# Accurate pedestrian tracking for statistical crowd dynamics

Alessandro Corbetta*(a,b), Chung-min Lee(c), Adrian Muntean(d), Federico Toschi(a)

*a.corbetta@tue.nl - (a) Eindhoven University of Technology, NL (b) Politecnico di Torino, IT
(c) California State University Long Beach, USA (d) Karlstads University, SE

## Crowd dynamics

Pedestrians walking in crowds show complex dynamics and stunning collective motion. The investigation of the underlining behaviors from single individuals to large-scale interactions is a topic of intense research. Nowadays, scientists are challenged by fundamental questions such as

- *Can we write quantitative models for the behavior of pedestrians walking in crowds?*
- *Are pedestrian crowds moving like fluid flows?*

Answers to these questions would have primary impact in engineering, as they enable accurate evacuation simulations, crowd management and interactive built environments.


*Figure 1: The main walkway of Eindhoven Train Station. Four overhead Kinect sensors record continuously the traffic flow.*

## High statistics measurements

Walking individuals have an intrinsically random behavior. A quantitative prediction of walking trajectories is thus impossible. Nevertheless, we expect walking pedestrians to exhibit universal features at the statistical level. In other words, we expect the distributions of position, velocity or acceleration to describe the dynamics. Comparison with measurements is paramount to shed light on this aspect. Hence, we perform extensive and highly accurate experimental measurements of pedestrian trajectories. To explore the statistical portrait including the rare events we perform 24/7 automatic data acquisition on a yearly basis. We established different measurement locations within TU/e [1, 2] and at Eindhoven Train Station (cf. Figure 1 and 2).

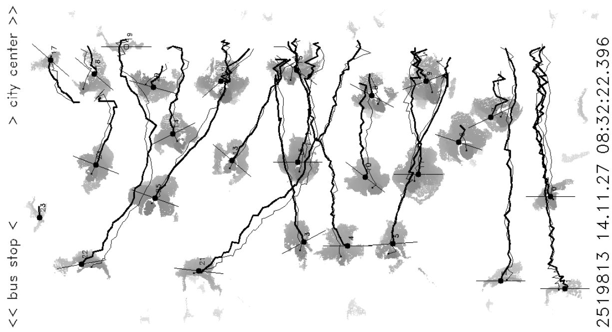


*Figure 2: A depth map reconstructed from the recordings of four Kinect sensors. Darker pixels are closer to the plane of the cameras. Pedestrian trajectories and bodies orientation are estimated via an ad hoc method.*

## 3D-range sensors for accurate tracking

To measure pedestrian trajectories accurately we employ an *ad hoc* technique utilizing multiple overhead Microsoft Kinect 3D-range sensors [1]. 3D-range sensors deliver depth maps that associate to each point its distance with the camera plane (cf. Figure 2). We perform pedestrian segmentation via clusterization algorithms applied on the 3D data. Thus, analyzing each cluster-pedestrian we identify the head, which we track as a particle in a flow.

## Quantitative modeling

We derive Langevin-like stochastic particle models to reproduce the dynamics of pedestrians. We deduce potentials in space and velocity to mimic and explain the observed non-Gaussian fluctuations up to rare events [2].

## References

[1] A. Corbetta, L. Bruno, A. Muntean, F. Toschi (2014). High statistics measurements of pedestrian dynamics. *Transportation Research Procedia* 2, 96–104.

[2] A. Corbetta, C. Lee, R. Benzi, A. Muntean, F. Toschi (2015). Fluctuations and mean behaviours in diluted pedestrian flows. *To be submitted*