Routing for Humans

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I) Introduction
Urban routing for non-motorized participants

Routing for vulnerable traffic participants

- Use of the side of roads is obviously safer
- Choice of the side influences optimal path significantly
- Strongly preferred crossings at traffic lights and similar

Currently publicly accessible routing solutions

- Routing centered on roads — as if there were no cars

Using OSM data for scalable & robust routing

- Use of detailed annotations where available — now!
II) The TERRAIN Project
Part of the TERRAIN research project

Independent urban mobility for pedestrians with blindness and low vision through audio-tactile navigation

“Many no longer feel confident leaving their homes, because they don't know what obstacles they encounter outside.”

http://www.terrain-projekt.de/
Part of the TERRAIN research project

- Scene Analysis by Computer Vision
- System Evaluation & Mobility Training
- Innovative Braille Integration
- User Centered Smartphone Solution

Multi-Modal Human-Computer Interaction
Roadside-aware Safe Routing
Experts and Citizens Involvement

http://www.terrain-projekt.de/

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III) „Pedestrian Routing“ — today
„Pedestrian Routing“ option on mobile solutions

- Use of the same map data as vehicle routing
- Resulting routes often centered on roads
- Some provided routes are very dangerous

Very limited navigation instructions

- Instructions are aiming at car navigation
- No information when and where to cross
- Crossing features do not exist
„Pedestrian Routing“ on Smartphones - today

„Pedestrian Routing“ option on mobile solutions

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Current pedestrian routing services compared

**Pedestrian routings compared**

- Google and Apple Maps
  - Paths are centered on streets
  - Traffic lights or sidewalks are ignored

- OpenRouteService (GraphHopper/OSM)
  - Prefers and uses *separate, explicit* sidewalks
  - Analyzes elevation and takes soil conditions into concern
  - Switches onto street at pedestrian traffic light

**Available public services rely on (rarely) given explicitly pedestrian paths and sidewalks.**
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IV) Solutions
OpenSideWalks / AccessMap project

Sidewalks as first class citizens

- Use of many data sources (municipality, height maps, …)
- Combination and synthesis with significant resources
- Extending OpenStreetMap by OpenSideWalks proposal
- Acquisition campaigns and continuous updates
- Considering various requirements (blind, wheelchair, …)
- Emphasis on metropolitan areas
- Routing with traditional OSM path finding

**Schmitz, Ertl:** Rule-based transformation of map data

**Pedestrian paths by map transforms**

1. Pedestrian paths parallel to roads ("sidewalk"-tag(!))
2. Additional orthogonal paths at crossings


Schmitz, Ertl: Rule-based transformation of map data

Pedestrian paths by map transforms

1. Pedestrian paths parallel to roads ("sidewalk"-tag(!))
2. Additional orthogonal paths at crossings
3. Orthogonal paths at intersections
4. Topological connections of paths at intersections
5. Topological connections of paths at crossings
6. Cut off overhanging paths
7. Add paths to house entrances

Schmitz, Ertl: Rule-based transformation of map data

Pedestrian paths by map transforms

- Extension of map by missing sidewalk paths
- Applying individual cost function at transform time
- Application of global transform to „sufficiently large“ tile
- Resulting map network open for all OSM path finding

V) Transparent Expansion
**Transparent Expansion: OSM data**

**OpenStreetMap’s pedestrian paths & sidewalks**

- **Explicit pedestrian paths**
  - Pedestrian paths can be given explicitly (green lines)
  - Shared paths are defined by specific tags
  - Path quality and special conditions may be given
  - Position is explicitly defined

- **Implicit sidewalks**
  - Sidewalks are implicitly given as properties to roads (gray lines)
  - Implicit position may be estimated by heuristics and road widths

- Data quality and completeness varies a lot

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**Transparent Expansion: Topological Expansion**

*Local topological expansion of OSM network*

1. An OSM point with $n$ ways expands to $n$ virtual points

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**Transparent Expansion: Topological Expansion**

*Local topological expansion of OSM network*

1. An OSM point with $n$ ways expands to $n$ virtual points

(!) Exact position of virtual points shown only for illustration, it is **not** relevant for the algorithm

**Transparent Expansion: Topological Expansion**

**Local topological expansion of OSM network**

1. An OSM point with $n$ ways expands to $n$ virtual points
2. Paths to neighboring points and originating OSM point

[JOSM, Map data © OpenStreetMap contributors]

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- **Needed look-up is local up to next OSM neighbor**
- **Geometric path position is computed later on demand**
- **Centered paths only for dedicated pedestrian paths**

[JOSM, Map data © OpenStreetMap contributors]

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**Transparent expansion on live OSM data**

Detailed roadside-aware pedestrian routing

- Virtual path network with all roadsides and crossings
- Explicit pedestrian paths are seamlessly included
- Routing can access OSM-data and roadside information
- Path finding open to all traditional algorithms
- Crossings contain “along“ and “across“ data
- Routing cost matrix needs significant extensions
- Path preference is encoded in cost matrix only

Applications: Safe path routing, wheelchair routing, …

**Transparent Expansion:** Benchmark problem

**Results on benchmark problem**

- Routing using A* algorithm with preliminary cost matrix
- Sidewalks as well as dedicated pedestrian paths are used
- Pedestrian traffic light is chosen as suitable crossing
- Estimated sidewalk positions fit well to satellite imaging
- Given accurate GPS data, accurate guiding is feasible
- Segmenting and instruction generation in development

**Route quality dependencies**

- Cost matrix & map data quality

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VI) Online Testinterface
Testsyste
"Meин Standort" oder Ort
Suche
Reset
Klicken Sie auf die Karte um Start und Ziel festzulegen
Datum: 21.02.2019
Routing © Routago
Datenschutzverklaung, Impressum

https://routago.de/pedestrian-routing/
Testsystem
Für die Gebiete Deutschland, Österreich und Schweiz

Mein Standort oder Ort
Suche
Reset

Klicken Sie auf die Karte um Start und Ziel festzulegen!

Route
Entfernung: 5,7 km
Zeit: 68 min:
- auf Zufahrt auf linker Seite
- nach 8 m: Links auf Fußweg
- nach 147 m: Links weiter auf Fußweg
- nach 56 m: Links auf Zufahrt auf linker Seite
- nach 15 m: Rechts Zufahrt überqueren
- nach 2 m: Leicht links auf Weg
- nach 17 m: Links auf Fußweg
- nach 16 m: Geradeaus Zufahrt überqueren ohne Markierung
- nach 2 m: Geradeaus auf Fußweg
- nach 2 m: Geradeaus Zufahrt überqueren ohne Markierung
- nach 5 m: Links auf Fußweg
- nach 68 m: Rechts weiter auf Fußweg
- nach 4 m: Links weiter auf Fußweg
- nach 37 m: Geradeaus auf Plattform auf linker Seite
- nach 22 m: Geradeaus auf Fußweg
- nach 63 m: Links weiter auf Fußweg

https://routago.de/pedestrian-routing/
VII) Modes of Human Locomotion
Numerous Modes of Human Locomotion

- "Standard" pedestrian
- Hiking
- Wheelchair
- Blind pedestrians
- Young ones
- Elder persons
- Various personal e-mobility
- Multi-modal transportation

- Various distinct needs
- Regional regulation, laws and habits
- Large variety in mapping quality
Traditional programmatic approach

Programmatic weighting for each mode

- Manual modeling of demands
  - „White box“ interpretation of expert knowledge

- Exact assumptions on regional representation
  - Demand for specific tags only implemented regionally

- Either quite general or continuous manual adaption
  - Usually not feasible…
Statistical weights on annotation combinations

Statistical weights based on routing learning sets

- Directly based on expert knowledge (proposed routes)
  - No interpretation, modeling or programming needed
- Automated and robust pattern recognition
  - Exploiting mapping reality, for highly attributed and low detail areas
- Automated adaption to map or rule updates
  - Nightly weight updates using „ground truth“ expert knowledge
- Scalable to various modes of locomotion
  - Any interest group may be supported with individual weighting
- Directly applicable to additional databases
  - Accessibility cloud and municipal data

Aiming to provide good routes with what OSM provides us.
VIII) Closing Remarks
Routago App will be available very soon

Final design subject to change
Feasibility of true human locomotion routing

- OSM provides information that was not used before

Various modes of human locomotion

- Experts & interest groups aided to build learning sets

Robustness for various data quality

- Statistical approach aims at the best we can now get

Scalability for large scale use

- Local network extension on-the-fly as it is needed

Dealing with mapping fallacies or contradictions

- Bundling challenges, informing experts on problems