Supplementary Material

1 EXAMPLE OF CONNECTION BETWEEN NETWORK MODEL AND AGENT-BASED MODEL

To exemplify the connection between the NM and the ABM, a small pedestrian domain as illustrated in Figure S1 is considered. This domain consists of four line segments at the domain boundary, namely S1 - S4, and a crosswalk.

The NM predictions would give an estimate of the full-day count of the number of pedestrians on each line segment. In this example, we choose the predictions to be $S_1 = 50, S_2 = 25, S_3 = 40, S_4 = 40$. This yields, the following ODM based on the formula from section 2.1.3:

$$\mathrm{ODM} = \begin{array}{c c} & \begin{array}{cccc} S_1 & S_2 & S_3 & S_4 \end{array} \\ \begin{array}{c} S_1 \\ S_2 \\ S_3 \\ S_4 \end{array} & \begin{bmatrix} 0 & 7.6 & 12.3 & 12.3 \\ 6.2 & 0 & 5.0 & 5.0 \\ 11.2 & 5.6 & 0 & 9.0 \\ 11.2 & 5.6 & 9.0 & 0 \end{bmatrix} \end{array} \tag{S1}$$

The sum of all entries in the matrix equals 100 % and each entry ODM_{ij} gives the percentage of pedestrians in the simulation heading from their origin S_i to their destination S_j.

In this example, intermediate targets are inserted at the sharp corner and the crosswalk to guide the pedestrians smoothly through the domain. The intermediate target T1 ensures that pedestrians head towards the crossing when going to or coming from segment S2 before taking the turn. This models familiarity with

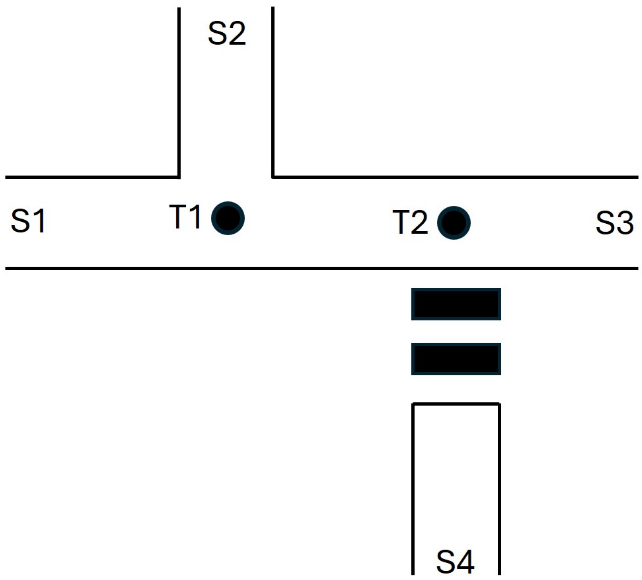

Figure S1: Example pedestrian domain with a crosswalk, line segments S1-S4 at the domain boundary and intermediate targets T1 and T2.

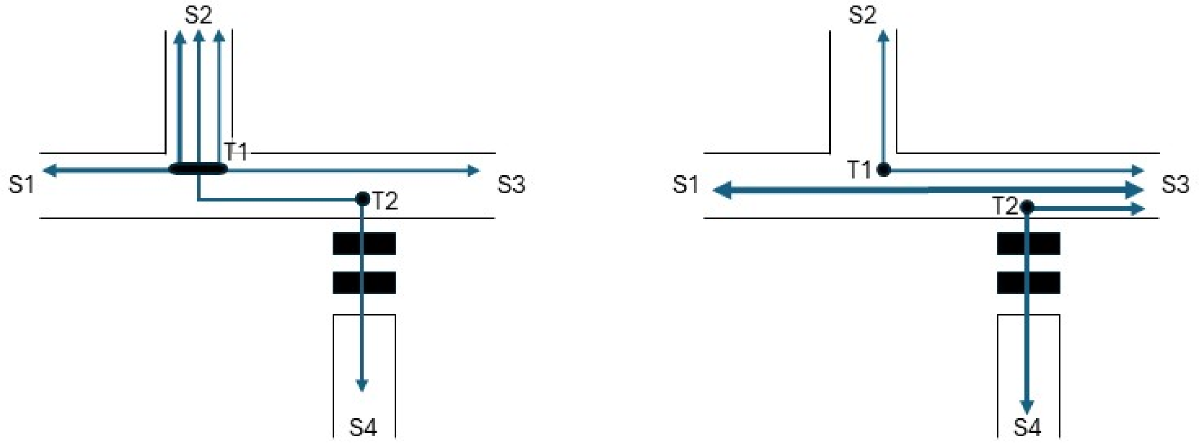

Figure S2: Pedestrian flow illustration for origin and destination S2 to the left and S3 to the right. Intermediate targets are indicated with black circles on the path.

the space since they otherwise purely rely on a line-of-sight without any knowledge of the street network. The intermediate target T2 ensures that the pedestrians walk over the crosswalk when going to or coming from segment S4. The placement of this intermediate target enables the implementation of the rule to walk over crosswalks when crossing a street.

Thus, the twelve different paths assigned to pedestrians in the ABM based on the ODM are:

$S_1 \rightarrow S_2$: S1, T1, S2
$S_1 \rightarrow S_3$: S1, S3
$S_1 \rightarrow S_4$: S1, T2, S4
$S_2 \rightarrow S_1$: S2, T1, S1
$S_2 \rightarrow S_3$: S2, T1, S3
$S_2 \rightarrow S_4$: S2, T1, T2, S4
$S_3 \rightarrow S_1$: S3, S1
$S_3 \rightarrow S_2$: S3, T1, S2
$S_3 \rightarrow S_4$: S3, T2, S4
$S_4 \rightarrow S_1$: S4, T2, S1
$S_4 \rightarrow S_2$: S4, T2, T1, S2
$S_4 \rightarrow S_3$: S4, T2, S3

In Figure S2 pedestrian flows are exemplified. To the left in Figure S2 pedestrian flows with the origin or destination at segment S2 are illustrated, corresponding to row 2 and column 2 of the ODM. The thickness of the flow arrows correlates to the values in the ODM and the black circles on the paths indicate the intermediate targets on this path.

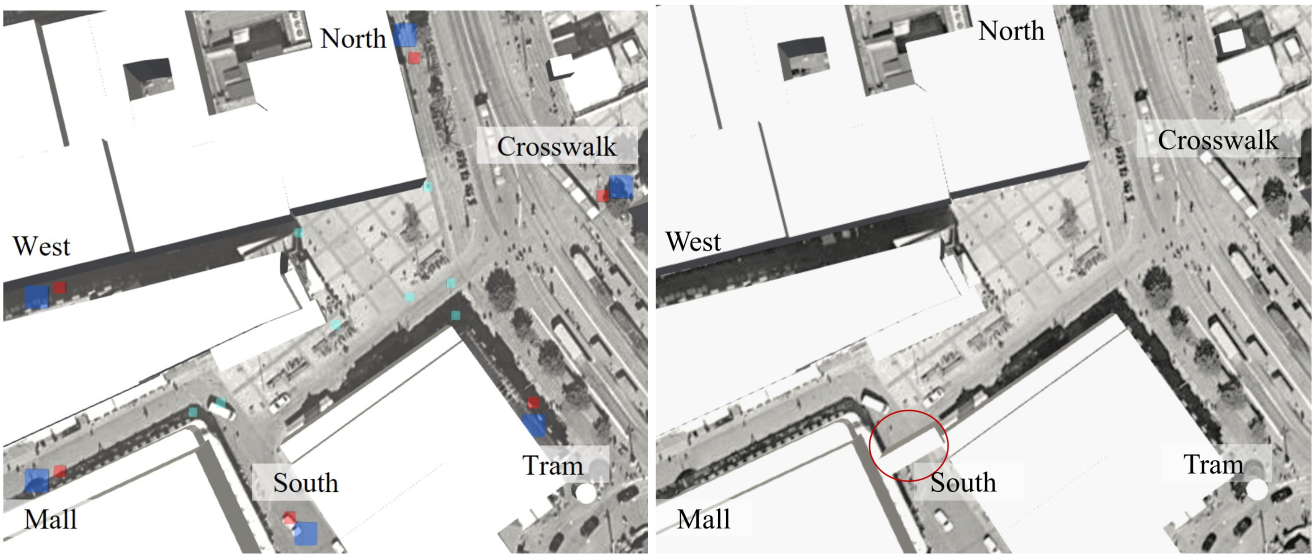

Figure S3: Setup of the standard simulation as described in the manuscript (left) and scenario with an additional micro-scale obstacle (right).

2 EXAMPLE SCENARIO FOR THE HYBRID MODEL

The hybrid model allows testing of different design and planning scenarios in different scales. If there is a change in the street network, then the NM will change to represent the new scenario and estimate the effects of this contextual change in the inflows and outflows of the domain, which will in turn affect the ABM. If, on the other hand, changes only appear on a local scale not affecting the street network, the ABM environment will change to represent the new scenario to estimate the change in the movement patterns. In this case, the NM part of the hybrid model does not need to change Here, we give one example of a scenario with a micro-scale change, namely a new obstacle in the ABM domain, representing a delivery truck, leading to a significant narrowing of the street.

The input into the ABM from the NM as well as the ABM simulation parameters remain the same as in the manuscript since the street network is not altered. The only change is the inclusion of the 3-dimensional object geometry representing the additional obstacle. The standard scenario with the general setup of sections and intermediate targets as well as the modified scenario are given in Figure S3 where the new obstacle is highlighted with a red circle.

In Figure S4, the pedestrian trajectories of the new scenario including an additional obstacle are shown. The deflection of the trajectories due to the obstacle is clearly visible, demonstrating a narrower range of movement in that area.

Figure 5 represents pedestrians that encounter conflicts and deviate from their target speed, similar to the analysis in the manuscript. The share of pedestrians in close proximity to others is depicted in Figure 5a, with black crosses marking pedestrians with a distance below 1.5 m and red circles those with a distance below 1 m. During the simulation, up to 15 % of the pedestrians are within 1 m of each other and between 10 and 35 % maintain a distance of less than 1.5 m. Around 450 seconds into the simulation, the share of pedestrians in conflict peaks at approximately 34 %. Compared to the original simulation in the manuscript, this scenario generally shows more pedestrians in conflict within 1 m and 1.5 m.

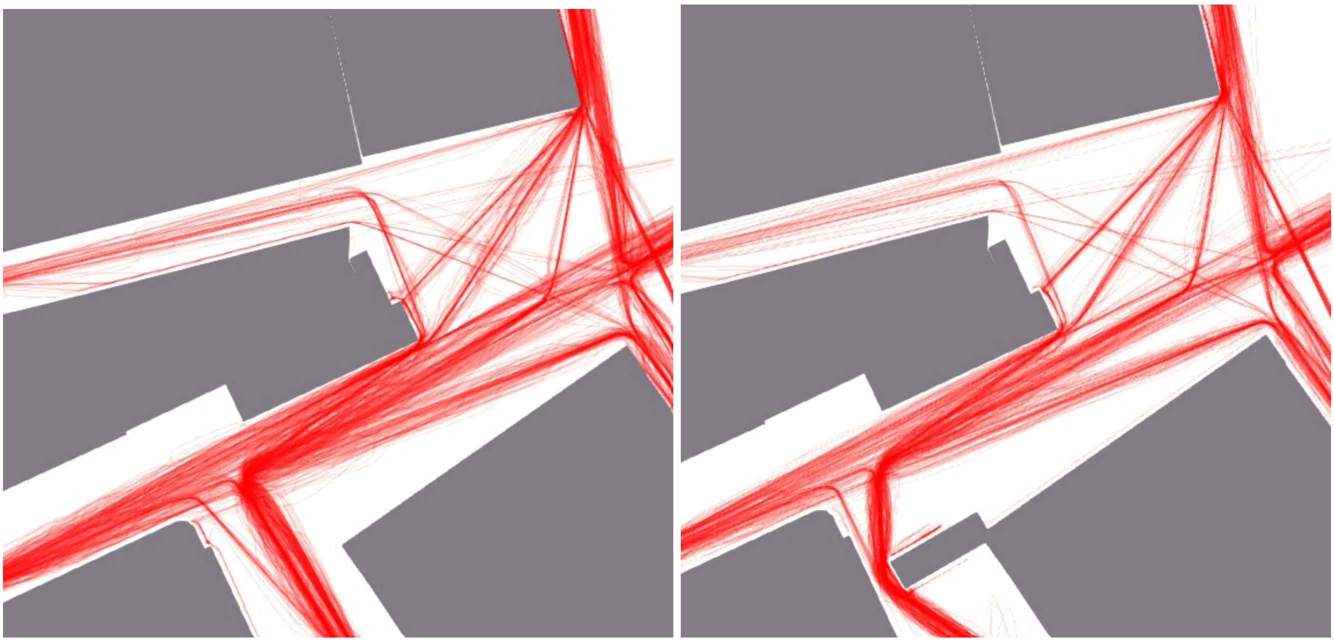

Figure S4: Visualisation of pedestrian trajectories from the standard case (left) and with the additional micro-scale obstacle (right).

The mean deviation from the desired speed of pedestrians is illustrated in Figure 5b. The majority of pedestrians changing speed is reducing their speed by 60 to 90 % of their desired speed, showing results similar to the original simulation.

Finally, Figure 5c shows the share of pedestrians that deviate from their desired speed. Initially, up to 20 % of pedestrians need to adapt their speed, increasing to 20 % to 40 % as the simulation progresses. These results differ from the original manuscript, indicating a higher share of pedestrians needing to change their speed.

In conclusion, the analysis of this scenario demonstrates the ability of the proposed workflow to study different scenarios and to enable a detailed study of pedestrian conflicts, which enables urban planners to evaluate the quality of pedestrian movement and test different measures for its improvement.

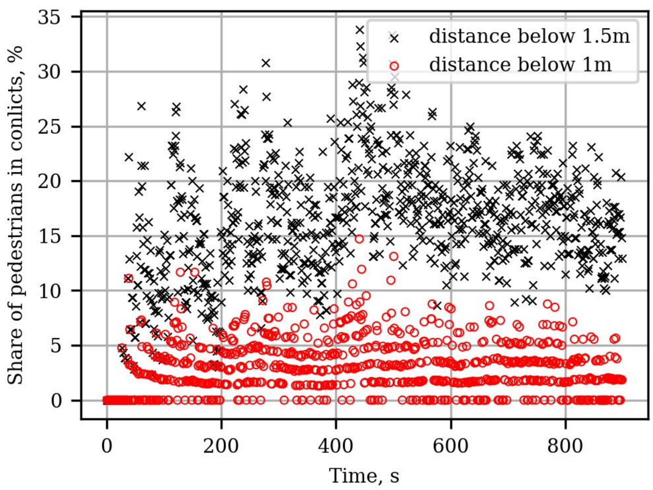

Figure 5a: Share of pedestrians in close proximity to other pedestrians.

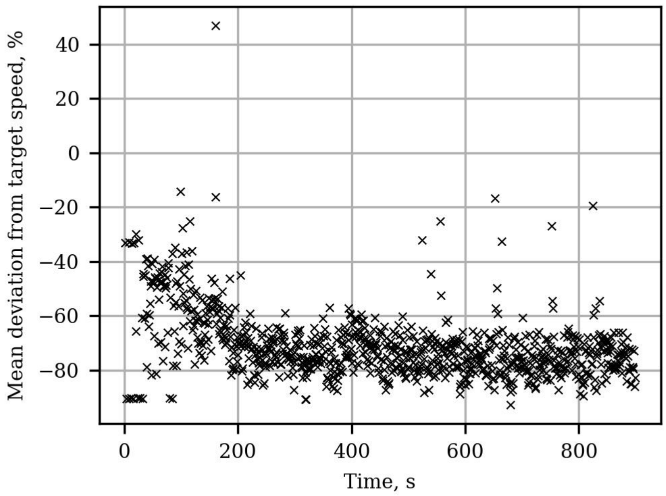

Figure 5b: Mean deviation from the desired speed of pedestrians in close proximity to other pedestrians.

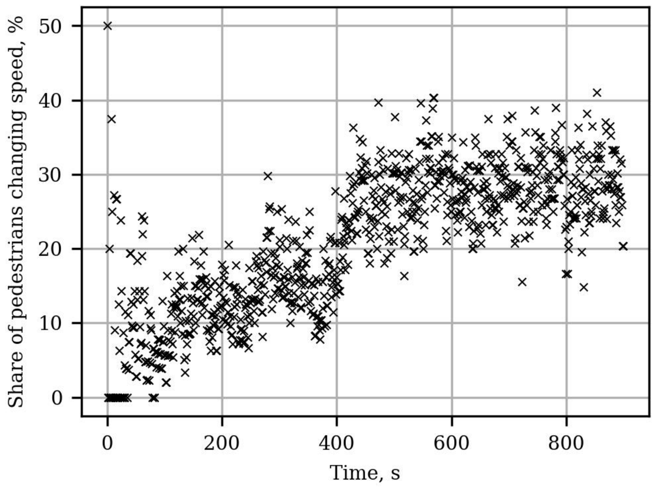

Figure 5c: The share of pedestrians that deviate from their desired speed.

Figure 5: Evaluation of speed deviation during and share of pedestrians that encounter conflicts to other pedestrians.