Prediction of Pedestrian Speed with Artificial Neural Networks

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Context and objective

- **Pedestrian dynamics depends on the type of facilities**

$\rightarrow$ Difficult prediction of pedestrians movements in **complex geometries** (including corridor, bottleneck or intersection) with models based on a single fundamental diagram (FD)

$\rightarrow$ **Artificial neural networks** could be suitable alternative for prediction of pedestrian dynamics in complex geometries

- Aim: Compare **estimations of pedestrian speed** with a FD-based model and a neural network for **combinations** of corridor and bottleneck **training and testing sets**

Models

Pedestrian speed models based on $K = 10$ closest neighbors

- **Weidmann FD model**

$$v = \text{FD}(\bar{s}_K, v_0, T, \ell) = v_0\Big(1 - e^{\frac{\ell - \bar{s}_K}{v_0 T}}\Big) \qquad (1)$$

with $\bar{s}_K = \frac{1}{K}\sum_i \sqrt{(x - x_i)^2 + (y - y_i)^2}$ the **mean spacing**

- **Artificial neural network** with hidden layers H

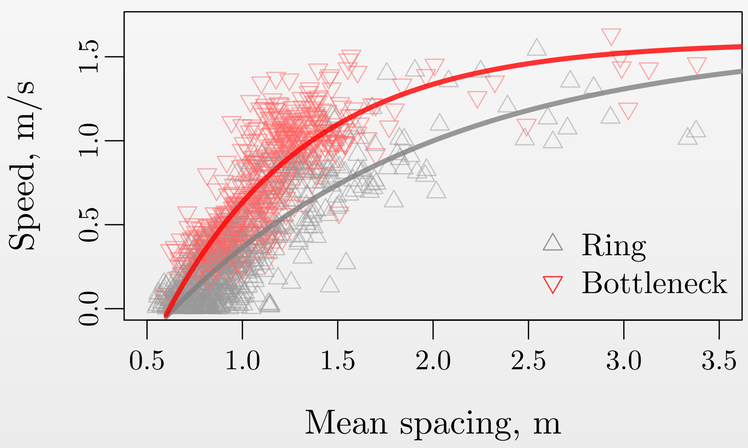
$$v = \text{NN}\big(H, \bar{s}_K, (x_i - x, y_i - y, 1 \leq i \leq K)\big) \qquad (2)$$

$2K + 1$ inputs: Mean spacing + K relative positions

Data

Two datasets obtained in laboratory conditions

- R: **Ring experiments**
- B: **Bottleneck experiments**



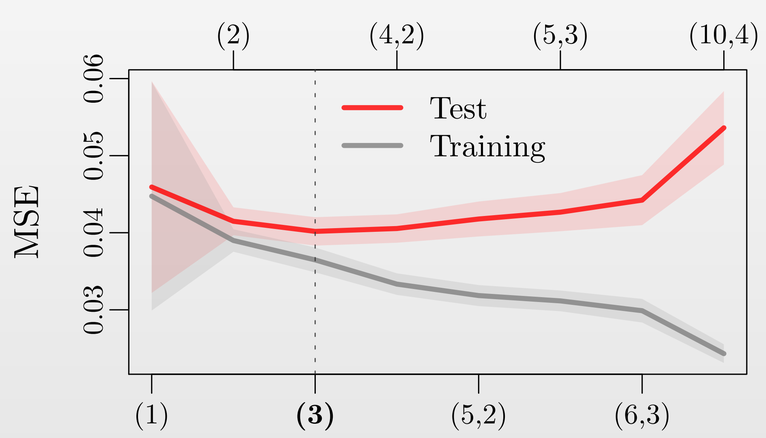
$\rightarrow$ **Different speed/spacing relations** (fundamental diagram)

	R	B	
ℓ	0.64	0.61	m
T	**0.86**	**0.48**	s
v_0	1.60	1.58	m/s

Setting the neural network

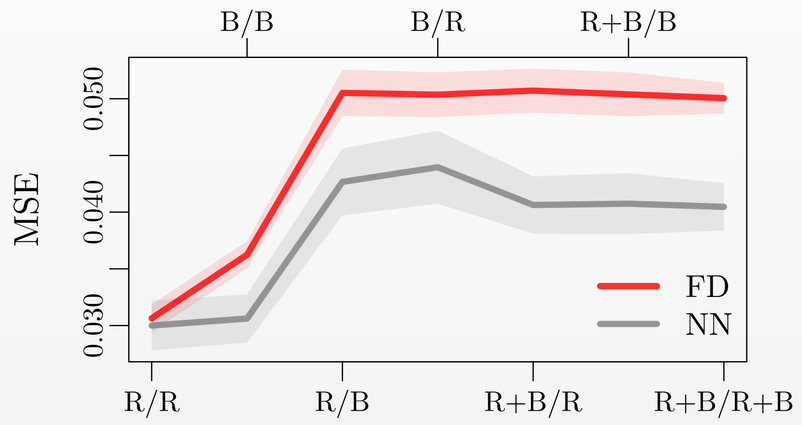
50-bootstrap cross-validation with training and testing sets

- Assessment of the fit by **mean square error** (MSE)
- Different hidden are tested: $H = (3)$ gives the **best fit**

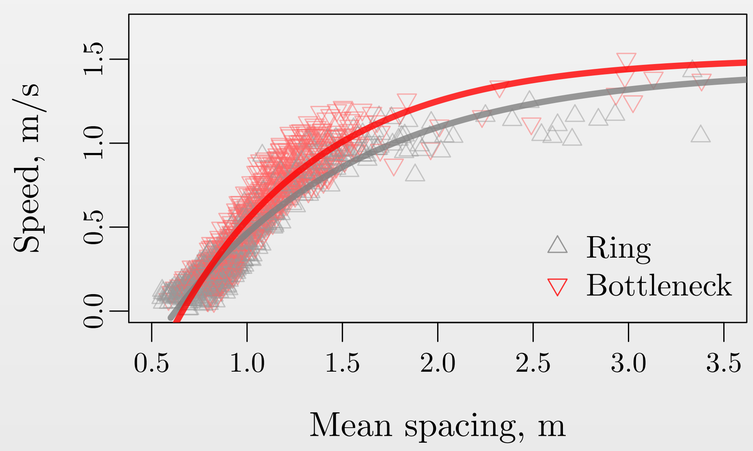


Results

Evaluation on **different combinations** of training/test sets



Speed prediction the for R+B/R+B set



$\rightarrow$ **Identification** (partial) of the **two geometries**

	R	B	
ℓ	0.63	0.66	m
T	**0.68**	**0.50**	s
v_0	1.44	1.51	m/s

Conclusion

- NN: **Improvement** of pedestrian speed prediction up to 20%; Other FD, inputs, hidden and training sets to be tested
- Computation time $\approx$10 h on a 2.7 Ghz processor ($n = 4000$): For large database the use of **super computers** is necessary
- **Simulation** of the NN model (recursive neural network)