A Unified Pedestrian Routing Model
Combining Multiple Graph-Based Navigation Methods

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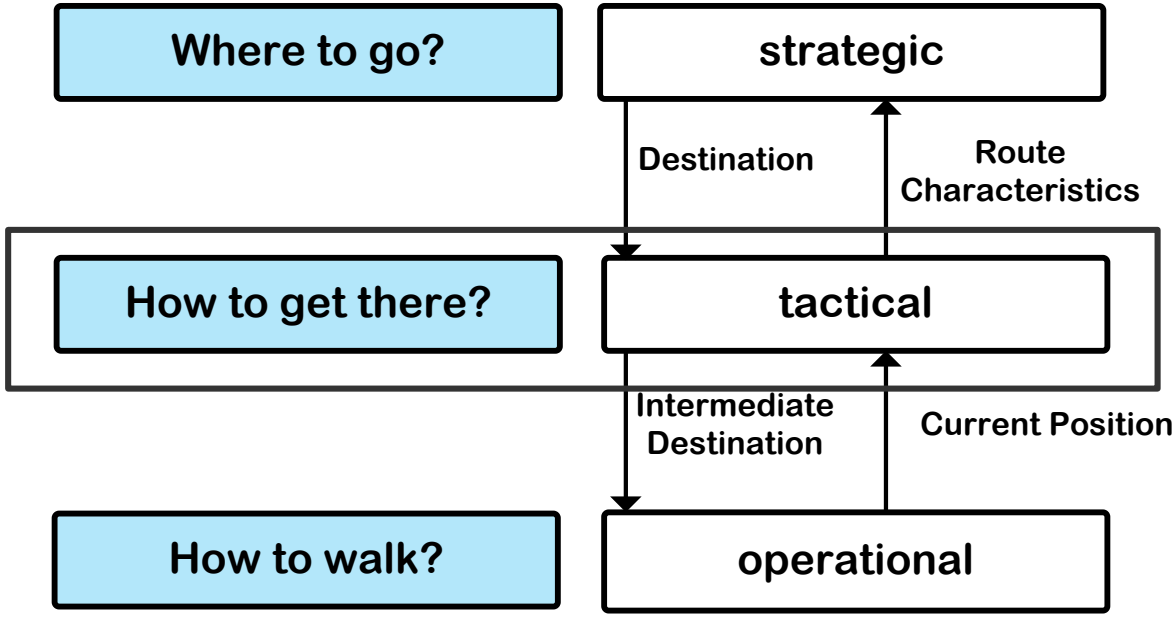
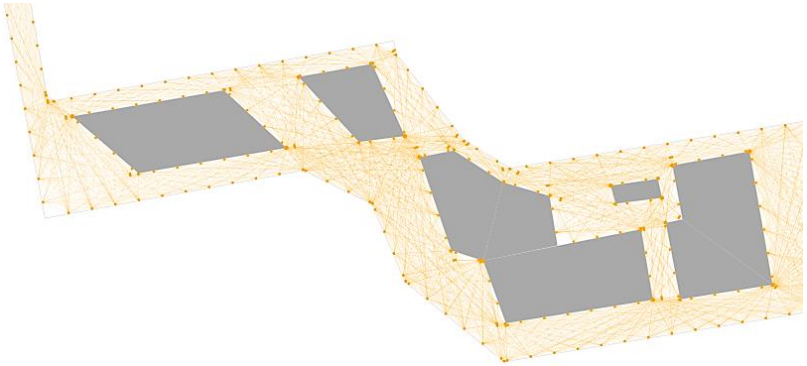
Microscopic Pedestrian Simulations

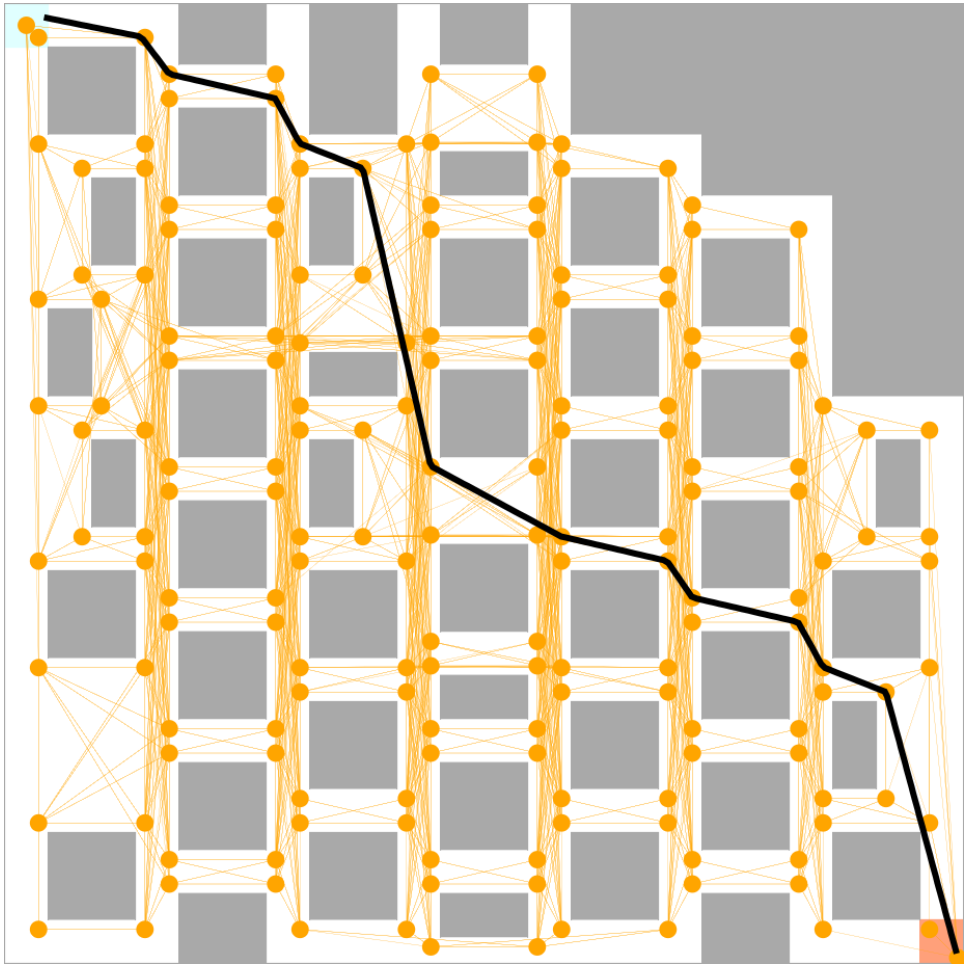
- Simulation of each pedestrian as individual
- Improving simulations by cognitive aspects



Routing on Graphs

- Graph Data structure
- Graph generation algorithms

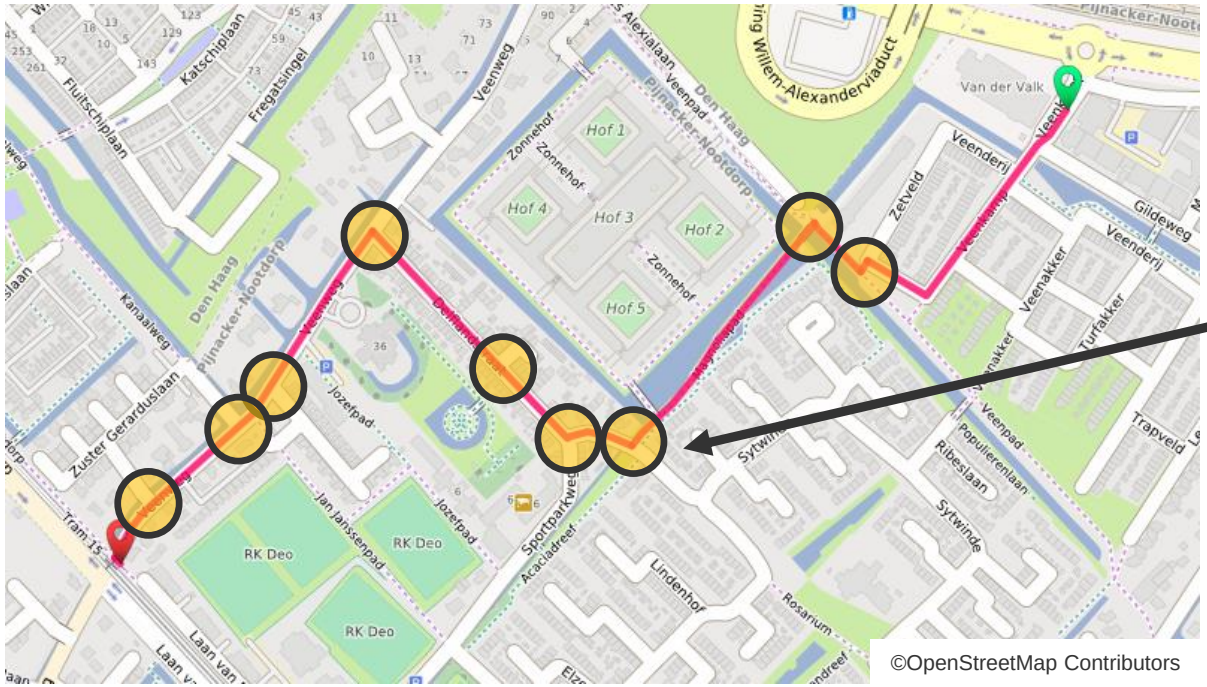




Kneidl, Angelika, André Borrmann, and Dirk Hartmann. *Advanced Engineering Informatics* 26.4 (2012): 669-680.

Modeling Pedestrian Routing Behavior

- Modeling route choice behavior in street networks



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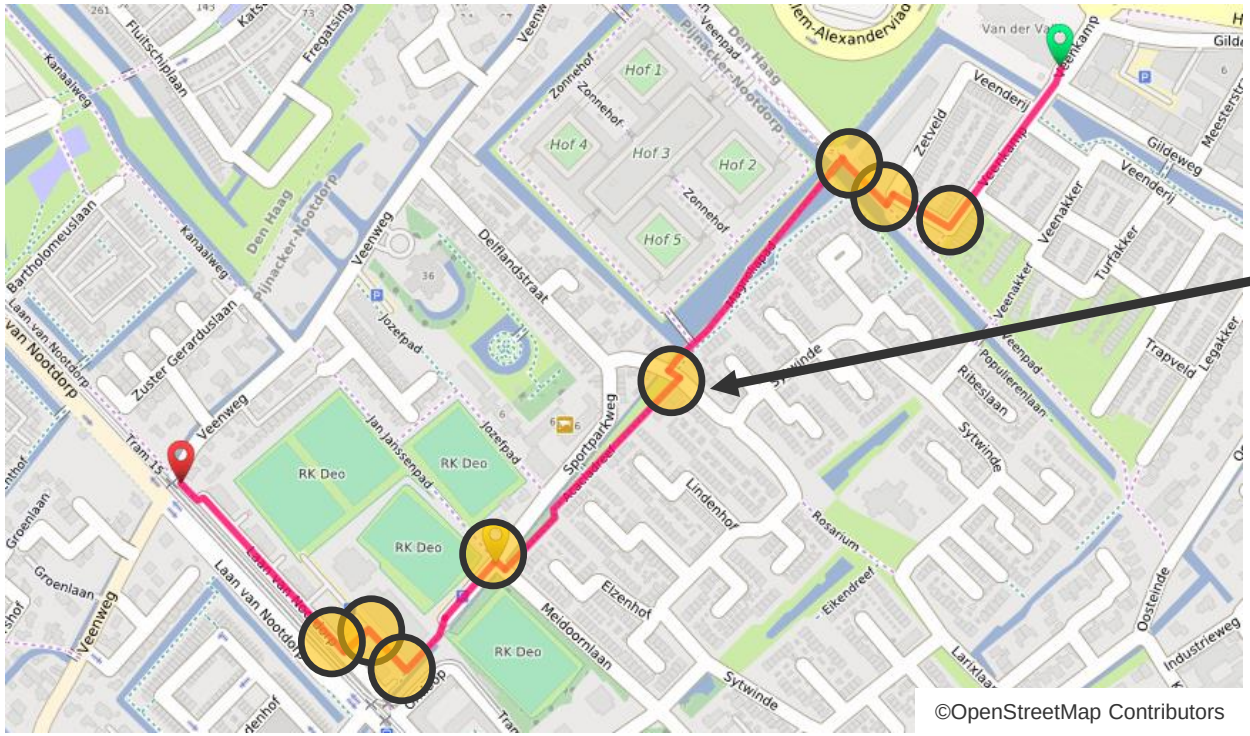
Modeling Pedestrian Routing Behavior

- Could it have been another way?



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Alternative Route Choice

Modeling Pedestrians‘ Routing Behavior

- How to model such variability?
- Apply spatial cognitive findings
- Combining routing methods
  that model
  allocentric and egocentric knowledge
  based routing behavior

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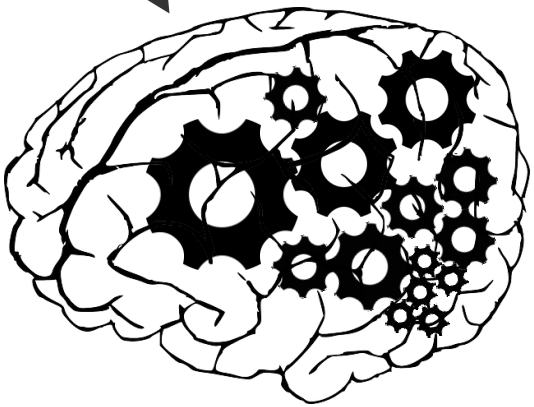
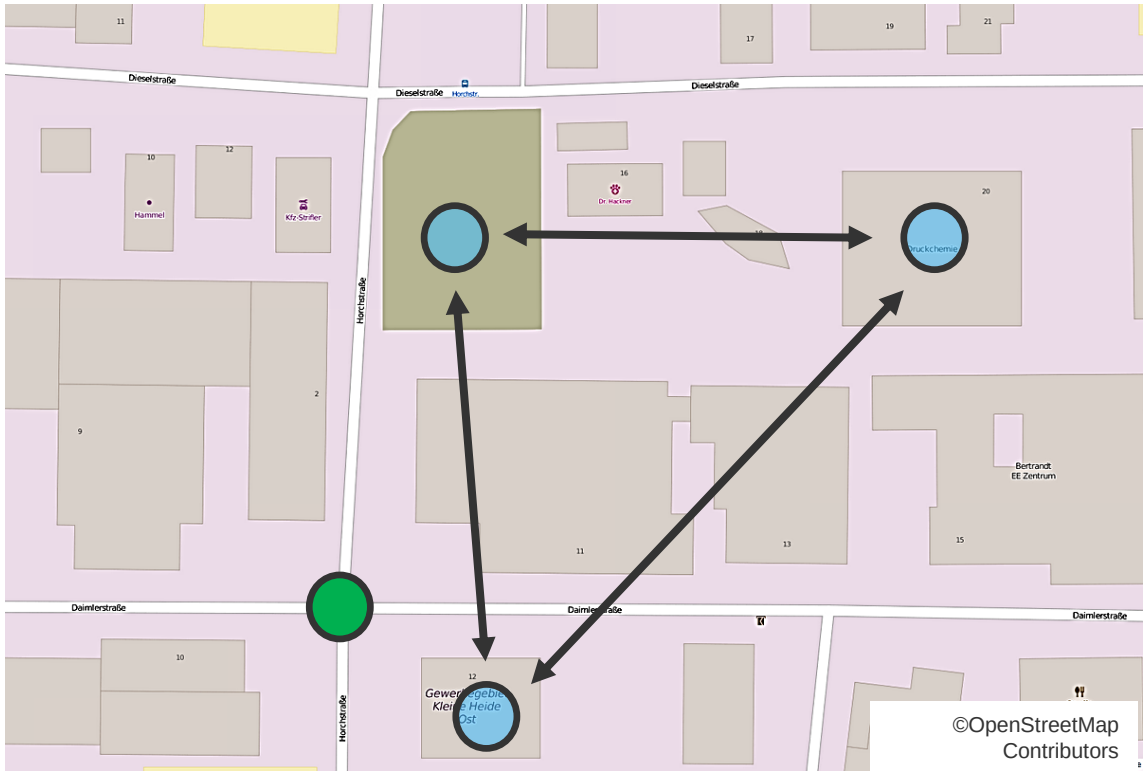


Allocentric survey knowledge

- High familiarity
- Know about locations
- Can find new paths
- Easy to self localize



Egocentric route knowledge

- Low familiarity
- Know local information
- Difficult to self localize

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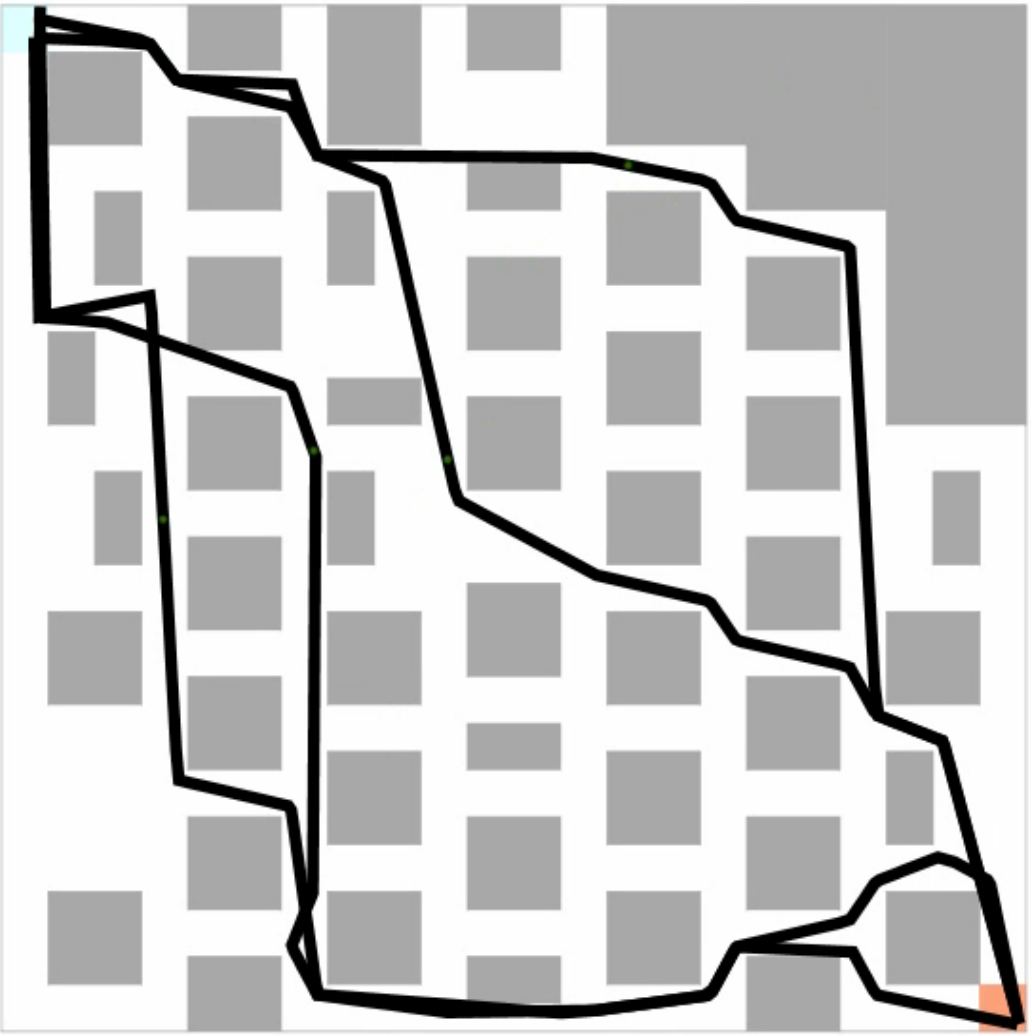
Work we build upon

- Two Allocentric Models

  Fastest Path
  Beeline Heuristics

- Two Egocentric Models

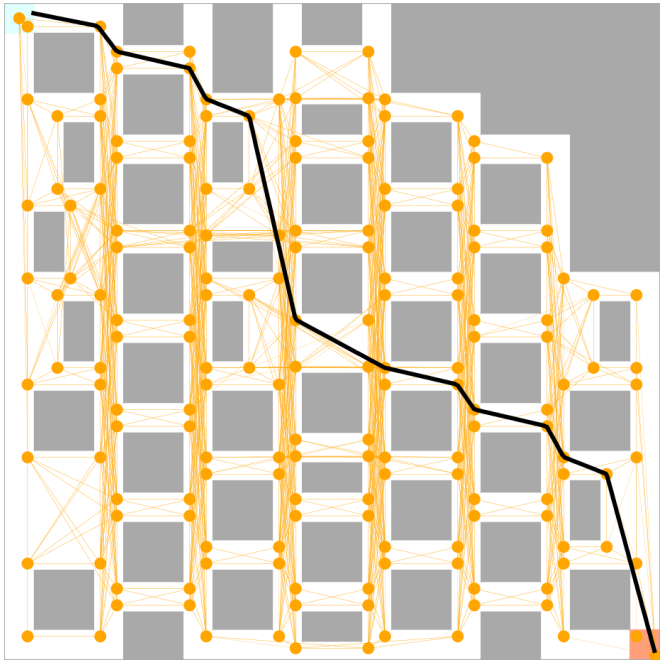
  Straight and Long Legs
  Greedy Beeline Heuristics



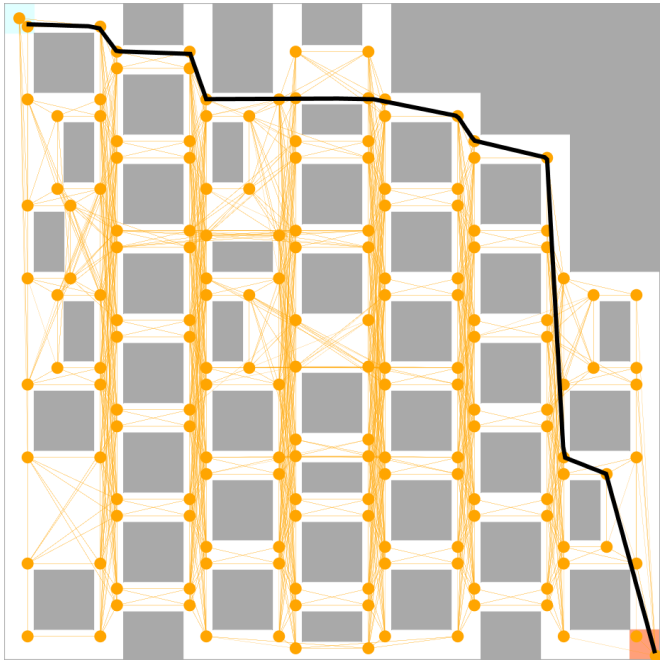
Kneidl, Angelika. *PhD Thesis*
Technische Universität München, 2013.

Original Methods: Allocentric routing models

- Fastest Path (FP)
- Based on Dijkstra's algorithm
- Optimal travel time

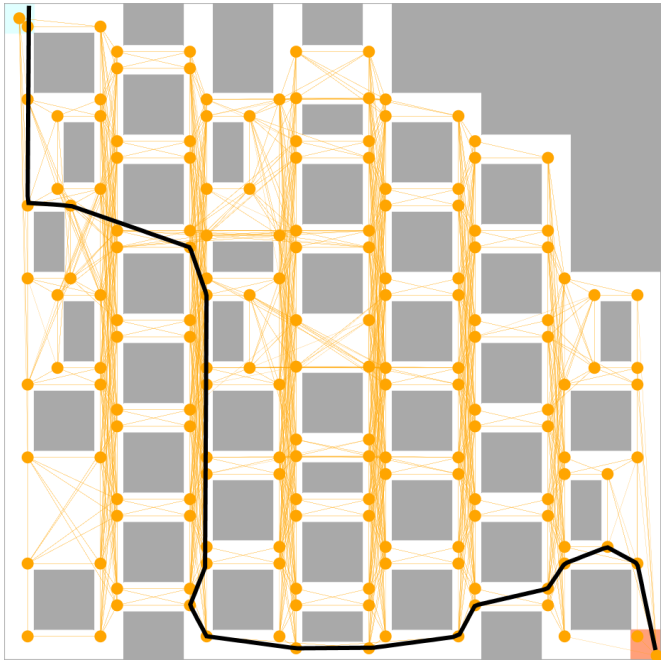


- Beeline Heuristics (BH)
- Based on the A-Start algorithm
- Optimal beeline to destination

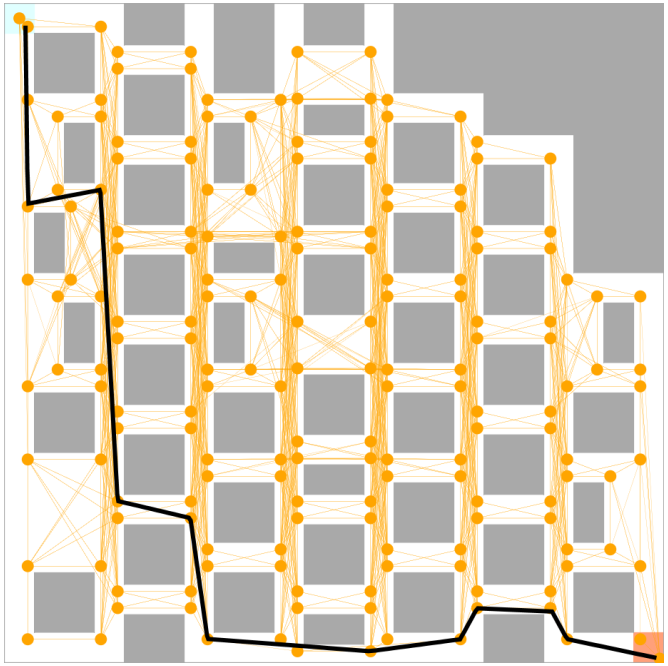


Original Methods: Egocentric routing model

- Straight and Long Legs (SALL)
- Based on stepwise optimization
- Choose straight streets

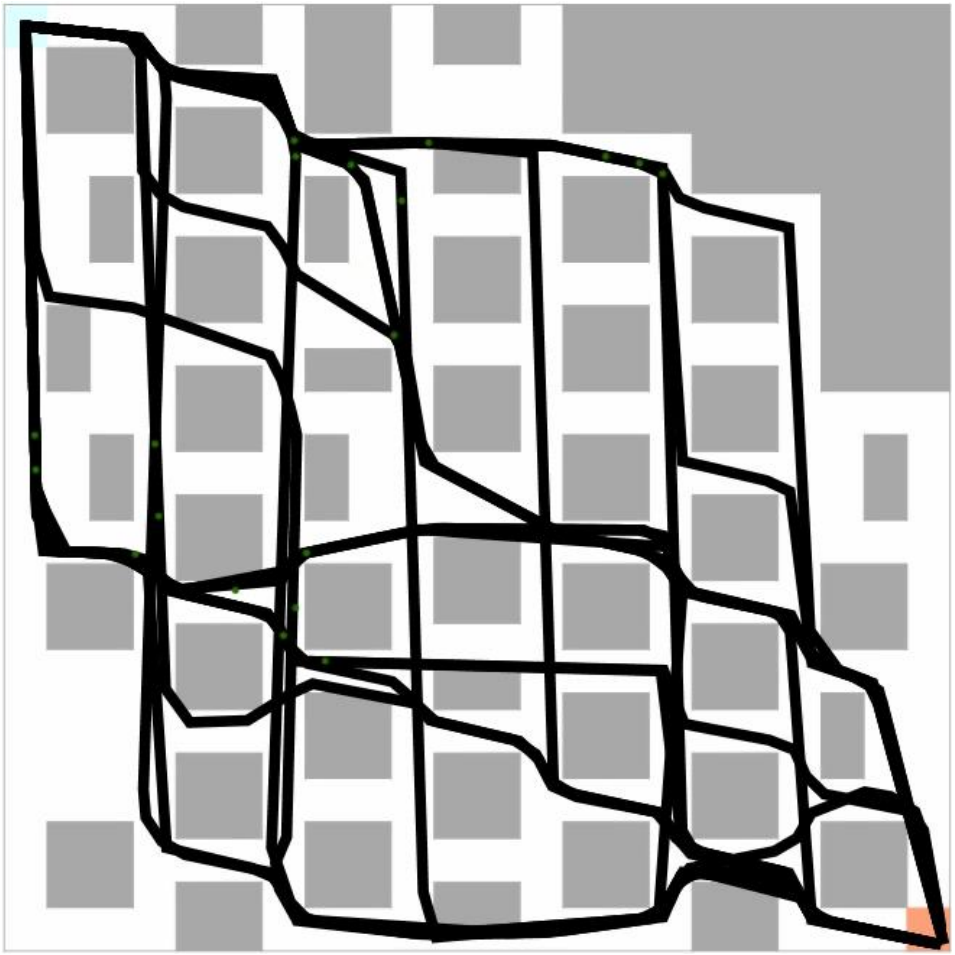


- Greedy Beeline Heuristics (GBH)
- Based on stepwise optimization
- Choose beeline to destination



Core Idea of the Unified Pedestrian Routing Model

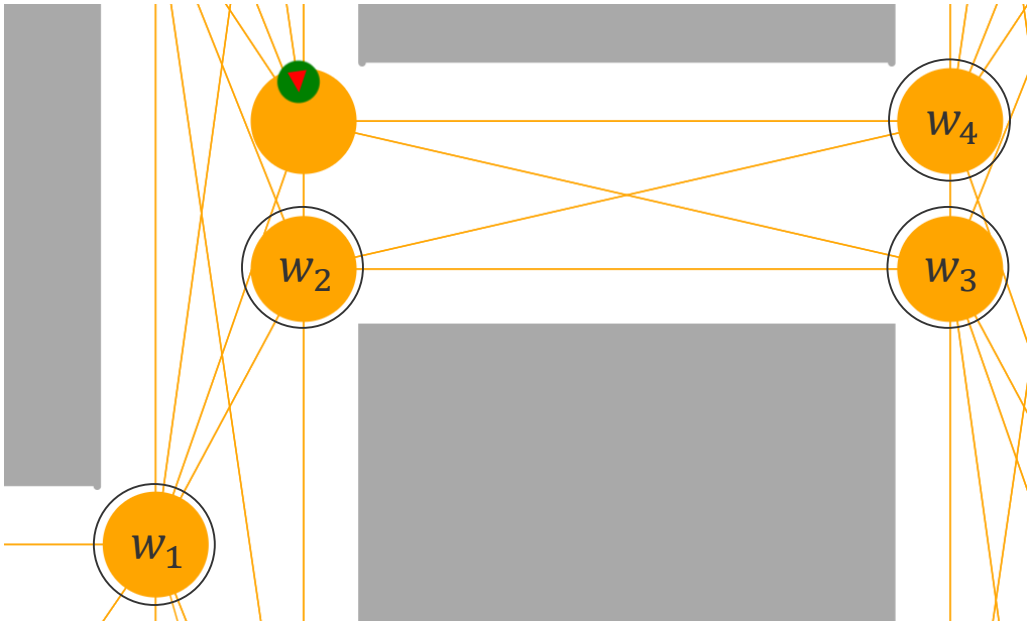
- Integration of all four models FP, BH, GBH, SALL
- In accordance to spatial cognitive findings
- Forecast of a high variety of route choices



Unified Pedestrian Routing Model Description

- Based on stepwise optimization
- $w_j = \zeta \cdot FP + \eta \cdot BH + \kappa \cdot SALL + \psi \cdot GBH$

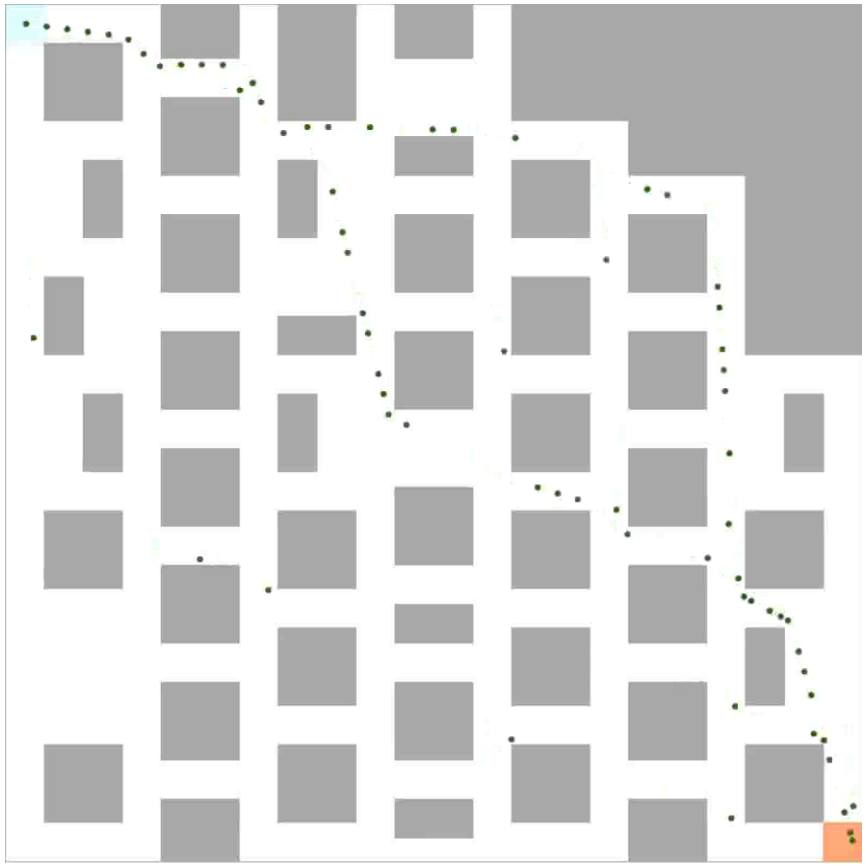
$(\zeta, \eta) \approx$ Allocentric Knowledge
$(\kappa, \psi) \approx$ Egocentric Knowledge



Generic Model Calibration Approach

- How to find appropriate factor combinations?

- Run test simulations
- Random factor combinations
- Path clustering
- Clusters reveal factors



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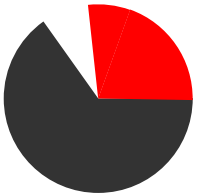
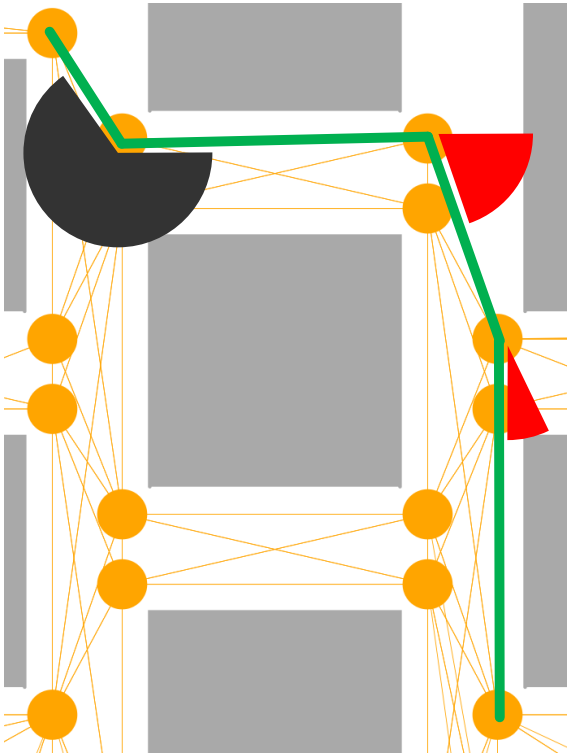
Technische Universität München, 2013.

Generic Model Calibration Approach

- Calculate turning angles

- Green angles





Generic Model Calibration Approach

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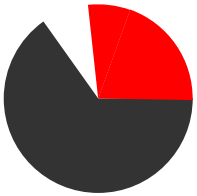
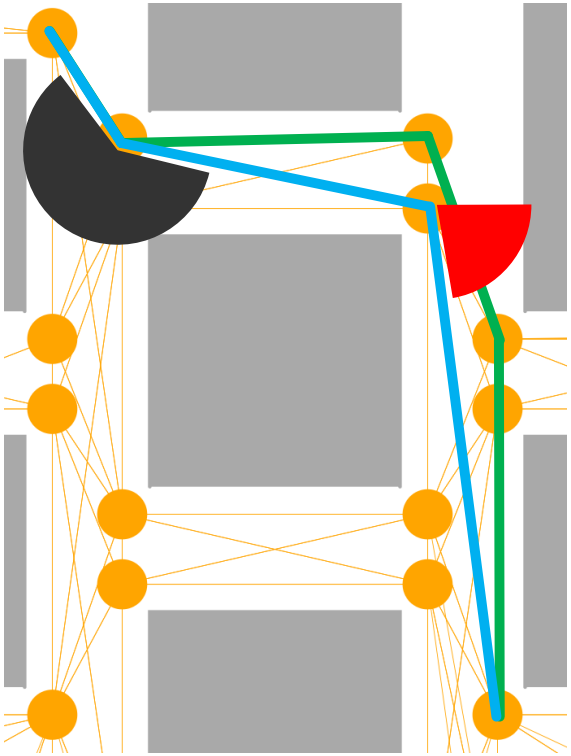


- Blue angles



Generic Model Calibration Approach

- Calculate turning angles

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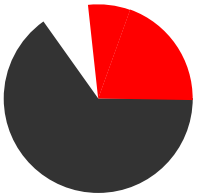
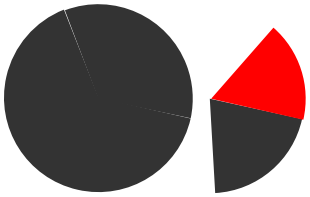
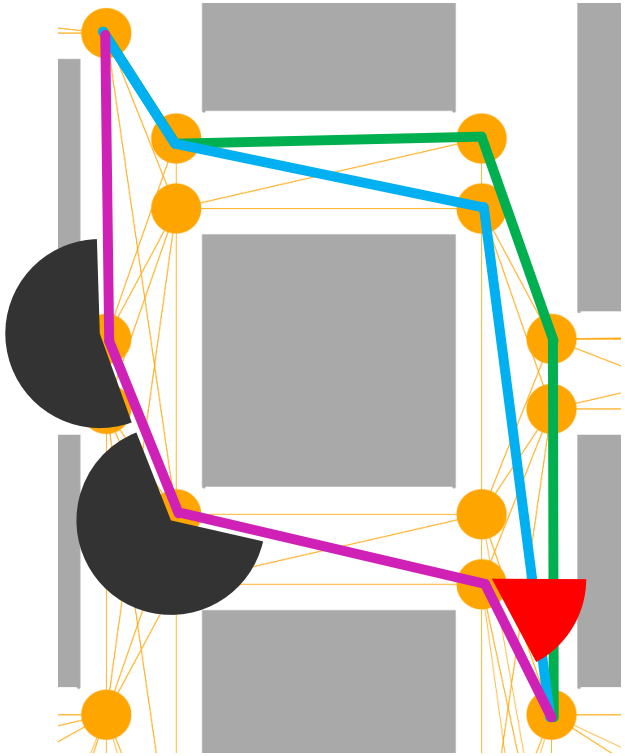


- Blue angles

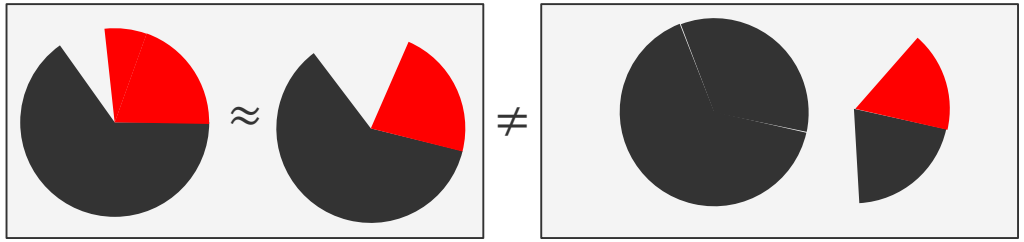
- Violet angles



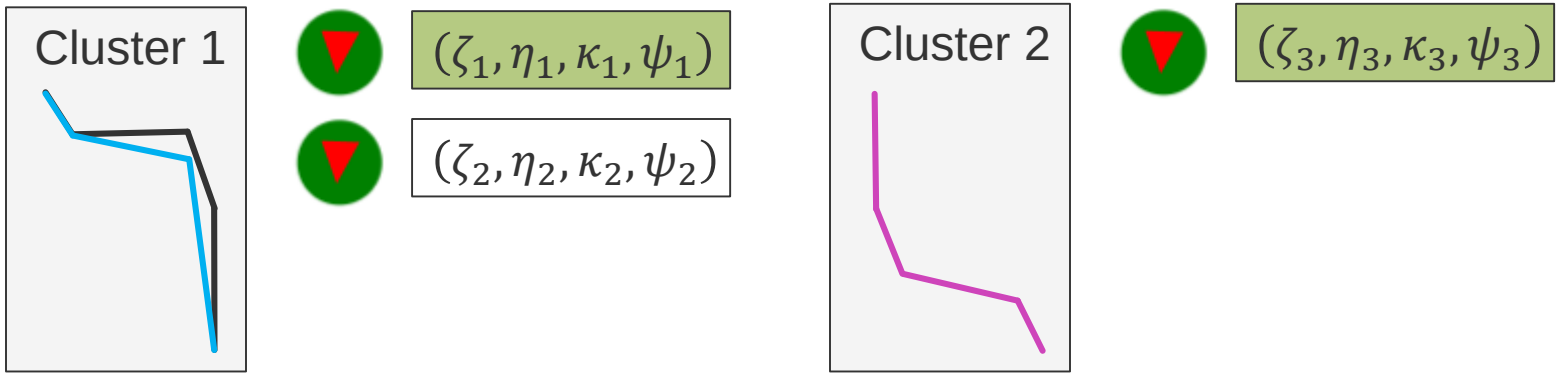


Generic Model Calibration Approach

- Cluster by total angles including tolerance



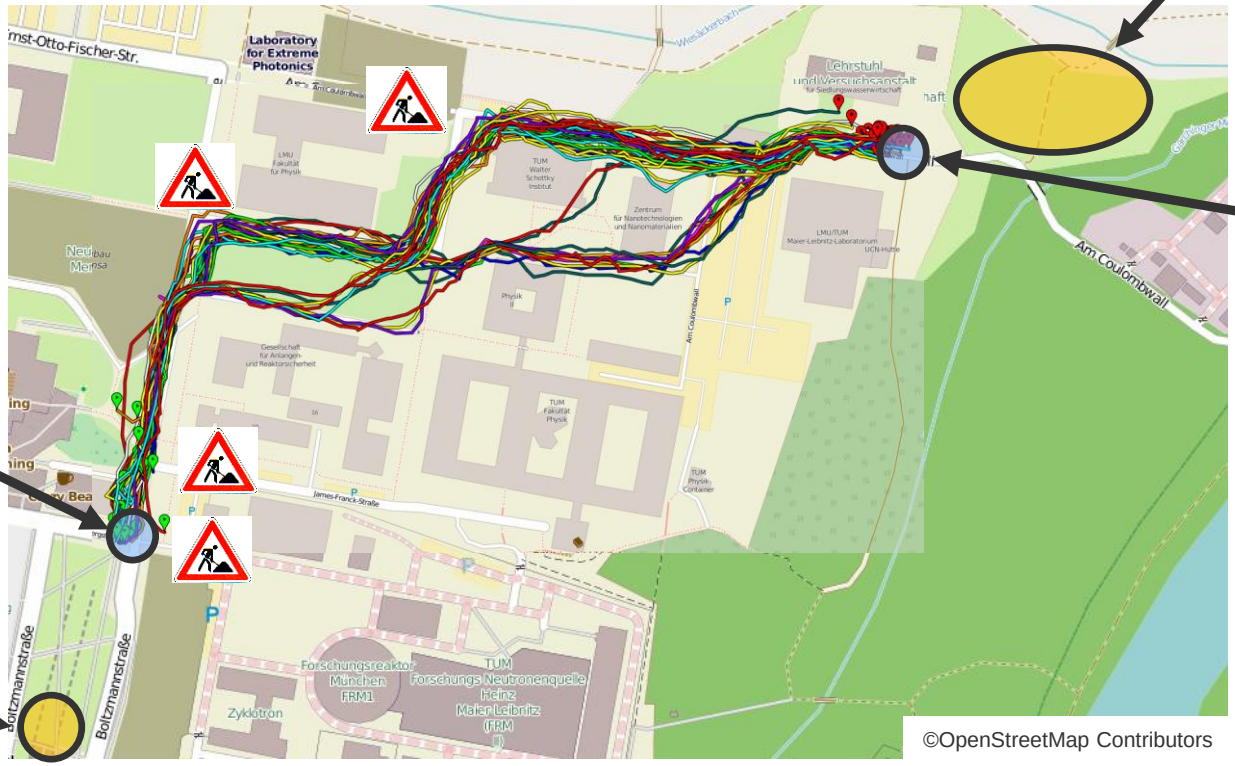
- Choose cluster representative



- Some additional calculations

Field Study for Model Validation

- Annual music festival, ca. 5000 visitors
- 71 GPS tracks via smart phones, 700 visitors measured



Measurement End

Measurement Start

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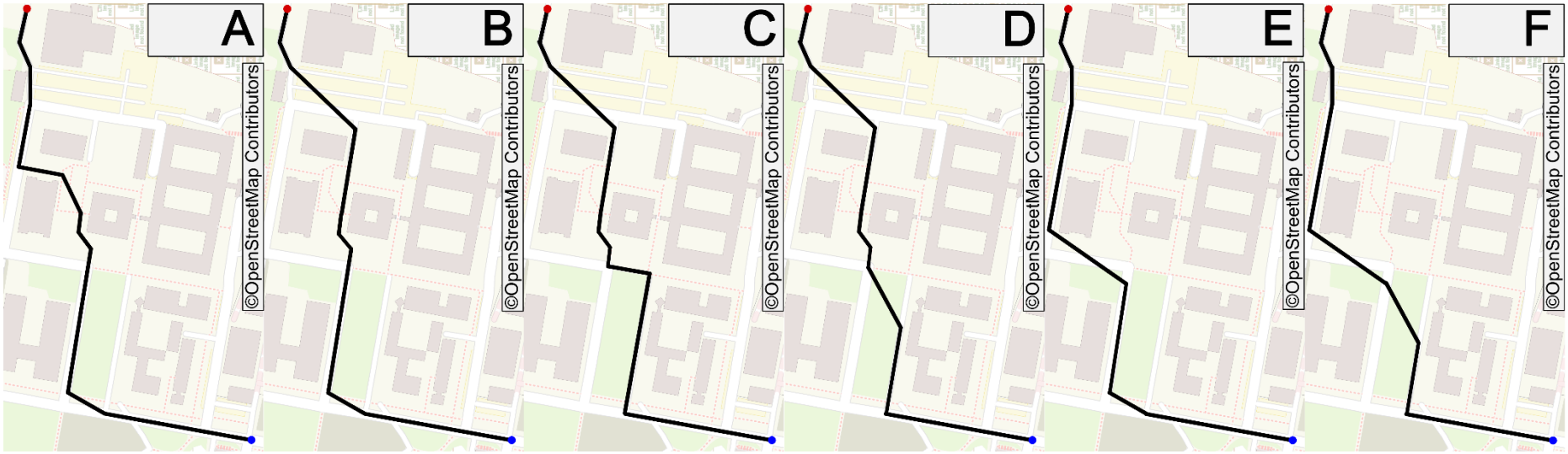
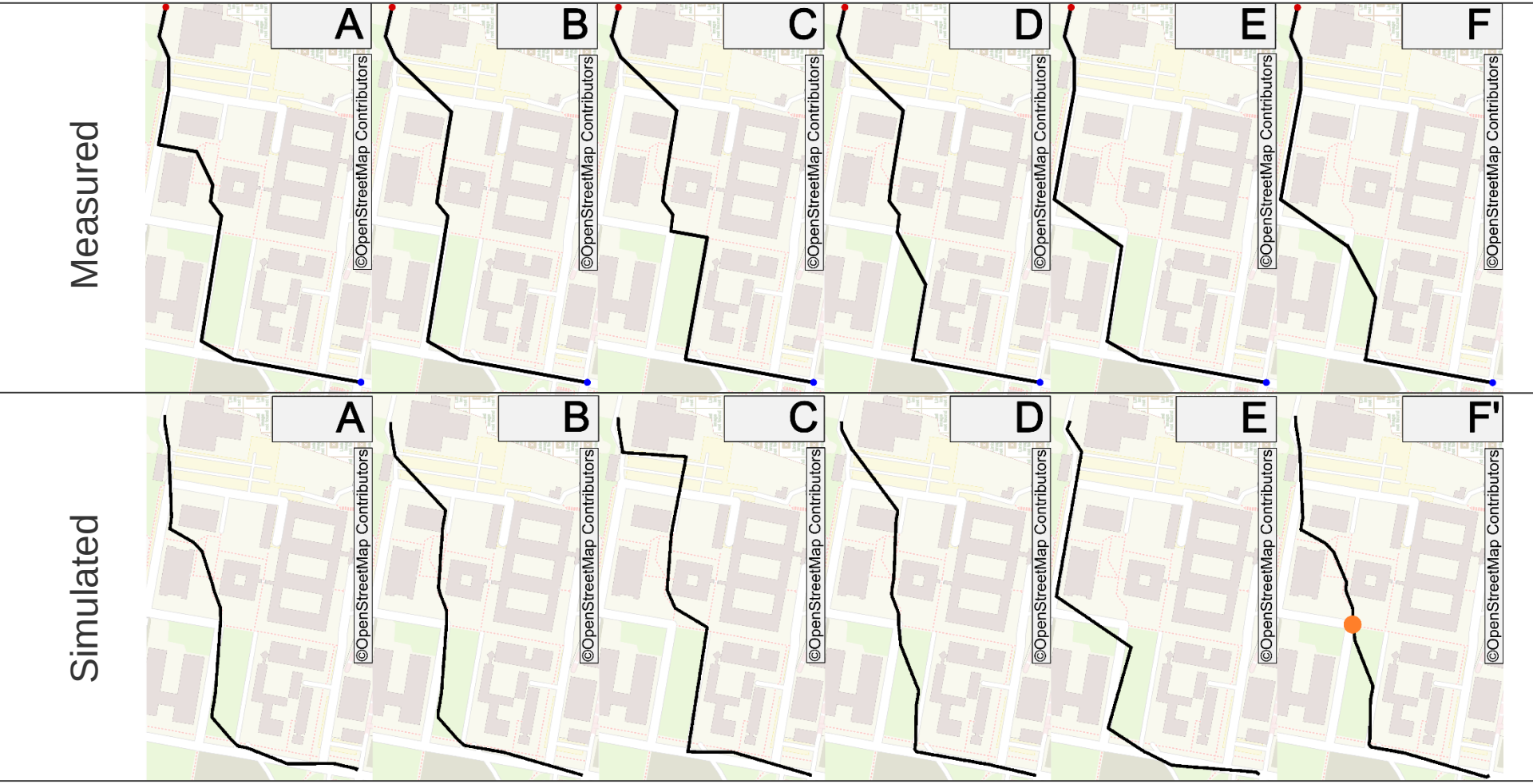
Field Study for Model Validation

- Nine routes without backtracking exist
- Visitors walked six different routes (A to F)

- Compare measured routes to simulated routes



Field Study for Model Validation



Conclusion

- New routing model
- Unifying graph-based models
- Based on spatial cognitive findings

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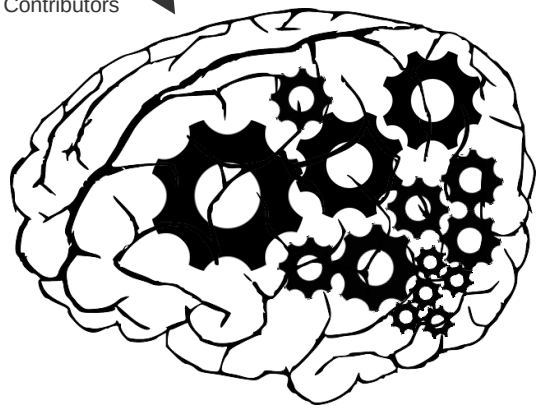
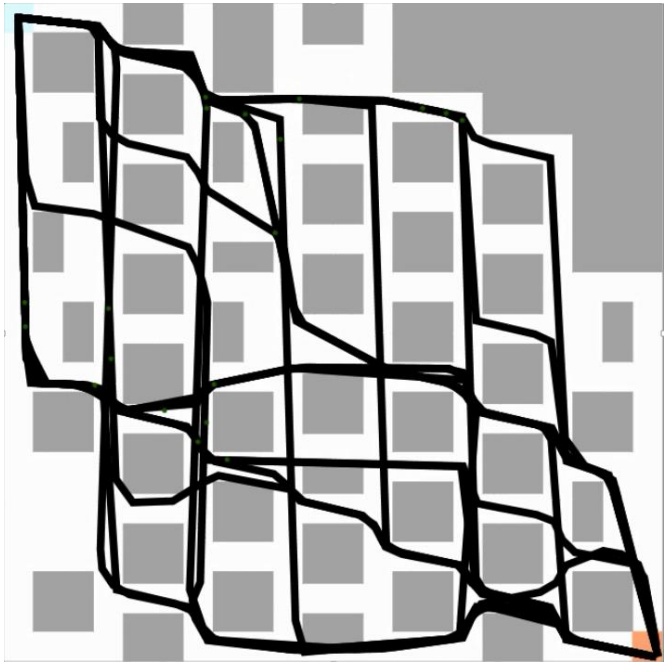


$$w_j = a \cdot w_{ij}^{FP} + b \cdot w_{ij}^{BH} + c \cdot w_{ij}^{GBH} / w_i^{GBH} + d \cdot w_{ij}^{SALL} / w_i^{SALL}$$

Conclusion

- New routing model
- Unifying graph-based models
- Based on spatial cognitive findings

- High variety of routes
- Generic calibration method

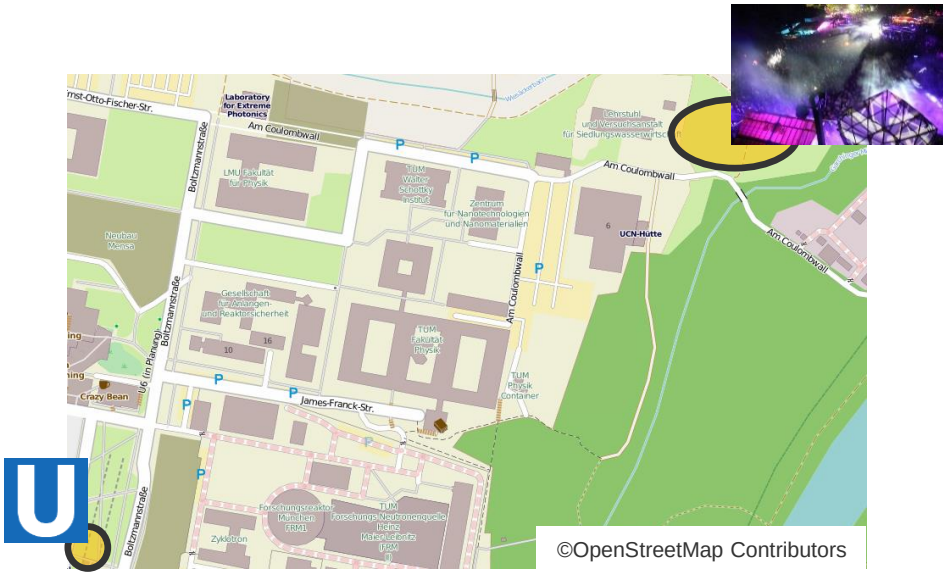


Conclusion

- New routing model
- Unifying graph-based models
- Based on spatial cognitive findings

- High variety of routes
- Generic calibration method

- Validated with data of a field studyz
- Predicted 5 out of 6 route



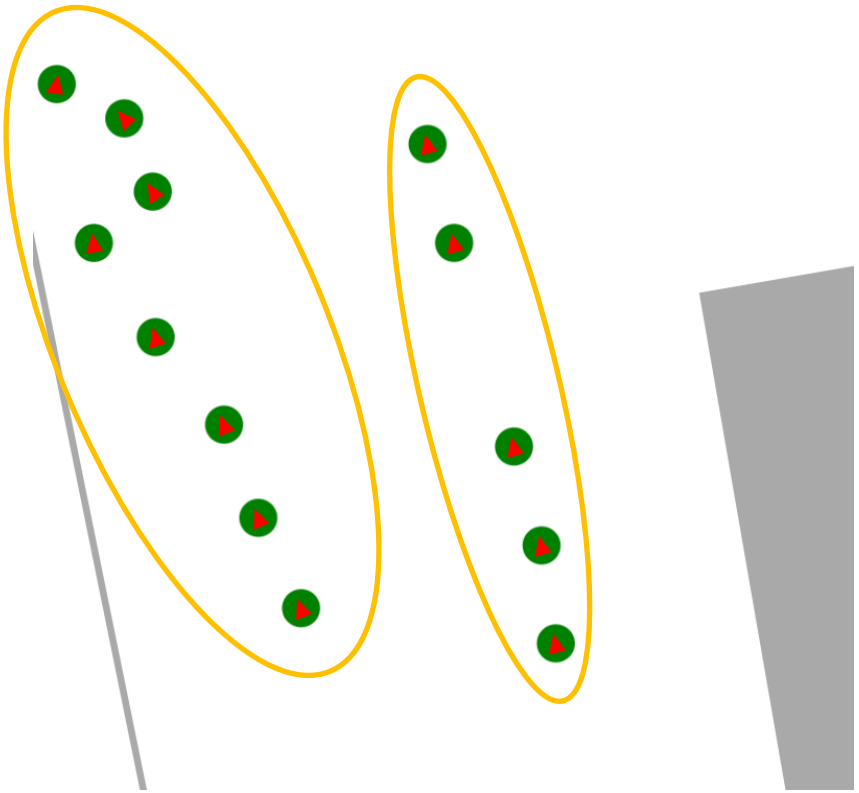
Conclusion

- New routing model
- Unifying graph-based models
- Based on spatial cognitive findings

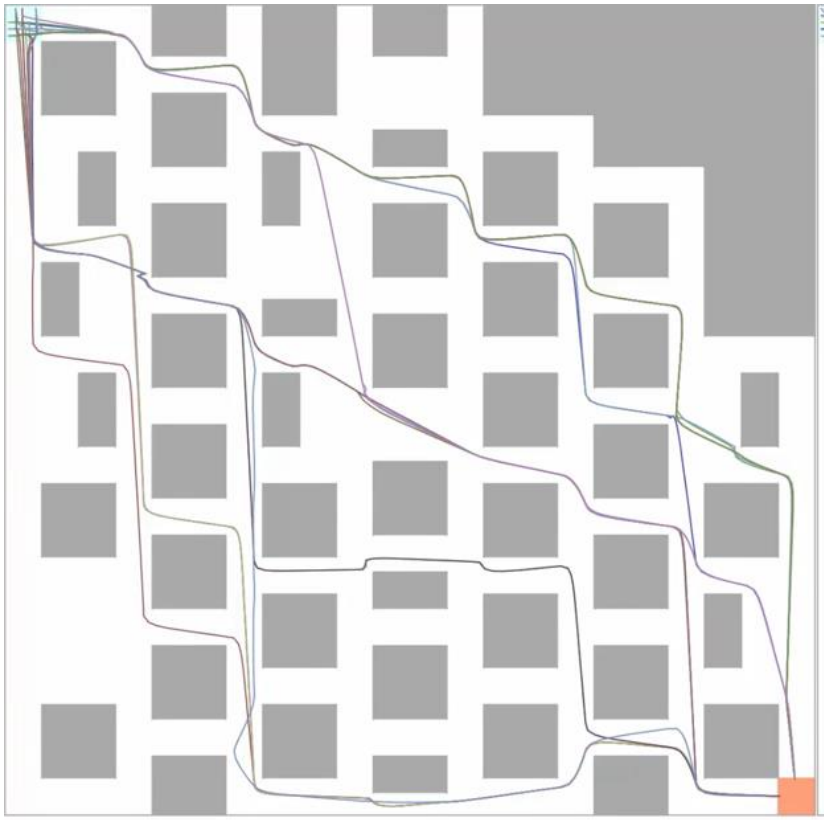
- High variety of routes
- Generic calibration method

- Validated with data of a field study
- Predicted 5 out of 6 route

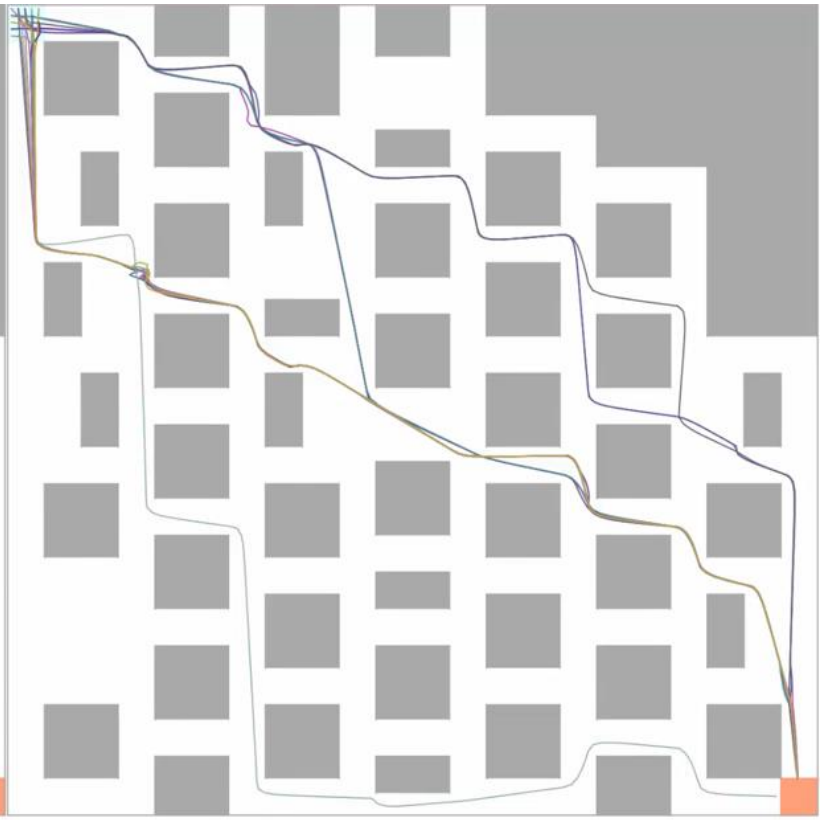
- Is there more? Social herding behavior!



Outlook



Unified Pedestrian Routing Model
without herding behavior



Unified Pedestrian Routing Model
with herding behavior

Thank you for your attention!

- Peter Kielar
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- Research Project

MultikOSi

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