The role of fluctuations and interactions in pedestrian dynamics

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Pedestrian dynamics

The dynamics of pedestrian crowds is a relevant topic for the design and safety of civil infrastructures and furthermore a fascinating subject deeply connected with many scientific disciplines, including statistical physics and fluid dynamics. Even in simple geometries, individuals always display, in addition to average behaviors, small fluctuations and, more rarely, large “anomalous” deviations.

High statistics measurements

We expect observation of the crowds with very high statistics to reveal the signature of both frequent and rare fluctuations. To this aim, back in 2013 we started several year-long experimental campaigns in real-life settings. Performing 24/7 continuous pedestrian tracking via ad hoc technologies in different locations, we collected an unprecedentedly large database of human trajectories (~10M) [1-3].

Figure 1: Real-life pedestrian tracking at Eindhoven train station. Raw data, as depth maps, is collected via grids of Microsoft KinectTM overhead sensors. Ad hoc algorithms are used to identify pedestrians that are tracked with Particle Tracking Velocimetry (PTV) techniques.

Figure 2: Probability distribution functions of (longitudinal) velocities of pedestrians walking undisturbed by others. Measurements from two locations are compared: A. corridor at Eindhoven university of Technology; B. Train station (cf. Fig. 1). In both cases rare turnback events emerge (negative velocities).

Figure 3: A Langevin model with a double-well velocity potential (1) enables frequent small fluctuations (S) and large, although rare, velocity leaps (L) to negative velocities, i.e. turningback events.

Figure 4: Comparison between the modeled and the measured dynamics in case of the corridor in Fig. 2A. (left) Probability distribution function of longitudinal velocities. (right) Number of pedestrians observed between two successive (rare) inversion events (roughly 1 in 450 on average, Poisson distributed).

Figure 5: Binary avoidance interactions are measured considering the variation of transversal (lateral) distance before and at the mutual by pass.

Interactions and outlook

Quantitative stochastic model for the undisturbed, i.e. diluted regime as (1) are a first step toward quantitative models for entire crowds. The analysis of binary interactions, ongoing for our train station data (Fig. 5), is the next step in this direction.

References: