
5. Description of your plate: One side of the petri dish is populated by individuals with a high fitness. It is likely that the fitness increases on that side, spreading to the other side of the dish.

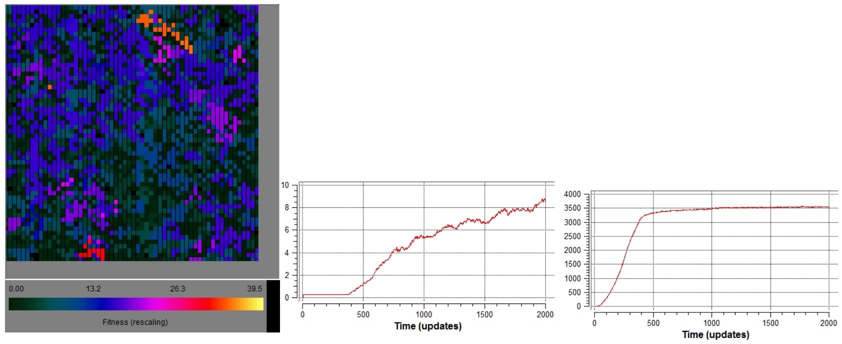


(a) Petri dish (b) Average fitness (c) Population size

Figure 5: Mutation rate 5%

Mutation rate 10%

1. Avg. Fitness at update 2000: 8.58
2. Pop. size at update 2000: 3565
3. Graph of avg. fitness as function of update: see figure 6b
4. Picture of your plate: see figure 6a
5. Description of your plate: There is little diversity in fitness, with only two islands of individuals with a high fitness on the dish which really distinguish themselves with the rest of the dish.

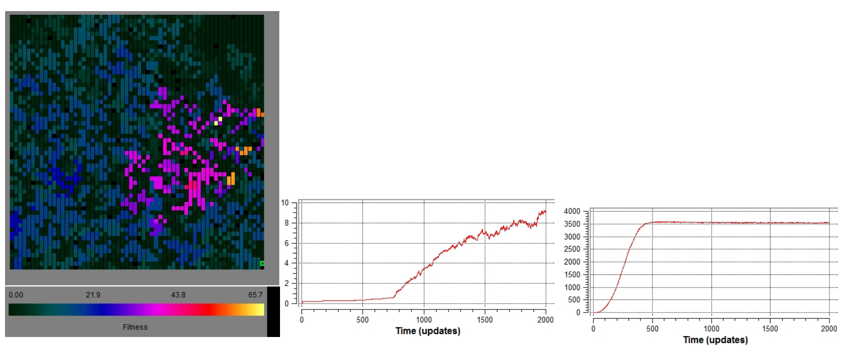


(a) Petri dish (b) Average fitness (c) Population size

Figure 6: Mutation rate 10%

Mutation rate 15%

1. Avg. Fitness at update 2000: 9.1
2. Pop. size at update 2000: 3546
3. Graph of avg. fitness as function of update: see figure 7b
4. Picture of your plate: see figure 7a
5. Description of your plate: The petri dish seems fairly well distributed, except for one big island with above average fitness.



(a) Petri dish (b) Average fitness (c) Population size

Figure 7: Mutation rate 15%

5.1 Discussion

The first hypothesis was *A greater mutation rate leads to a faster increasing average fitness of individuals.* This was not supported by our data, as the 5%

mutation rate seemed to achieve the higher average fitness. It could be that there is some optimal mutation rate here, or that such a high fitness value simply developed by pure chance and that a single simulation is not enough to conclude anything about the relationship between mutation rate and average population fitness value.

The second hypothesis was *A greater mutation rate leads to fluctuations in population size.* This was not supported by our findings: In every case the population keeps increasing steadily to a size of 3550 individuals and stabilizes there. The restriction on population size in this case is the size of the petri dish (which is 60x60 = 3600). As soon as an individual dies off, it is immediately replaced by another due to overpopulation.