A directly Programmed Implementation of ARGESIM Comparisons C17 “SIR-type Epidemic” using MATLAB

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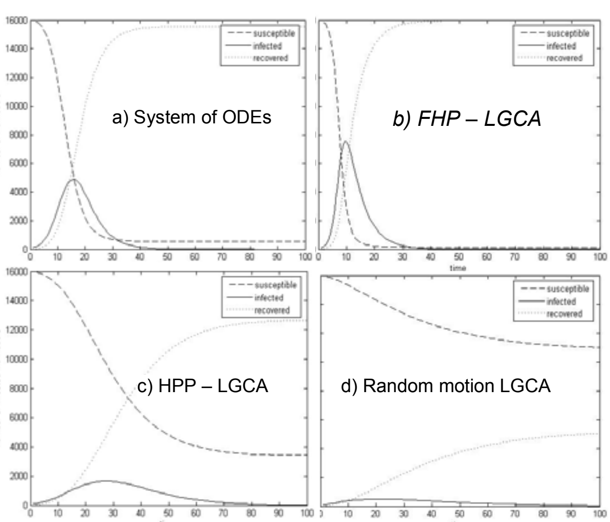
Simulator. MATLAB is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numerical computation.

Model. The numerical solution of the given system of ODEs is not a problem for modern computer algebra systems or numerical libraries for other high-level programming languages. To implement the LGCA, a straight-forward approach has been chosen. Simple matrices contain the single cells whereas one cell is represented through 6 elements in the matrix for the FHP model and 4 elements for the HPP model respectively. Therefore, every element of the matrix `lgm(i,j)` can hold 4 different states: 0 if there is no particle at the corresponding position in the cell, 1 for susceptible, 2 for infected and 3 for recovered individuals. Propagation and Collision rules must be implemented once for a cell of the LGCA and hence for 6 (or 4) elements of the corresponding matrix, always being aware of periodic boundary conditions.

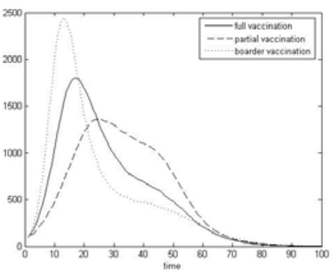
Task a - CA and ODE Simulations. To solve the given system of ODEs in MATLAB, an explicit Runge-Kutta formula of order (4,5) has been applied.

```
g = inline('[- 0.6/10000*y(1)*y(2);
0.6/10000*y(1)*y(2) - 0.2*y(2); 0.2*y(2)]',
't', 'y');
[ts,ys] = ode45(g,[1,150],[16000; 100; 0]);
plot(ts,ys)
```

The results are of similar qualitative nature but differ quantitatively for the different approaches:

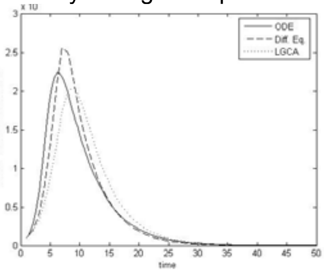


The reason for this is the fact that infected individuals form spatial groupings in the LGCA and thus slow down the speed of the epidemic. When using the same parameters of infection rate r and recovery rate a, one must be aware that epidemic spread is much slower in the HPP model. Infection occurs within one cell of the automaton and so the infection-probability is much lower as no more than 4 individuals can “meet” in one cell. When we introduce total random motion in a HPP-LGCA, the speed of the epidemic slows down even more since nearly no mixture of individuals takes place.



Task b – Vaccination Strategies in CAs. Different vaccination strategies can easily be introduced in the LGCA model by defining vaccination areas and initially setting a particle state of 3 for the number of individuals to be vaccinated. Vaccinating individuals at the borders of the epidemic area leads to a rapid outbreak in the epidemic area but as infected individuals initially remain isolated, the duration of the epidemic is shorter compared to other strategies. Homogeneous vaccination in the whole domain can only partially slow down epidemic spread whereas specific vaccination in the epidemic area slows down the infection process but due to diffusion of infected individuals can not stop the epidemic from spreading all over the domain.

Task c - ODE vs. CA Solutions. Changing the parameter values and initial conditions to the given values and avoiding inhomogenities by rearranging all individuals after every time step of the automaton results in fairly similar behaviour for the system of ODEs, the difference equations and the FHP-LGCA. The slight differences arise due to a relatively big step size of 1 for the discrete approaches. Dividing the parameters *a* and *r* by 10 basically changes step size of the according explicit Euler method and thus leads to even better concordance. The number of infected individuals remains lower in the LGCA because the solution of the difference equations serves as upper bound for the automaton.



C17 Classification: Directly Programmed Appr.
Simulator: MATLAB 6.5