CSiS: Evaluation project for pedestrian dynamics using NetLogo

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1 Pedestrian Dynamics

In this project, the movement of agents in a one-dimensional corridor of length $L = 52\,\mathrm{m}$ is simulated with **periodic boundary conditions** (see screenshot in Figure 1).[1]

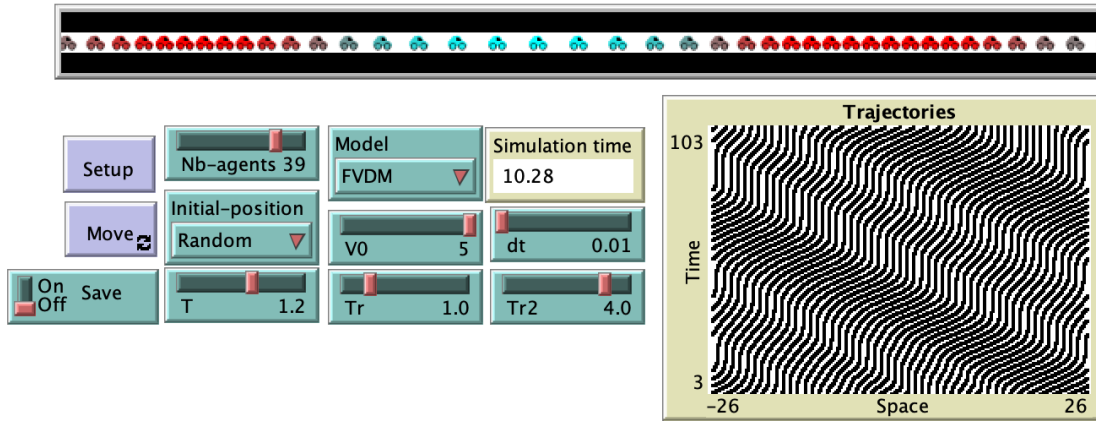The NetLogo-model can be downloaded from https://zenodo.org/record/6540931

Figure 1: Graphical interface of the simulation program
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2 Simulation with NetLogo

Before each simulation, the number of agents **Nb-agents** must be chosen. Then the simulation is initiated with the selected parameters using the **Setup** button. The simulation is started with **Move** and runs until it is activated again. Optionally, it is possible to write the calculated trajectories of the simulation to a csv file by setting **Save** to **On**. The name of the file corresponds to the pattern „N-Nb-agents.csv", where the value **Nb-agents** corresponds to the number of actually simulated agents.

The file of trajectories consists of three columns separated by commas:

- **time**: Time of simulation in seconds

- **id**: Identification number of the agents

- **x**: The position of the agents in meters. Since the simulation is one-dimensional, the values of Y and Z are not output (see Figure 2.).

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[1]To download NetLogo visit this page: https://ccl.northwestern.edu/netlogo/download.shtml

```
# time,id,x
5.01,4,-15.88596046251033
5.01,20,-23.2294866335043
5.01,16,22.10324408424182
5.01,9,-7.483268840221741
5.01,28,16.56471806941885
```

Figure 2: excerpt from a trajectory file. The file starts with a header and contains three comma-separated columns

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3 Measurement of fundamental diagram (FD)

The state of dynamics in the corridor corresponding to Figure 1 can be described by the density ρ and the velocity v, . In this context, the variation of the velocity v as a function of the density ρ, also known as the fundamental diagram, is of particular importance. Furthermore, the equation

$$J = \rho \cdot v, \tag{1}$$

gives an alternative representation of the fundamental diagram, which allows an investigation of the dependence of the flux on the density. In this regard, the capacity of the system is relevant

$$C = \max(J). \tag{2}$$

3.1 Measurement methods

To measure the velocity of an agent i at time t, the following difference formula is used:

$$v_i(t) = \frac{x_i(t + \delta t) - x_i(t)}{\delta t} \quad . \tag{3}$$

Where δt corresponds to the difference of two consecutive time steps. The averaged macroscopic velocity of a system with N agents can be calculated over a period of N_t time steps in a simplified way as follows:

$$v = \frac{1}{N \cdot N_t} \sum_{i=0}^{N} \sum_{t=t_{start}}^{t_{end}} v_i(t) \quad . \tag{4}$$

The global density in the system can be calculated with Equation (5),

$$\rho = \frac{N}{L}, \tag{5}$$

where L is the length of the corridor and N is the number of agents in the system.

3.2 Input parameter

The following parameters should be used to process the project.

- model: FVDM

- desired velocity v_0: $5\,\mathrm{m\,s^{-1}}$

- time interval T: $1.2\,\mathrm{s}$

- relaxation time 1 T_r: 1.0 s

- relaxation time 2 T_{r2}: 4.0 s

- time step Δt: 0.01 s

- agent numbers: $N \in \{2, 3, 4, 5, 10, 15, 20, 25, 35, 45\}$.

3.3 Task

1. For different numbers of agents and parameters according to Section 3.2, simulate the system described above. Make sure that the simulations compute a sufficiently long time period.

   The simulation time of each run must be at least 1 minute (*simulation time* > 60).

   Create a separate file for each agent count, as described in Section 2. Read the data sets with Python and plot the trajectories with the MATPLOTLIB Module analogous to the plot in NETLOGO.

   note: Consider the periodic properties of the system in this as well as in subsequent tasks. An agent that leaves the system re-enters it at the following time step, taking into account its instantaneous velocity as well as the distances to the two adjacent agents.

2. Create, taking into account all data sets, the fundamental diagram (v in dependence of ρ) with Equation (5) and Equation (3). Represent the entire corridor as a macroscopic model in the process. The macroscopic velocity of the system can be determined by Equation (4).

3. Fit the above created data of the fundamental diagram according to the following model function for the fundamental diagram

$$v(\rho) = a \left(1 - \exp \left(-b \left(\frac{1}{\rho} - \frac{1}{c} \right) \right) \right). \tag{6}$$

   The model function contains three parameters (a, b, c), which must be determined using the data points. Plausible value ranges for the three parameters are

   - $a \in [0; 10]$,
   - $b \in \,]0; 10]$,
   - $c \in \,]0; 10]$,

   Interpret the model parameters a and c in terms of a relationship with other quantities in the context of this scenario. Discuss any differences in the numerical values of these pairs of values, if applicable.

4. Plot the fit function of the fundamental plots from the Item 2 based on the model function according to Equation (6) in a common plot.

5. Using Equation (1), calculate the flux from the density and velocity. Convert the fundamental diagrams from the Item 2 into the form $(\rho, \ J)$.

6. From the fundamental diagrams you calculated in Item 5, determine the capacity of the system according to Equation (2) and the associated critical density.