Sensitivity analysis of the MATSim transport model

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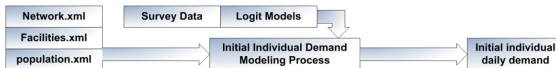[3] UMR CNRS 8504 Géographie-cités

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Urban transportation models

MATSim model: heterogenous data and integration of many sub-models

(a) scenario creation: transport network / locations, capacities and opentimes for activities / synthetic population

(b) initial individual demand modeling: complete daily demand for each individual of the scenario
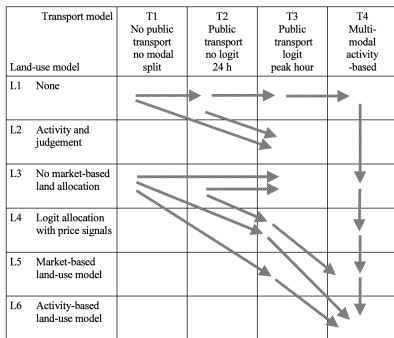
(c) demand optimization: systematic relaxation process to optimize user specified parts of the daily demand, i.e. route, departure time and activity duration choice

(d) statistical analysis: dynamic traffic volumes / work place occupation density / spider analysis / winner-looser statistics / dynamic traffic visualization / counts comparison / etc.

Source: [Balmer et al., 2009]

Land-use transport models as a progressive complexification through coupling of detailed sub-models

Transport model / Land-use model	T1 No public transport no modal split	T2 Public transport no logit 24 h	T3 Public transport logit peak hour	T4 Multi-modal activity -based
L1 None				
L2 Activity and judgement				
L3 No market-based land allocation				
L4 Logit allocation with price signals				
L5 Market-based land-use model				
L6 Activity-based land-use model				

Models	Speed of change							
	Very slow		Slow		Fast		Immediate	
	Networks	Land use	Work-places	Housing	Employ-ment	Popula-tion	Goods transport	Travel
BOYCE	+				+	+		+
CUFM		+	+	+	+	+		
DELTA/START	+	+	+	+	+	+	+	+
HUDS				+	+	+		
IMREL	+	+	+	+	+	+		+
IRPUD	+	+	+	+	+	+		+
ITLUP	+	+			+	+		+
KIM	+				+	+	+	+
LILT	+	+	+	+	+	+		+
MEPLAN	+	+	+	+	+	+	+	+
METROSIM	+	+	+	+	+	+		+
MUSSA	+	+			+	+		+
POLIS		+			+	+		+
RURBAN		+			+	+		+
STASA	+	+	+	+	+	+	+	+
TRANUS	+	+	+	+	+	+	+	+
URBANSIM		+	+	+	+	+		+

Source: [Wegener and Fürst, 2004]

[Zhuge et al., 2019]

MATSim model integration

Modular four-step multimodal transportation model using open source projects and data

Integrated models:

- MATSim model (MATSim Community) for the transportation system
  https://www.matsim.org/ [W Axhausen et al., 2016]
- SPENSER model (University of Leeds) for the synthetic population
  https://github.com/nismod/microsimulation
- QUANT model (CASA, University College London) for spatial
  interactions to generate home-work plans
  http://quant.casa.ucl.ac.uk/ [Batty and Milton, 2021]
- spatialdata library (OpenMOLE community) for data processing
  https://github.com/openmole/spatialdata
  [Raimbault et al., 2020]

Data:

Generic for any Functional Urban Area (GHSL [Florczyk et al., 2019]) or any arbitrary area in the UK: NOMIS census, OrdnanceSurvey roads, Traveline National Dataset for public transport

Workflow systems:

- DAFNI facility funded by UKCRIC https://dafni.ac.uk
- OpenMOLE software https://openmole.org/ [Reuillon et al., 2013]

Implementation

- Synthetic SPENSER population distributed at the micro level using OSM buildings
- QUANT model to generate home-work commuting flows, job locations determined by sampling flows
- Network and plans (simple uniform commuting plans) prepared into MATSim xml files and fed into a multimodal MATSim model
- Models integrated as Docker containers

$\rightarrow$ Road network preprocessing: implemented into the `spatialdata` scala library [Raimbault et al., 2020]

GHS FUAs

OS Roads tiles

Merge for queried FUA

Construct topological network
Export to MATSim xml
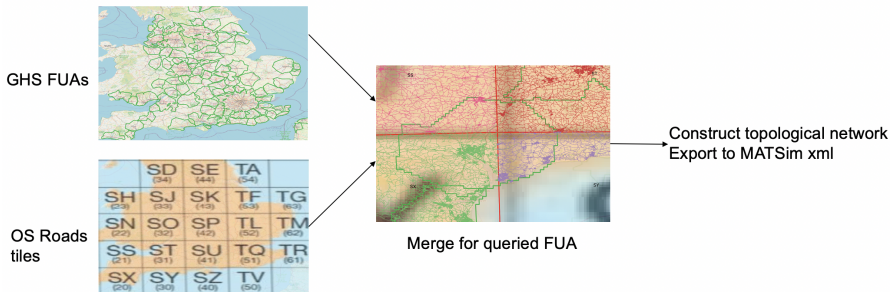
$\rightarrow$ Public transport data: from TransXchange (TNDS) to GTFS using UK2GTFS R package [**?**]; GTFS to MATSim xml schedule using `pt2matsim` library

OpenMOLE workflow engine

OpenMOLE model exploration open source software
[Reuillon et al., 2013]

*Enables seamlessly (i) model embedding; (ii) access to HPC resources;
(iii) exploration and optimization algorithms*

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https://openmole.org/
```

Parameter sampled for the sensitivity analysis:

- Functional Urban Area (spatial context [Raimbault et al., 2019])
- Random seed (influence of stochasticity [Bienzeisler et al., 2021])
- Synthetic population sampling share
- Modal choice parameters [Hörl, 2021]: mode constants in scoring function (car, public transport, walking)

FUA: Taunton
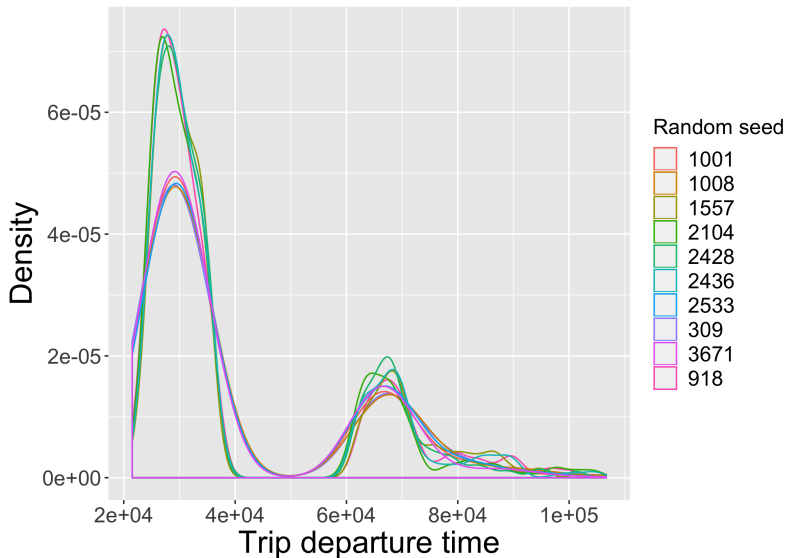
Method based on the estimation of conditional relative variances
[Saltelli et al., 2010]

First order index

$$S_i \frac{Var\left[E_{\mathbf{X}_{\sim i}}Y|X_i\right]}{Var\,Y}$$

is the expected relative variance reduction if X_i would be fixed

Total effect index

$$ST_i \frac{E_{\mathbf{X}_{\sim i}}\left[Var\,Y|\mathbf{X}_{\sim i}\right]}{Var\,Y}$$

is the expected relative variance if all factors but X_i are fixed (includes interaction effects)

$\rightarrow$

$\rightarrow$

Open repositories

https://github.com/JusteRaimbault/UrbanDynamics/Models/Matsim
for containers and workflows

https://github.com/openmole/spatialdata for data processing

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