# Comparing indoor and outdoor network models for automatically calculating turns

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#### **PROBLEM STATEMENT**



- Algorithms for <u>indoor</u> navigation: shortest paths
- Outdoor <u>cognitive</u> algorithms
  - Closer to natural wayfinding behaviour
  - E.g. simplest paths, simplest instructions, least risk paths
- Indoor environments induce a more challenged wayfinding (less visibility, multiple levels, disorientation)



### WHAT IS A TURN?



- Directional change from a reference line
- Not every change of direction perceived as turn → enforced deviation from current direction (Winter, 2002)
- Some turns: more important than others in navigation

Turn = directional change deviating from straight ahead by an angle of 45° or more (~Hölscher et al., 2011)

#### **CALCULATING TURNS**



- Angle measurement based on grade of slope between three consecutive nodes
- Requires coordinates of network nodes





# **OUTDOOR TURN CALCULATION (1)**



• GDF standard as outdoor network example



# **OUTDOOR TURN CALCULATION (2)**



Road with 1 Road Element & with 2 Road Elements



## **OUTDOOR TURN CALCULATION (3)**



- Road with 1 Road Element & with 2 Road Elements
- Road with no Road Elements



• Outdoor turn calculations do not induce any problems in common road and intersection situations.

**INDOOR TURN CALCULATION (1)** 





Network	Actual walking pattern	Center-Node Network	Geometric Network (room)
Path 1	6	3	4
Path 2	2	1	6

**INDOOR TURN CALCULATION (2)** 

(d) Cell-decomposed Network (c) Geometric Network (room+door) (e) Visibility-based Network Node 4 Node 4 Node 4 Node 2 Node 2 Node 2 1 A3 A2 A1 Node 3 Node 3 Node 3 Legend Legend Legend No turn point No turn point No turn point ۲ Turn point ۲ ٠ Turn point Turn point Start and endpoint ٠ Start and endpoint Start and endpoint Spatial unit Node 1 Spatial unit Node 1 Spatial unit Node 1 Door Door Door

Network	Actual walking pattern	Geometric Network (room+door)	Cell- decomposed Network	Visibility-based Network
Path 1	6	7	6	3
Path 2	2	8	6	1

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#### **INDOOR TURN CALCULATION (3)**





Indoor turn calculations do not return accurate turn calculations.



- At which point are turns calculated indoor versus outdoor?
  → Examine different decision node criteria
- Outdoor GDF standard



# **DISCUSSION (2)**



Network model	Decision node criterion	Visualization
Center-Node Network	Center of the room	
GNM (only room nodes)	Center of the room + door projections on corridor line	
GNM (room and door nodes)	Center of the room + door projections on corridor line + doors between all rooms	
Cell-decomposed model	Center of the room + door projections on corridor line + center of functional unit within a large room	
Visibility-based model	Doors between all rooms	
Actual walking pattern	Doors between all rooms and/or intermediate nodes along the visibility path	



Apply outdoor decision node criteria on indoor space





Turn calculations OK Decision nodes not necessarily linked to spatial units

#### **Centerlines through door openings**



Decision nodes sometimes outside spatial unit + not necessarily linked to spatial units



• Indoor spatial parameters influencing turn calculations





• Perception-based turn calculation algorithm for indoor spaces



No. Turns in convex spatial unit



#### CONCLUSIONS



- Goal: automatically calculating no. of turns on a network
- Comparison of several indoor and outdoor networks.
- Indoor aberrations ~ different formation of decision nodes
- Proposed network-independent turn calculation algorithm for indoor spaces



Comparing indoor and outdoor network models for automatically calculating turns

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