Multi-Modal Route Planning in Road and Transit Networks

Daniel Tischner

Master's thesis
SS 18
Contents

- What's it about?
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What's it about?

- Finding *optimal* route from A to B

- Road networks
  - Well understood, many algorithms
  - Dijkstra, A*, ALT, Arc-Flags, CH, SHARC, CHASE, HLC, TNR

- Public Transit networks (train, bus, tram, ...)
  - Differ a lot from road networks
  - Transfer Patterns, RAPTOR, CSA
What's it about?

- Multi-modal routing
  - Combining road and transit networks

- Hard to combine
  - Algorithms exploit network properties
  - Network structure is very different

- Access Node Routing
  - Compute route piecewise in isolated networks
Models

- Road graph
  - Nodes: Road junctions
  - Edges: Roads connecting the junctions
Models

- Transit graph (realistic time expanded)
  - One node per event
    - arrival
    - departure
    - transfer
  - Edges indicating
    - traveling
    - transfer
Models
Models

- Link graph
  - Find road node for every transit stop
    - For example: nearest
  - Link edges
    - From road node to
    - all arrival nodes of transit stop

- Graph based combined network
Models

- **Timetable**
  - non-graph based transit network
  - tuple \((S, T, C, F)\)

- **Stops** \(S = \{ f, o, k \}\)

- **Trips** \(T = \{ t_{104}, t_{17024}, t_{17322}, t_{79} \}\)
Models

- **Connections C**
  - (f, o, 3:56 pm, 4:28 pm, t104)
  - (o, k, 4:29 pm, 4:58 pm, t104)
  - (f, o, 4:03 pm, 4:50 pm, t17024)
  - (o, k, 4:35 pm, 5:19 pm, t17322)
  - (k, f, 7:10 pm, 8:10 pm, t79)

- **Footpaths F**
  - (f, 300, f)
  - (o, 300, o)
  - (k, 300, k)
Routing

- Multi-modal route planning
  - Combining road and transit networks
  - Queries have transportation mode restrictions

- Modified Dijkstra
  - Simple baseline
  - Runs on Link graph
  - Combinable with optimizations (A*, ALT, ...)

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Routing

- Access Node Routing
  - Generic approach
  - Piecewise computation on isolated networks
  - Any road algorithm for road network (ALT)
  - Any transit algorithm for transit network (CSA)

- Access nodes for A and B
  - A and B in road network
  - Access nodes in transit network
Routing

- **Good access nodes**
  - Difficult to find, focus of research
  - Simple solution: \( k \)-nearest nodes (\( k = 3 \))

- Route consists of
  - A to access nodes (road network)
  - Access nodes of A to access nodes of B (transit network)
  - Access nodes to B (road network)
Routing
Experiments

- Generic route planning framework Cobweb
  - Data formatted as OSM or GTFS
  - Database for metadata
  - Represented in models (with serialization)
  - Extensive configuration and documentation

- Several algorithms
  - Dijkstra, A*, ALT,
  - CSA,
  - Modified Dijkstra, ANR,
  - Cover Trees,
  - Fuzzy prefix search
Experiments

- Model sizes

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Experiments

- Dijkstra rank
  - Measure for distance
  - The higher the rank, the greater the distance

- Experiments
  - Time independent (Dijkstra, A*, ALT)
  - Time dependent (Dijkstra, CSA)
  - Multi-modal (Modified Dijkstra, ANR)
Experiments

- Bad scaling for increasing range
- $A^*$ is bad, ALT can perform better
Experiments

- CSA is way faster than Dijkstra
- CSA is viable
Experiments

- CSA is subject to traffic congestion
Experiments

- ANR has much overhead
- If used with good algorithms, faster and feasible
Conclusion

- Multi-modal routing
  - Difficult, networks are very different

- Instead, hybrid approach
  - Isolate networks
  - Specialized algorithms for individual networks

- ANR is a promising technique
Conclusion

- However, still a lot to do
  - Turn penalties
  - Multi-criteria routing
  - Complex transportation mode restriction models
  - Integrating real-time data

- Many subproblems
  - Leading to many specialized techniques
  - So far, no viable approach that addresses all problems
Related links

- **Cobweb, a multi-modal journey planner**
  - [https://github.com/ZabuzaW/Cobweb](https://github.com/ZabuzaW/Cobweb)

- **Route Planning in Transportation Networks**
Related links

- **Connection Scan Algorithm**

- **Accelerating Multi-modal Route Planning by Access-Nodes**
  - [https://link.springer.com/chapter/10.1007/978-3-642-04128-0_53](https://link.springer.com/chapter/10.1007/978-3-642-04128-0_53)
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