

On-Street Parking

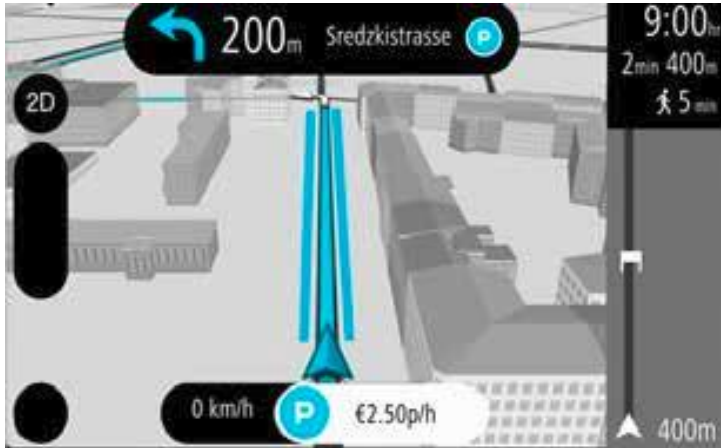
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Falk Hüffner
falk.hueffner@tomtom.com



Idea: Parking routes

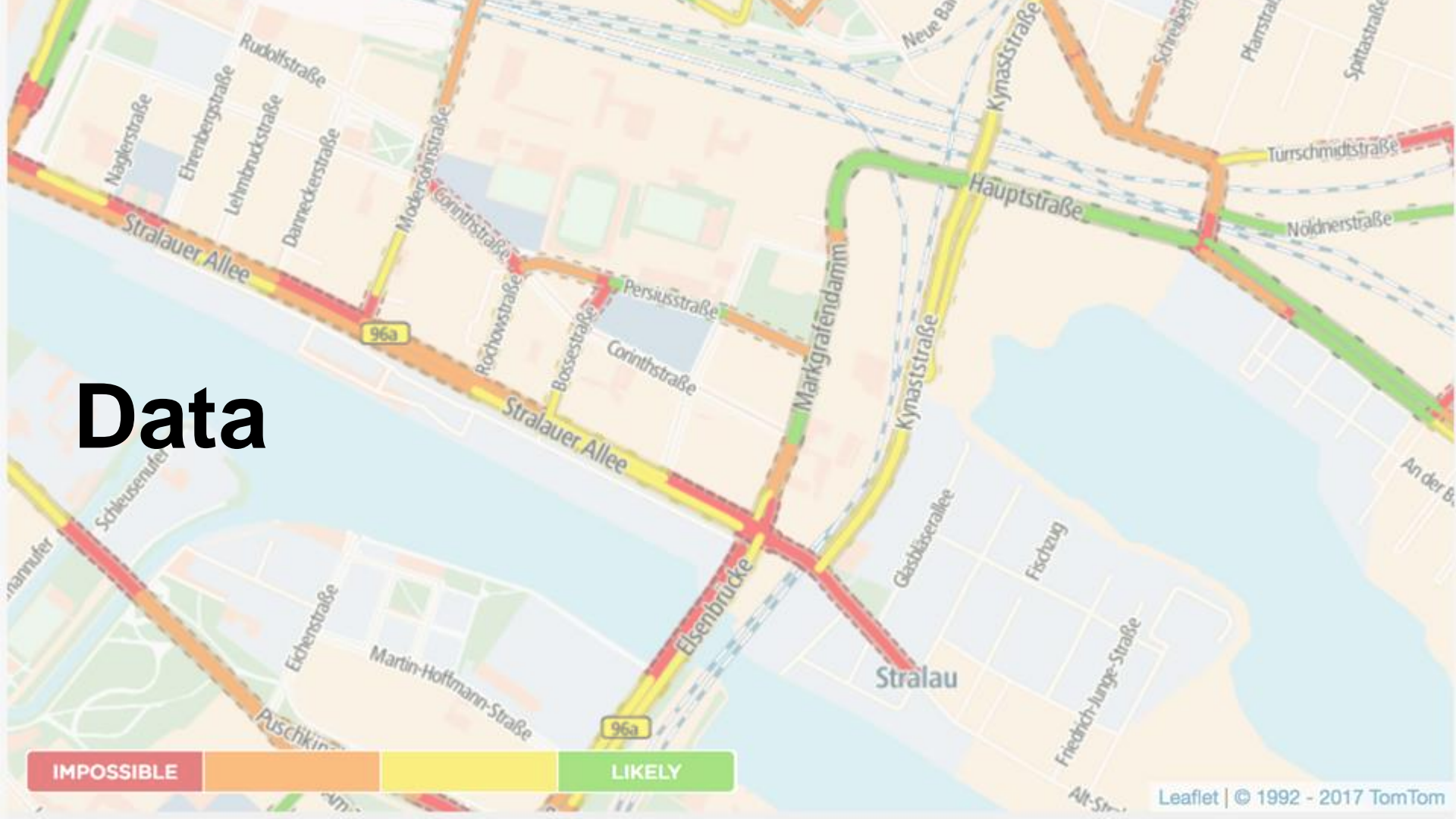
- Give turn-by-turn instructions that guide towards likely free parking spaces;
- Visualizing the parking situation on a map.



Advantages:

- Faster to find parking space
- Less stressful

Data



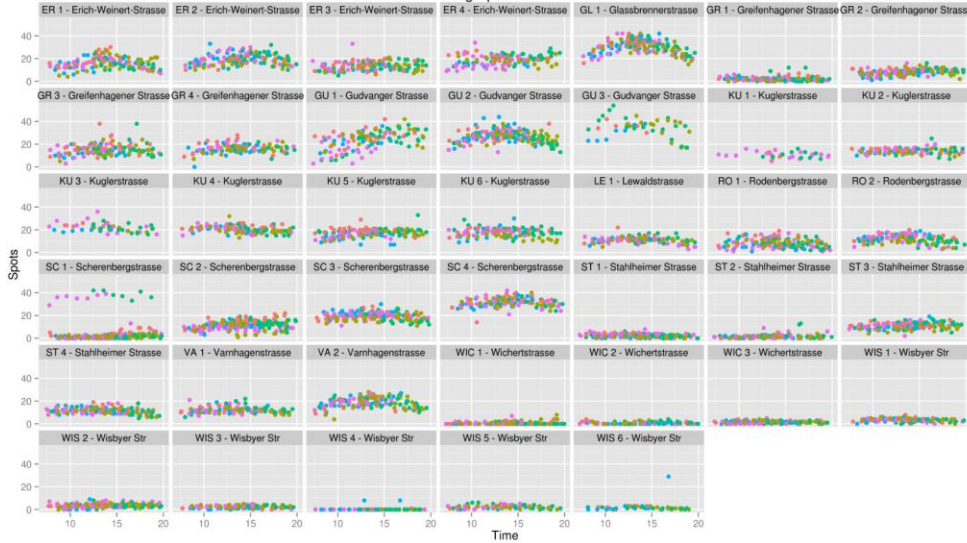
Parking probabilities

Need: For each street segment around current position, the probability that there is a parking space right now

Our approach: Use historic data; assume that parking probability depends only on time of day and day of week

Ground truth: Prenzlauer Berg

Parking Spots Over Time



Parking detection

Idea: use GPS traces from 550 million devices



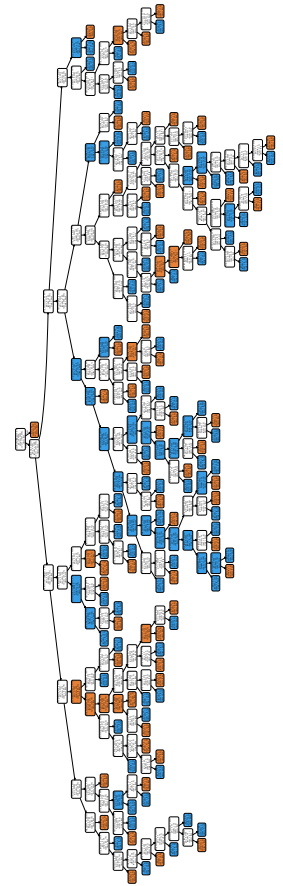
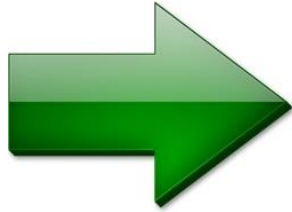
Detect: driver has found parking

Update parking probability for this time slot

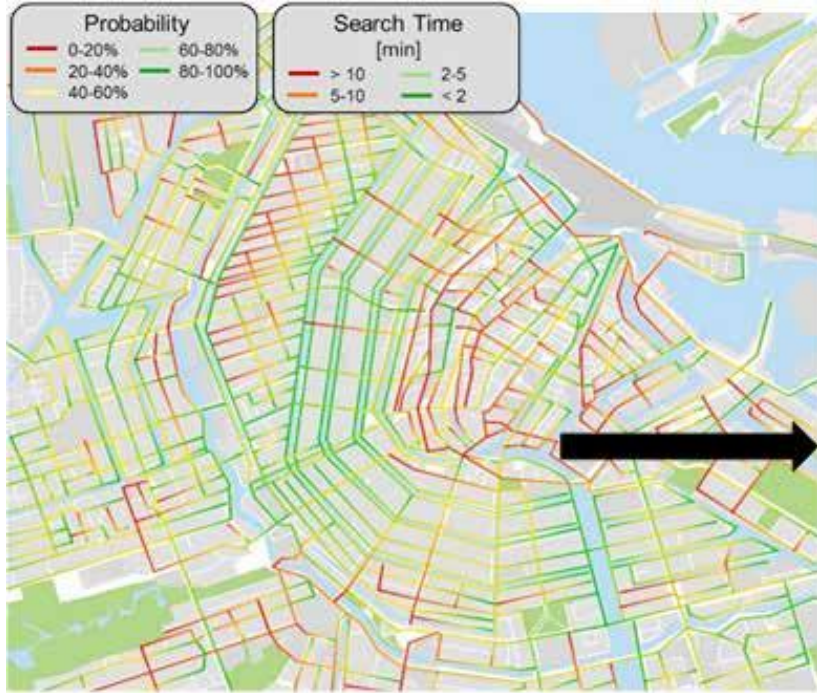
Parking detection: Filters and heuristics



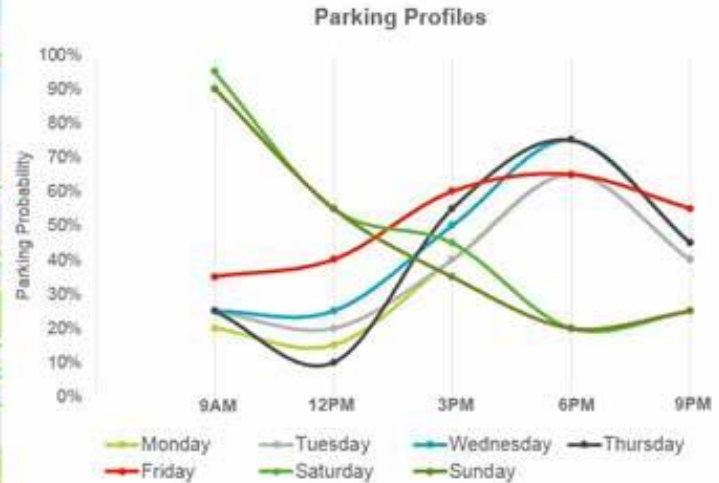
Parking Detection: Machine learning



Parking probabilities



On-Street Parking Map



Parking Profiles


Parking probabilities: API (100 cities in Europe)

<https://api.tomtom.com/parkingprobabilities/v1/nl/amsterdam/probabilities?key=e554a8c8-9e33>



```
<roadSegment>
  <uuid>00000000-069f-6d7a-017f-78b7f701185b</uuid>
  <hourlyData>
    <hourOfDay>0</hourOfDay>
    <parkingProbability>0.10</parkingProbability>
  </hourlyData>
  ...
```

9:10
10 min

 Eberswalder Strasse

Parking Routes



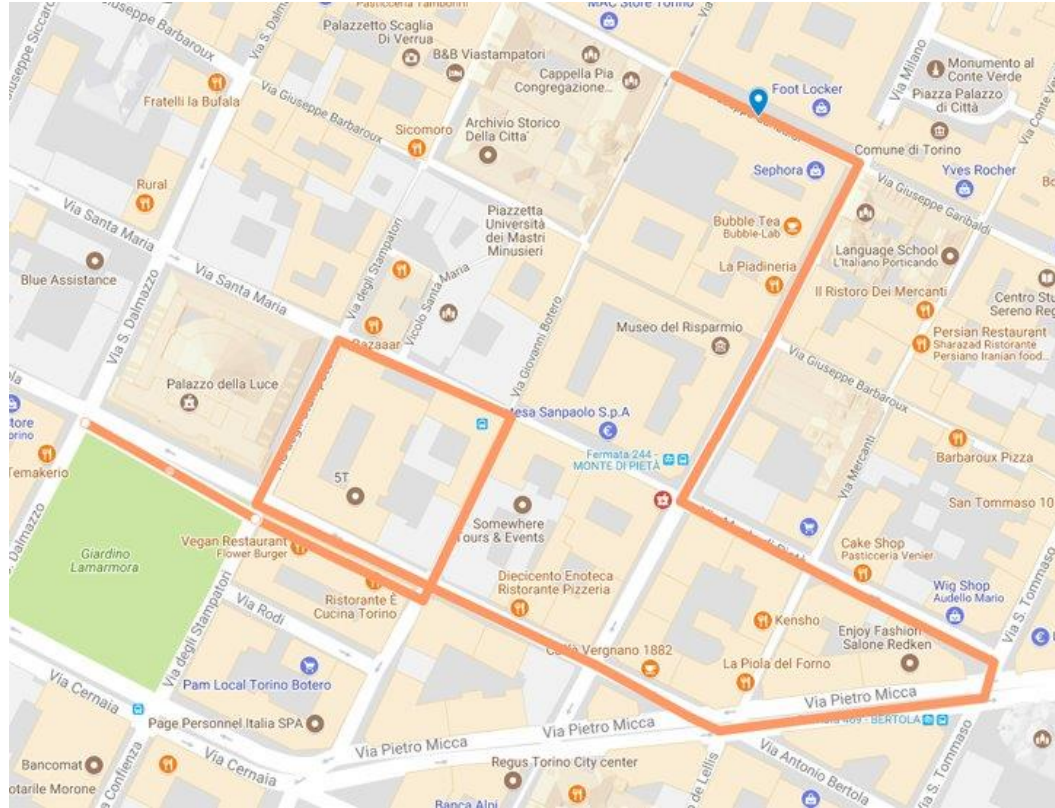
⋮ Menu

Parking route ON 



400m

Parking routes



Visualization by Google Maps

Parking routes: mathematical model

Objective: minimize expected driving and walking time

Input:

- Directed graph representing the road network
- Current location as a vertex in the graph
- For each arc:
 - Probability that we'll find parking there
 - Time to drive through it
 - Time to walk from this arc to the destination

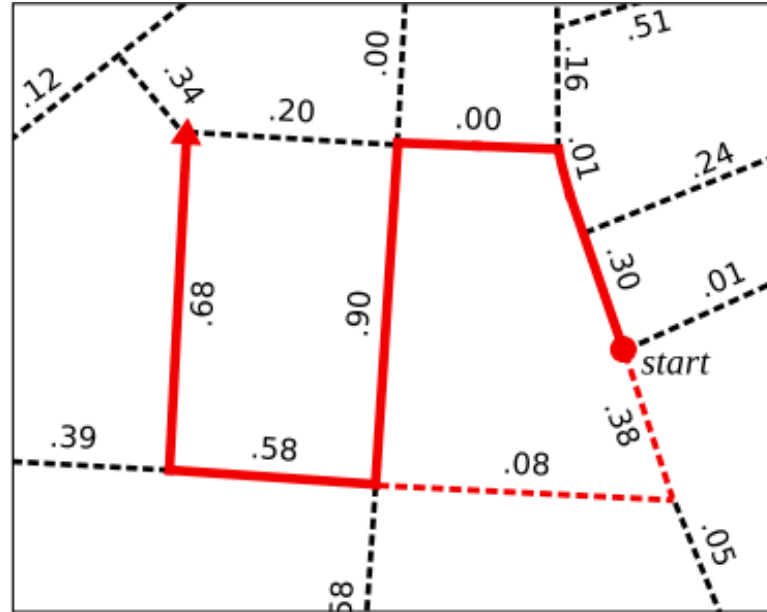
Output: Path starting in current location that minimizes objective

Arndt et al.: Probabilistic routing for on-street parking search, ESA 2016

Parking routes: mathematical model

Problem as formalized is NP-hard

Greedy (red dashed)
not doing so well



Arndt et al.: Probabilistic routing for on-street parking search, ESA 2016

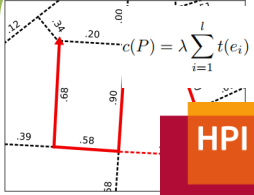
Parking routes: algorithm

Breadth-first-search strategy:

- Set of paths is seeded with empty path
- Path p from set is selected
- All possibilities of extending p by one arc are generated and added to the set, unless they exceed a maximum length
- Best ever recorded path is returned.

Arndt et al.: Probabilistic routing for on-street parking search, ESA 2016

Parking routes



$$c(P) = \lambda \sum_{i=1}^l t(e_i) \cdot \left(\prod_{\substack{j=1: \\ \forall k < j: e_j \notin D(e_k)}}^{i-1} (1 - p(e_j)) \right)$$

HPI Hasso Plattner Institut
IT Systems Engineering | Universität Potsdam

Algorithm



```
ParkingRoute  
BfsParkingRouteBuilder::build()  
{  
  std::set<Parking  
  const std::vecto  
  {(iParkingRouteC  
  const auto initi  
  CalculateParking  
  ParkingRouteW  
  {initialArcs,  
  }
```



NAVKIT

Prototype



Drive Tests

Thanks to...



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- C++ Software Engineer (Berlin)