Pedestrian Density Estimates and Their Real Applications

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Starting Point

- Microscopic decision-based model
  - Definition of the rules
  - Model calibration
- Definition of pedestrian density
  - Concept, Parametric study
  - Applications

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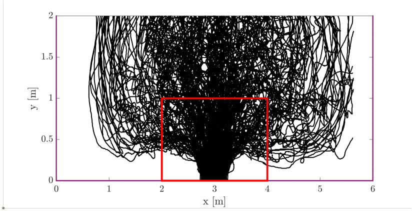
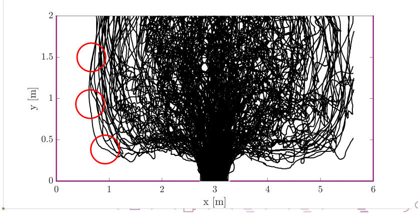
Pedestrian Density Estimate

- Every single pedestrian is a source of density distribution
- Definition of density in the detector A

$$\rho = \frac{N}{|A|} = \frac{\int_A p(\vec{x})\,\mathrm{d}\vec{x}}{|A|} = \frac{\int_A \sum_{\alpha=1}^{N} p_\alpha(\vec{x})\,\mathrm{d}\vec{x}}{|A|} = \sum_{\alpha=1}^{N} \frac{\int_A p_\alpha(\vec{x})\,\mathrm{d}\vec{x}}{|A|},$$

  where $|A|$ the size of considered area A and $p(\vec{x}) = \sum_{\alpha=1}^{N} p_\alpha(\vec{x})$ the density distribution in the area A
- Detector A can be static or dynamic ($\Rightarrow$ individual density)





Type of Kernels

$\vec{x}_\alpha$ ... the position of pedestrian α at fixed time

- Point approximation

$$p_\alpha(\vec{x}) = \delta_{\vec{x},\vec{x}_\alpha},$$

- Stepwise function

$$p_\alpha(\vec{x}) = \begin{cases} \frac{1}{|A_\alpha|} & \text{if} \quad \vec{x} \in A_\alpha, \\ 0 & \text{otherwise,} \end{cases}$$

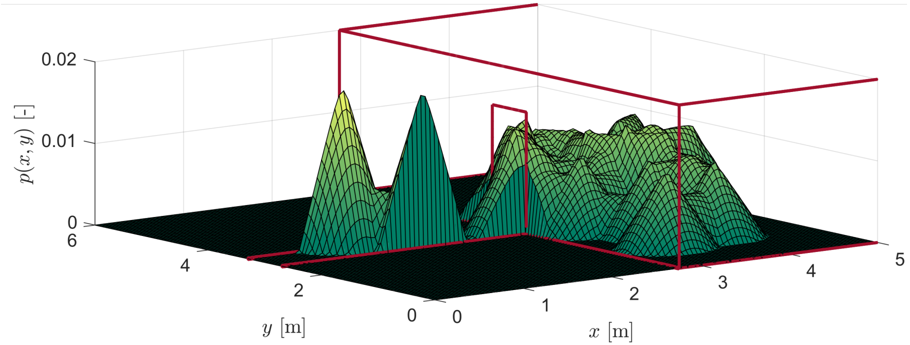
  1. Cylindrical distribution: $A_\alpha = \left\{ \vec{x} \in \mathrm{R}^2 : \|\vec{x} - \vec{x}_\alpha\| < R \right\}$
  2. Voronoi distribution: A_α is a Voronoi cell: each point $\vec{x}$ is assigned to the nearest pedestrian $\vec{x}_\alpha$

- Linear (conic) distribution

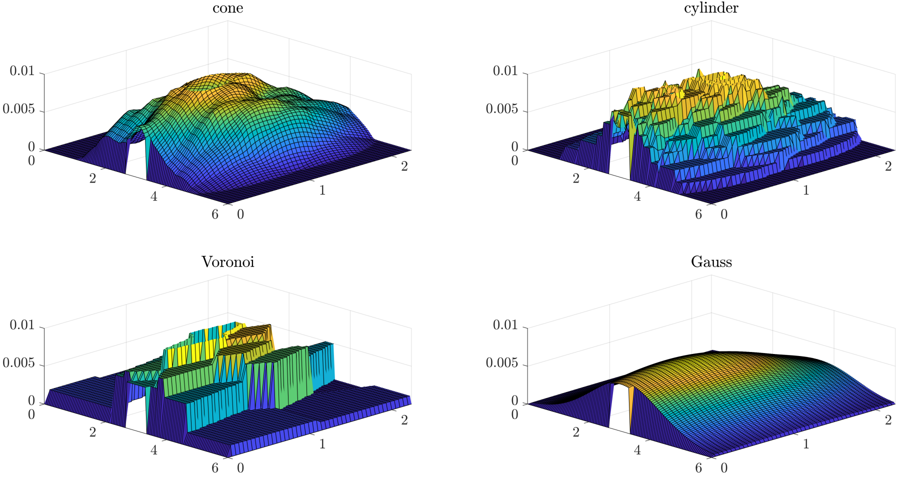
$$p_\alpha(\vec{x}) = \begin{cases} \frac{3}{R^3\pi}(R - \|\vec{x} - \vec{x}_\alpha\|) & \text{if} \quad \|\vec{x} - \vec{x}_\alpha\| < R, \\ 0 & \text{otherwise} \end{cases}$$

- Gaussian distribution

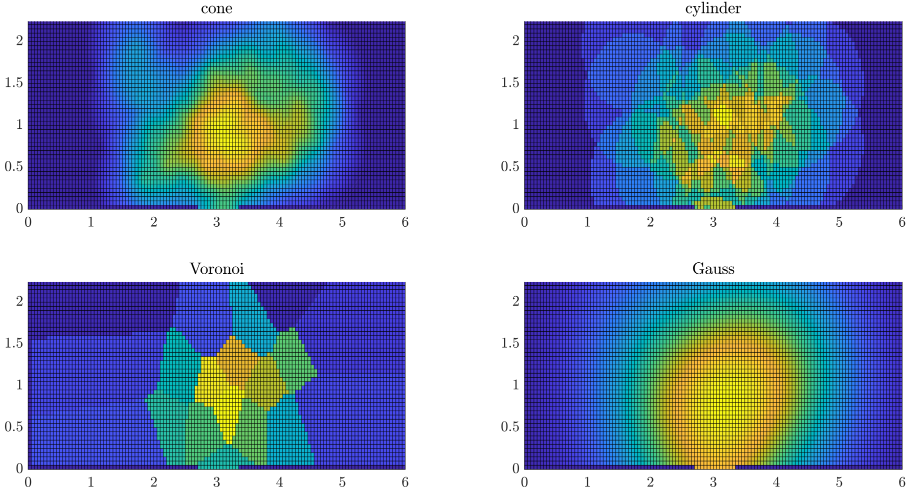
Density distribution - Conic Kernel $p_\alpha(\vec{x})$



Density distribution - Different Kernels

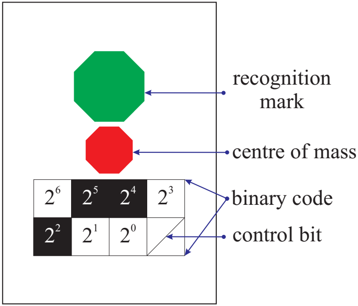


Density distribution - Different Kernels



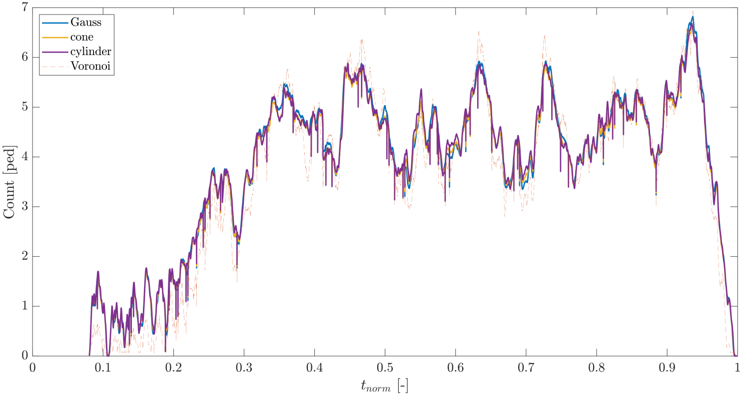
- Different kernels, different properties

Experimental Data

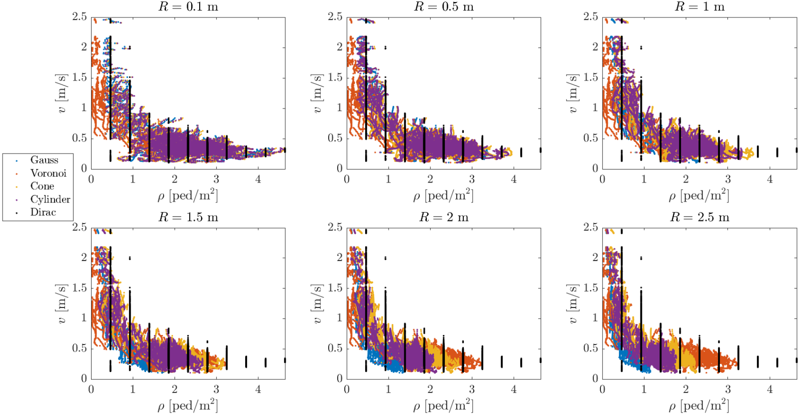


- Study hall of our faculty
- Artificial room: 7.2 m × 4.4 m
- One exit: 0.6 m wide
- Three entrances
- Three cameras
- Recognition caps
- 10 runs

Parametric Study - Preliminary Results 1

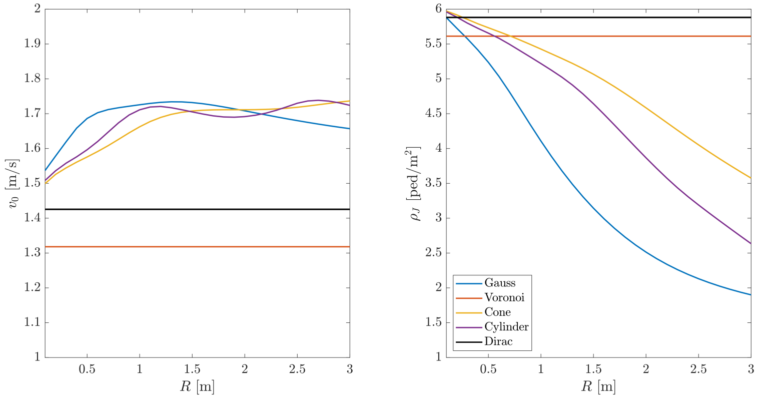


Parametric Study - Preliminary Results 2



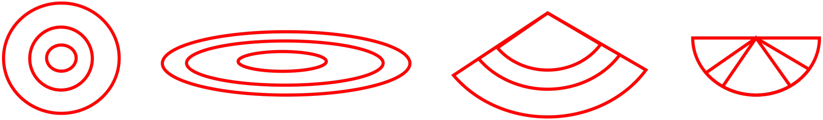
Parametric Study - Preliminary Results 3

$$v(\rho) = v_0 \cdot \left(1 - \frac{\rho}{\rho_J}\right)^3$$



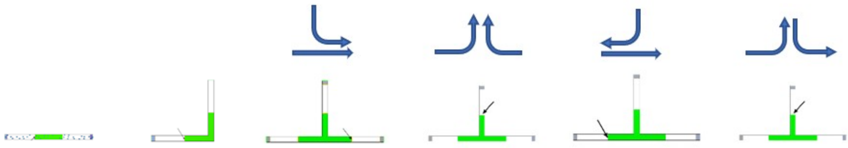
Parametric Study - To Do

- Individual density: different types of surroundings
  - Circle: radius
  - Ellipse: semi-mayor axis, semi-minor axis
  - Sector: angle, radius
- Huge parametric space

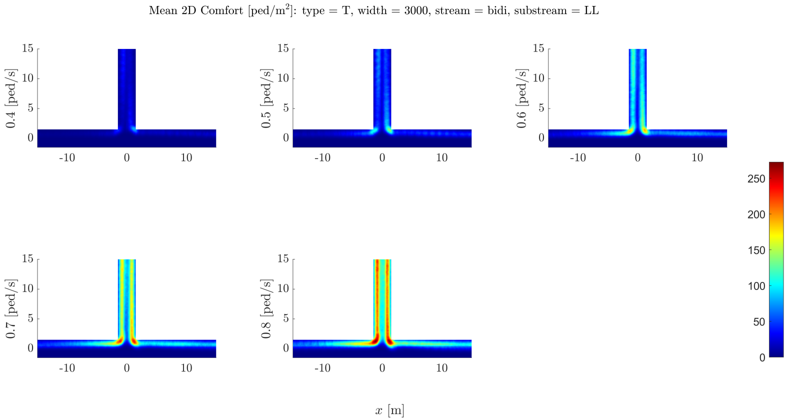


Application 1 - Project ZETA - Comfort

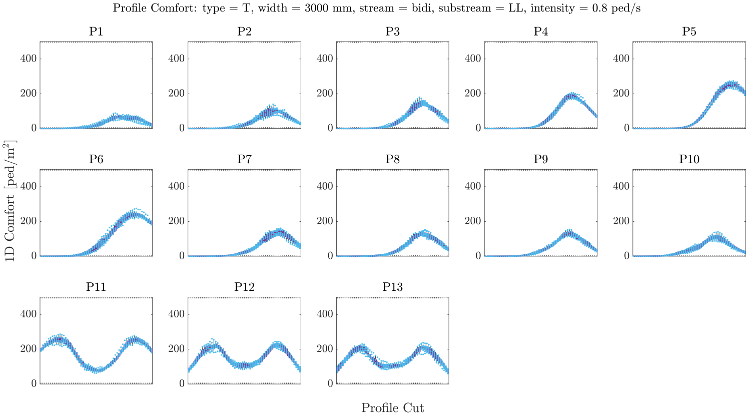
- **Team Members:** Martina Kratochvílová, Jana Vacková, Jiří Apeltauer, Ondřej Uhlík, Petra Okřinová, Tomáš Apeltauer, Jan Podroužek
- **Goal:**
  - Tool to alert the user in real-time about insufficient space capacity
  - Database of scenarios



Application 1 - Project ZETA - 2D Comfort

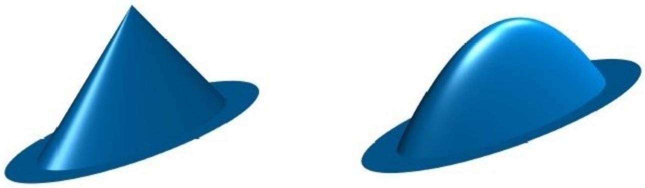


Application 1 - Project ZETA - Profile Comfort



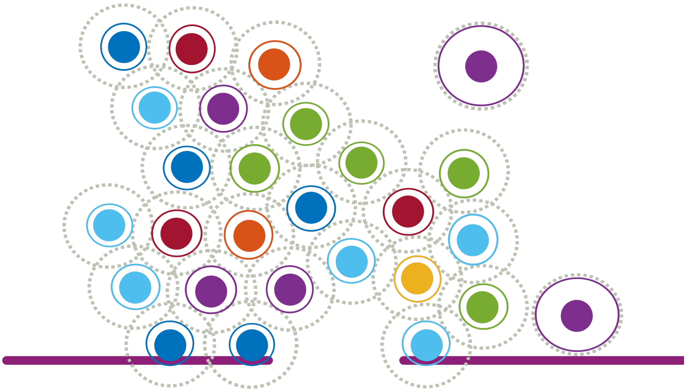
Application 2 - Individual Comfort

- **Team Members:** Milan Krbálek, Jiří Apeltauer, Jana Vacková, Ondřej Uhlík
- **Goal:** to summarize generalized terminology and define (diss)comfort for every single pedestrian
- Adaptive kernels with non-symmetric support etc.



Application 3 - Model Calibration

- **Team Members:** me (and my supervisors as support)
- **Goal:** my dissertation, i.e. the calibration of my decision-based model



Summary

- There is not only one correct estimate of pedestrian density.

Thank you for your attention.