MWGen: A Mini World Generator

Jianqiu Xu and Ralf Hartmut Güting

Database Systems for New Applications, Mathematics and Computer Science
FernUniversität in Hagen, Germany

July, 2012

Outline

Problem Description

- Moving objects Databases
- Moving objects with transportation modes
  1. Inferring outdoor transportation modes (e.g., cycling, walking, driving) from GPS data [1,2,3]: Geolife Project in Microsoft
  2. Advanced trip planning [4], different modes (e.g., *Walk* $\rightarrow$ *Bus*) and constraints (e.g., less than two bus transfers)

[1] Y. Zheng, L. Liu, L. Wang, X. Xie: Learning transportation mode from raw gps data for geographic applications on the WWW, 2008.
[2] Y. Zheng, Y. Chen, Q. Li, X. Xie, W.Y. Ma: Understanding transportation modes based on GPS data for web applications. ACM Transaction on the Web, 4(1), 2010.
[3] L. Stenneth, O. Wolfson, P. S. Yu, B. Xu: Transportation mode detection using mobile phones and GIS information. GIS, 2011.
[4] J. Booth, A. P. Sistla, O. Wolfson, I. F. Cruz: A data model for trip planning in multimodal transportation systems. EDBT, 2009.

Problem Description

- Example trips
  1. *Indoor* $\rightarrow$ *Walk* $\rightarrow$ *Car*
  2. *Bus* $\rightarrow$ *Walk* $\rightarrow$ *Indoor*

- Global Work: Represent and manage moving objects with different transportation modes in a database system and provide efficient query processing.
  1. Data Model: J. Xu and R.H. Güting. A Generic Data Model for Moving Objects, Geoinformatica, 2012.
  2. **Data Generator: J. Xu and R.H. Güting. MWGen: A Mini World Generator, MDM, 2012.**
  3. Benchmark: J. Xu and R.H Güting. GMOBench: A Benchmark for Generic Moving Objects, Informatik-Report 362, FernUni in Hagen, Germany, 2012.

Problem Description

- The goal: Generating moving objects in different environments where (1) the precise location in each environment and (2) transportation modes are managed.

- Existing data generators for moving objects
  1. free space: GSTD [1], BerlinMOD [2]
  2. road network: [3]
  3. indoor: [4]

[1] Y. Theodoridis, J. R. O. Silva, M. A. Nascimento: On the Generation of Spatiotemporal Datasets. SSD, 1999.
[2] C. Düntgen, T. Behr, R.H. Güting: BerlinMOD: a benchmark for moving object databases. VLDB J. , 18(6):1335-1368, 2009.
[3] T. Brinkhoff, A Framework for Generating Network-Based Moving Objects. GeoInformatica 6(2):153-180, 2002.
[4] C. S. Jensen, H. Lu, B. Yang, Indexing the Trajectories of Moving Objects in Symbolic Indoor Space. SSTD, 2009.

Method

1. Preliminary
2. Framework
3. Trip plannings
4. Moving objects generation
5. Experimental results

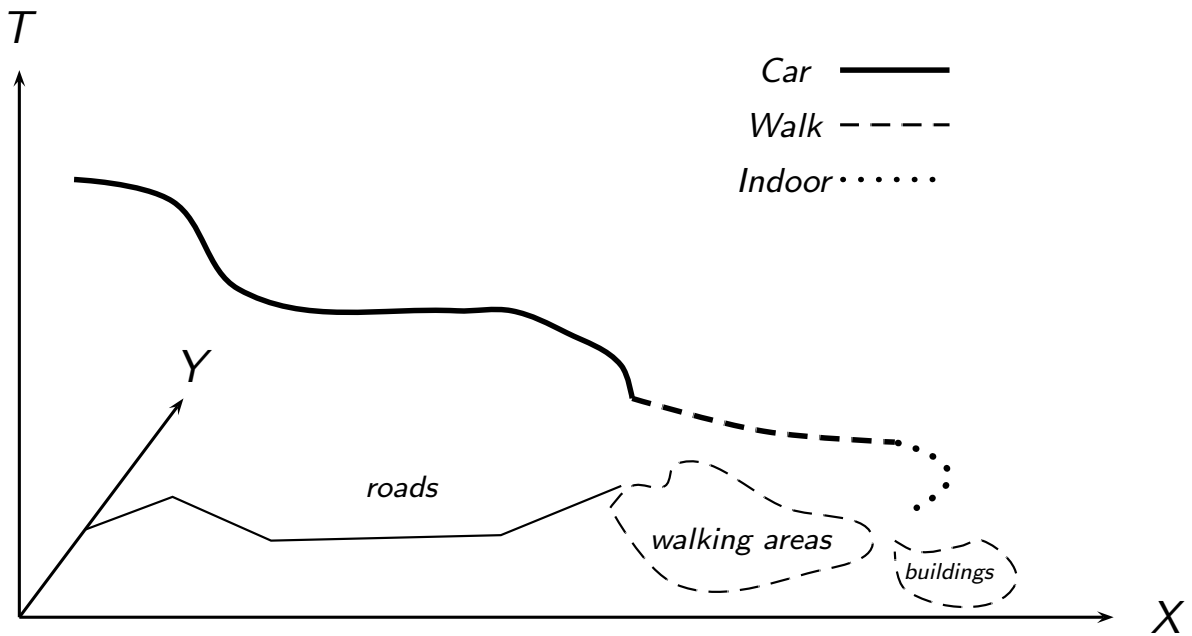
Method - Preliminary

- Available environments
  1. Road Network
  2. Region-based Outdoor
  3. Bus Network and Metro Network
  4. Indoor
- Transportation modes
  $TM = \{Car,\ Taxi,\ Bike,\ Walk,\ Bus,\ Metro,\ Indoor\}$

Method - Preliminary

- Data representation (location and moving objects)

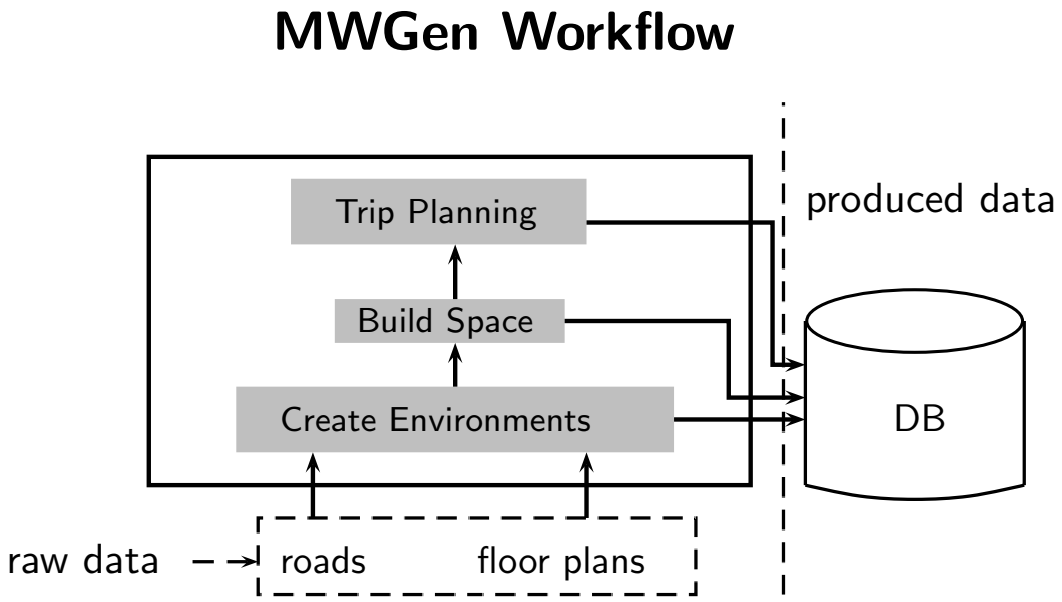
  (1) $D_{\underline{genloc}} = \{(oid, (loc_1, loc_2)) | oid \in D_{\underline{int}}, loc_1, loc_2 \in D_{\underline{real}}\}$
  (2) $mo = < u_1, u_2, ..., u_n >$ where $u_i = (t, gl_1, gl_2, m)$, $gl_1, gl_2 \in D_{\underline{genloc}}$, $m \in D_{\underline{TM}}$



$mo = <u_1(t_1,$ Indoor_loc1, Indoor_loc2, *Indoor*$), \ldots, u_i(t_i,$ Pave_loc1, Pave_loc2, *Walk*$), \ldots, u_n(t_n,$ Road_loc1, Road_loc2, *Car*$)>$

Method - Framework

- Framework



- **Input**:
  1. a set of roads represented by lines
  2. floor plans
  3. parameters such as road width
- **Output**:
  1. Environments: Road Network, Region-based Outdoor, Bus Network, Metro Network, and Indoor
  2. Moving objects with multiple transportation modes such as *Indoor* $\rightarrow$ *Walk* $\rightarrow$ *Bus* $\rightarrow$ *Walk*

Method - Framework

$$
\left.
\begin{array}{rr}
roads \rightarrow & Road\ Network \\
 & Region-based\ Outdoor \\
roads + parameters \Rrightarrow & Bus\ Network \\
 & Metro\ Network \\
floor\ plans \rightarrow & Indoor
\end{array}
\right\} \text{Space}
$$

1. Road Network: roads and junctions
2. Region-based Outdoor: pavements and zebra crossings
3. Bus and Metro Network: routes, stops and moving buses (metros)
4. Indoor: rooms, corridors, staircases and doors.

Method - Framework

$$
\begin{array}{rrl}
roads \rightarrow & Road\ Network & \\
 & Region-based\ Outdoor & \\
roads + parameters \Rrightarrow & Bus\ Network & \} \ \text{Space} \\
 & Metro\ Network & \\
floor\ plans \rightarrow & Indoor &
\end{array}
$$

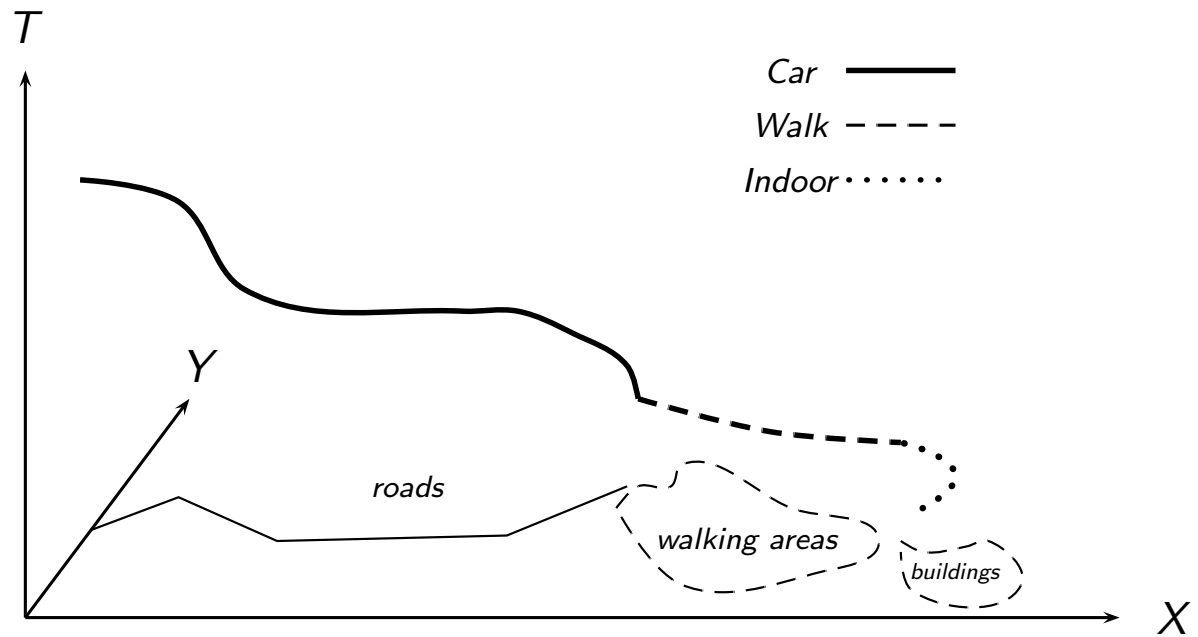
- An Environment
  1. the object set
  2. indices (B-tree and R-tree)
  3. a graph for routing
- Space
  1. managing each environment
  2. location mapping (e.g., bus stop)
  3. an interface between moving objects and underlying geographic objects such as roads, bus routes and rooms

Method - Trip Planning

- Trip Planning
  - One environment
    1. shortest path searching in a road network
    2. shortest path searching for pedestrians (a large polygon with obstacles)
    3. routing in a bus network (combine bus and walk movements); routing in a metro network
    4. indoor navigation (precise path inside a building)
  - Time Complexity Analysis
  - Multiple environments (graphs and location mapping):
    1. $Indoor \rightarrow Walk \rightarrow Car \rightarrow Walk$
    2. $Walk \rightarrow Bus \rightarrow Walk \rightarrow Indoor$

Method - Moving Objects Generation

- Moving Objects Generation: paths + speed values



Method - Experimental Results

- Results

Input

Roads	Berlin (3,250); Houston (4,575)
Floor plans	office building, shopping mall, university... (8 in total)
Parameters	road width, pavement width, etc.

Output

	Berlin	Houston
X Range	[0, 44411]	[0, 133573]
Y Range	[0, 34781]	[0, 163280]
No. Vertices in P	116,516	437,279
Bus Routes	89	92
Metro Routes	10	16
Buildings	4,996	5,992

Trip No.	Berlin		Houston	
	Time (h)	Size (GB)	Time (h)	Size (GB)
4k	0.32	0.052	0.57	0.038
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
500k	39.75	6.35	74.06	4.95

Moving objects with different transportation modes:
Walk + *Indoor* + *Car*(*Taxi*, *Bus*, *Metro*)

Time Cost (sec) for Outdoor Trip Planning

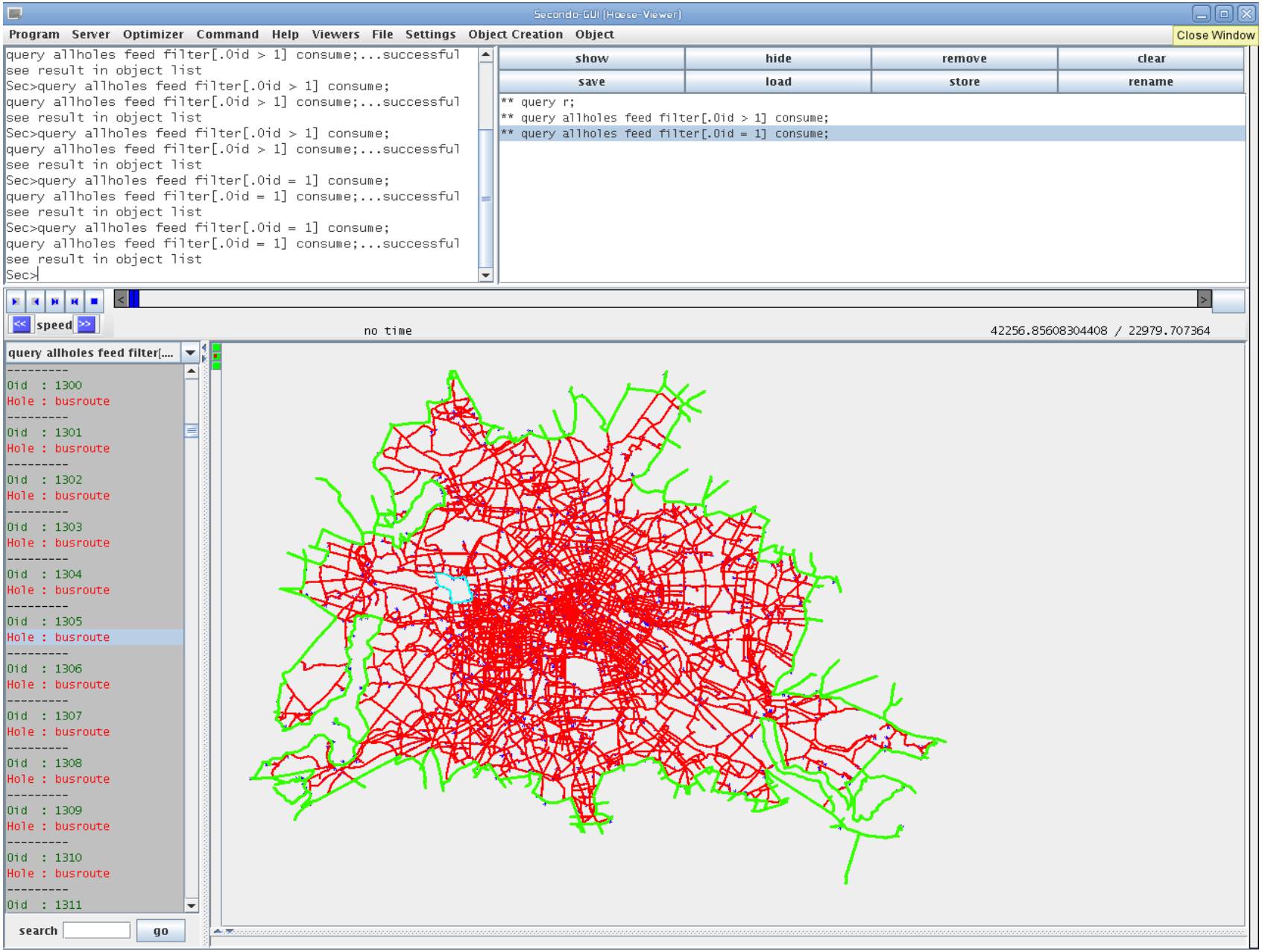
	Berlin	Houston
Region-based Outdoor	0.78	2.4
Bus Network	0.13	0.23
Metro Network	< 0.1	< 0.1

Time Cost (sec) for Indoor Navigation

officeA	0.25	officeB	0.27
mall	0.37	cinema	0.32
hotel	1.57	hospital	0.35
university	0.123	trains station	0.1

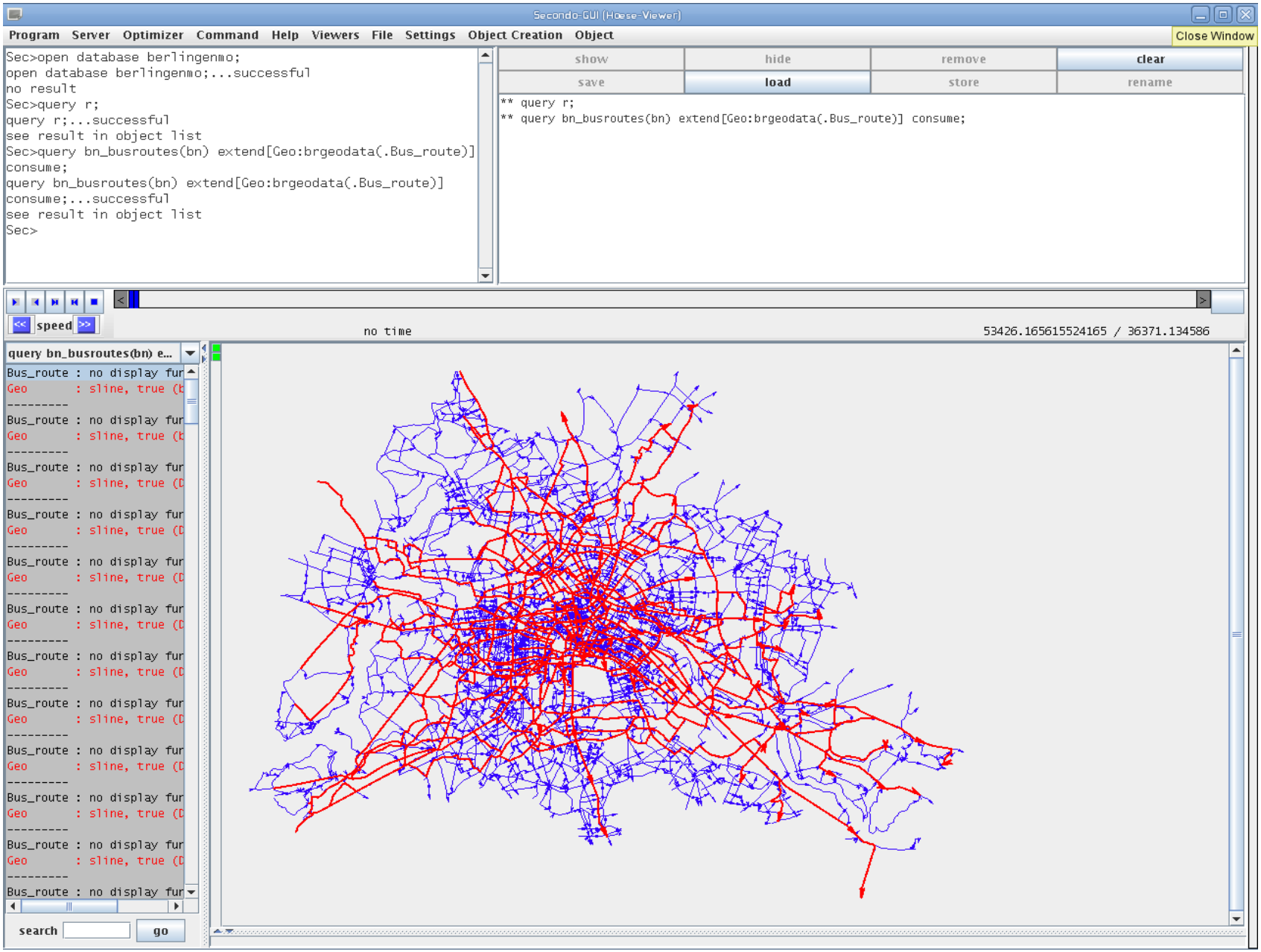
Method - Experimental Results

Berlin: Pavements



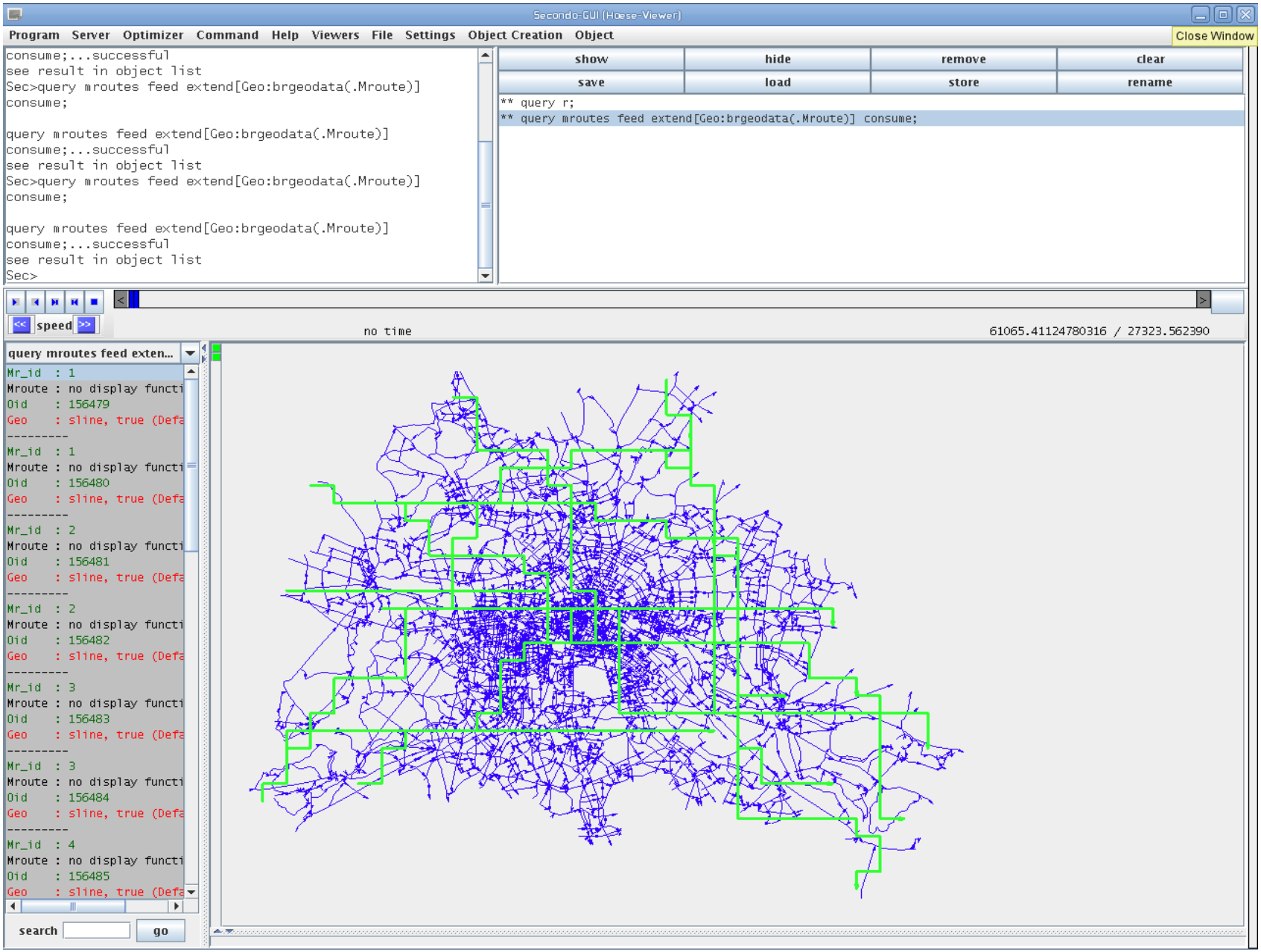
Methods and Solutions – MWGen

Berlin: Roads + Bus Routes



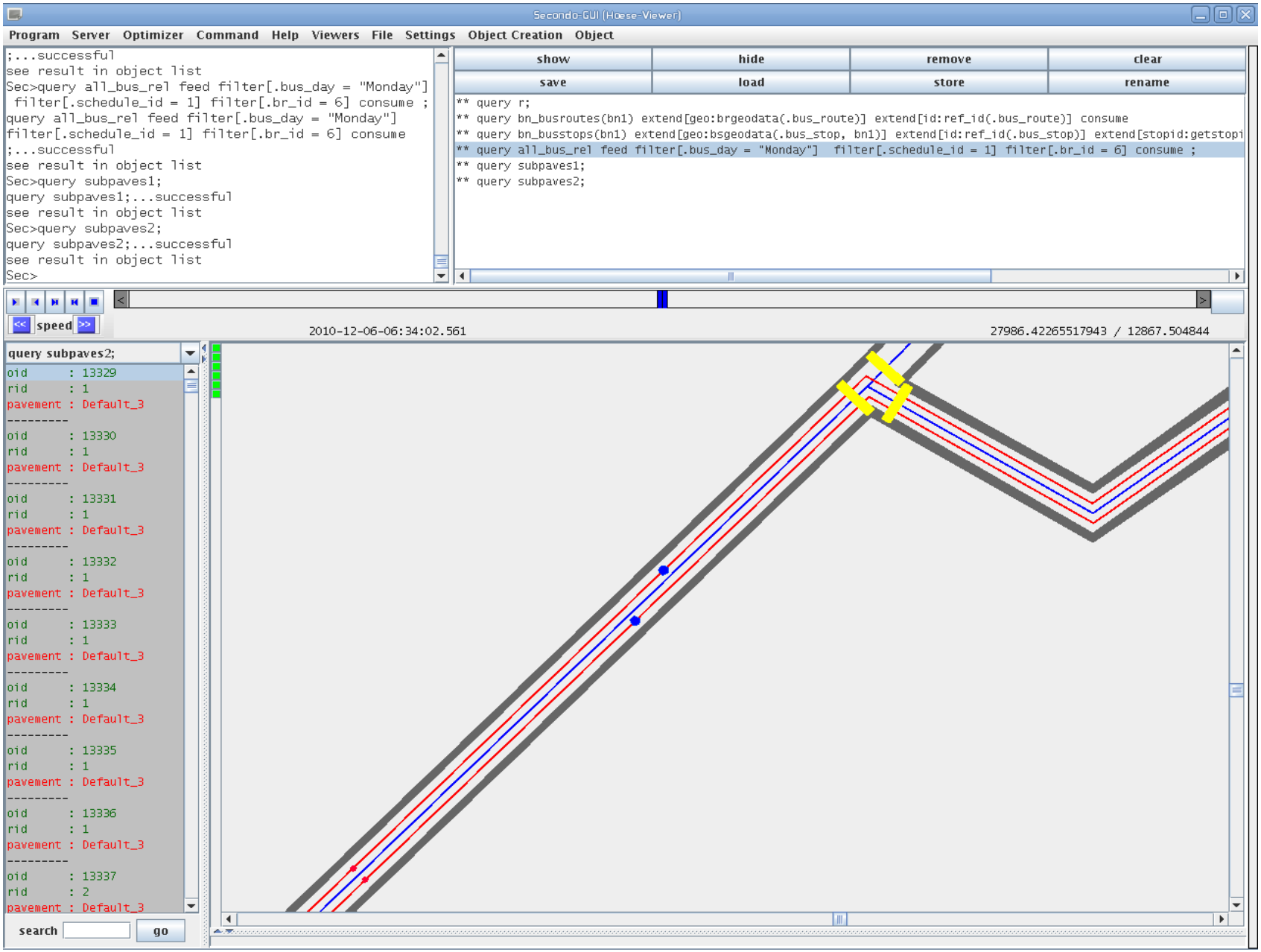
Methods and Solutions – MWGen

Berlin: Roads + Metro Routes

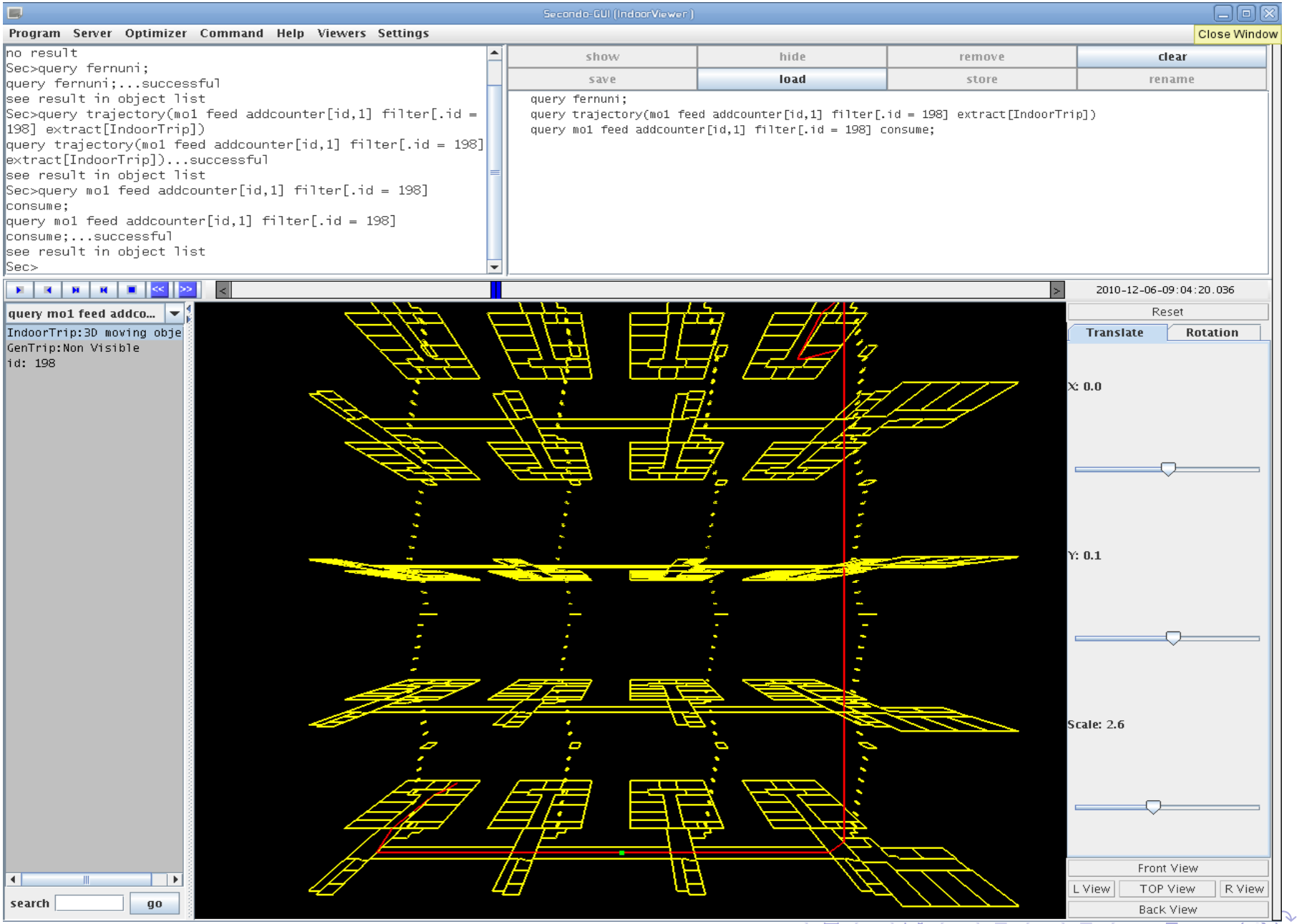


Methods – MWGen

Berlin: A Close View (pavements, zebra crossings, bus routes, roads)



Method - Experimental Results



Conclusions

- Conclusion
  We developed a tool called MWGen that can
  1. create the following environments road network, region-based outdoor, bus network, metro network, and indoor based on roads and floor plans;
  2. provide trip plannings in one environment and multiple environments;
  3. generate moving objects with multiple transportation modes based on the result of trip plannings.
- Future Work
  1. Creating moving objects by considering human movement patterns such as home↔work, work↔work, nearest neighbor searching.
- Transportation Mode Web Page:
  http://dna.fernuni-hagen.de/secondo/TransportationMode/TM.html

Thank you !