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Route Choice Modelling for Cyclists on Dense Urban Networks

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1 Introduction

- **MOBIS-COVID dataset [1]** used to model the route choice of cyclists in Zurich, recorded through GPS-tracking app.
- Dataset includes socio-demographics and various contextual variables.
- **Mixed Logit with Path-Size [2]** correction, formulated in **Value-of-Distance space [3].**
- Choice set generation using **BFSLE algorithm [4]**, adapted to account for high network density.
- Explicit modelling of e-bikes and respective taste heterogeneity.

2 Data

- Raw GPS tracks, including **4500 cycling trajectories**.
- Trajectories come from a total of **100 respondents**, sample slightly male, educated, higher income.
- E-bikers more male, older, educated, higher income.
- Network sourced from OSM, enriched with gradients, traffic signals, speedlimits, traffic volume, bike path (separated from traffic) and bike lanes (mixed traffic).
- Map matching with HMM approach, post-match filtering based on divergence, F-score, speed-delta.
- **3602 regular bikes**, avg. speed 15.6kmh, avg. distance 2.7km
- **830 e-bikes**, avg. speed 19.5kmh, avg. distance 3.5km

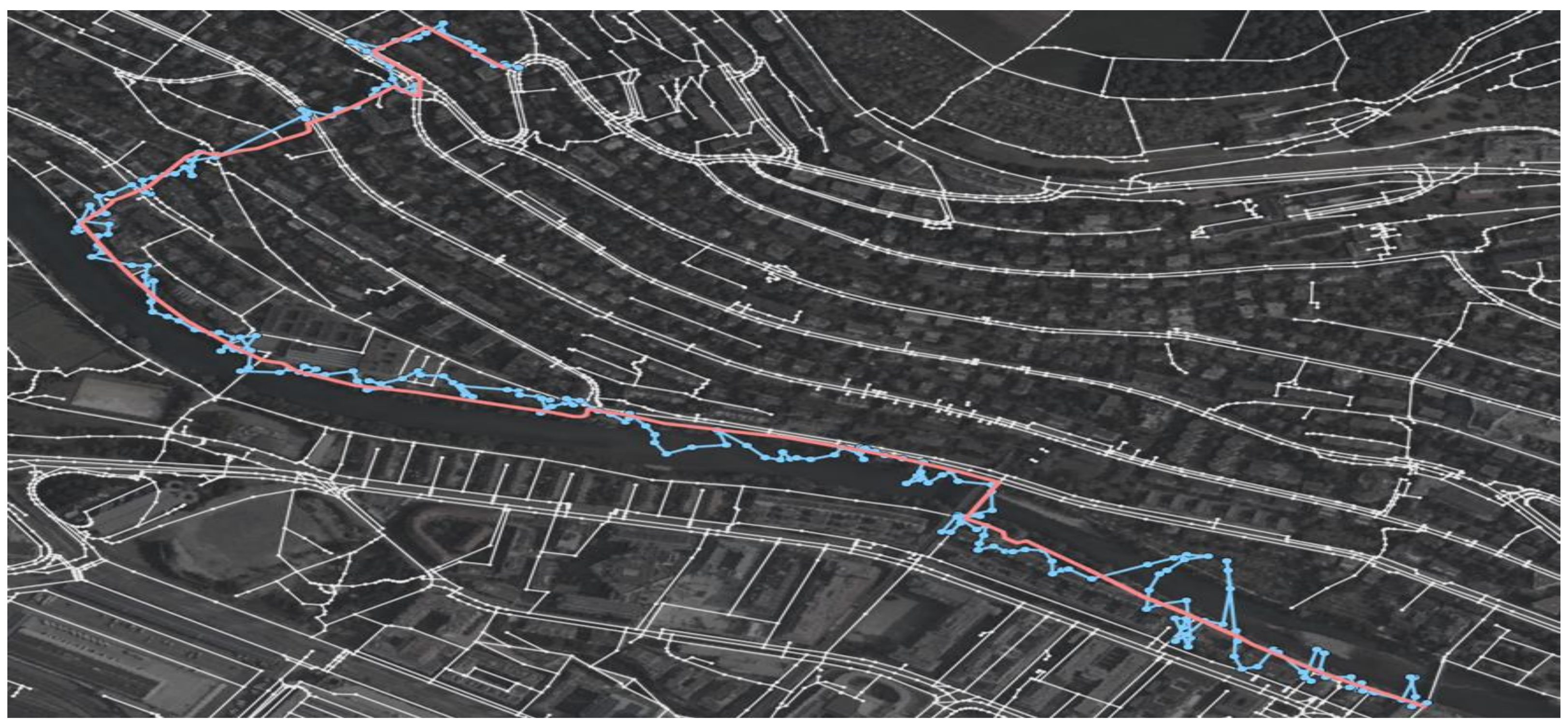

Fig 1: exemplary map matching results

3 Modelling

- Mixed Logit formulation with Path-size correction term.
- Utility function given by:

$$U_{int} = -1 \cdot \lambda_n^{scale} \cdot [distance_{it} + \sum^{LOS} \beta_n^{LOS} \cdot x_{it}^{LOS}] + \beta_{it}^{PS} \cdot ln(PS_{int}) + \varepsilon_{int}$$

$$\lambda_n^{scale} = exp(\beta_{scale} + \eta_n)$$

$$PS_{int} = \sum_{a \in \Gamma_i} \frac{l_a}{L_i} \frac{1}{\sum_{j \in C_{nt}} \delta_{aj}}$$

- Utility function parameterized in Value-of-Distance (analog WTP) space.
- Error components capture panel effects.
- Estimated parameter represent marginal rates of substitution (of length).
- Length acts as scale parameter (beta_scale) with imposed negative log-likelihood distribution
- Attributes modelled using normal distributions (mixed Logit), various interaction effects.
- Estimated using mixl R-package, choice set size 40, simulation of likelihood function with 5000 draws.

4 Choice set generation

- BFSLE algorithm: repeated least-cost path with iterative removal of network links.
- Problem: developed on sparse networks, link elimination not effective when using highly dense networks (parallel links, complex intersections).
- Solution: additional link-penalty method in routing cost function
- Requirements for choice sets: spatially diverse, relevant trade-offs, realistic.
- Figure 2: 5 alternatives (colors) + chosen route (white) without (left) and with (right) link-penalty method.

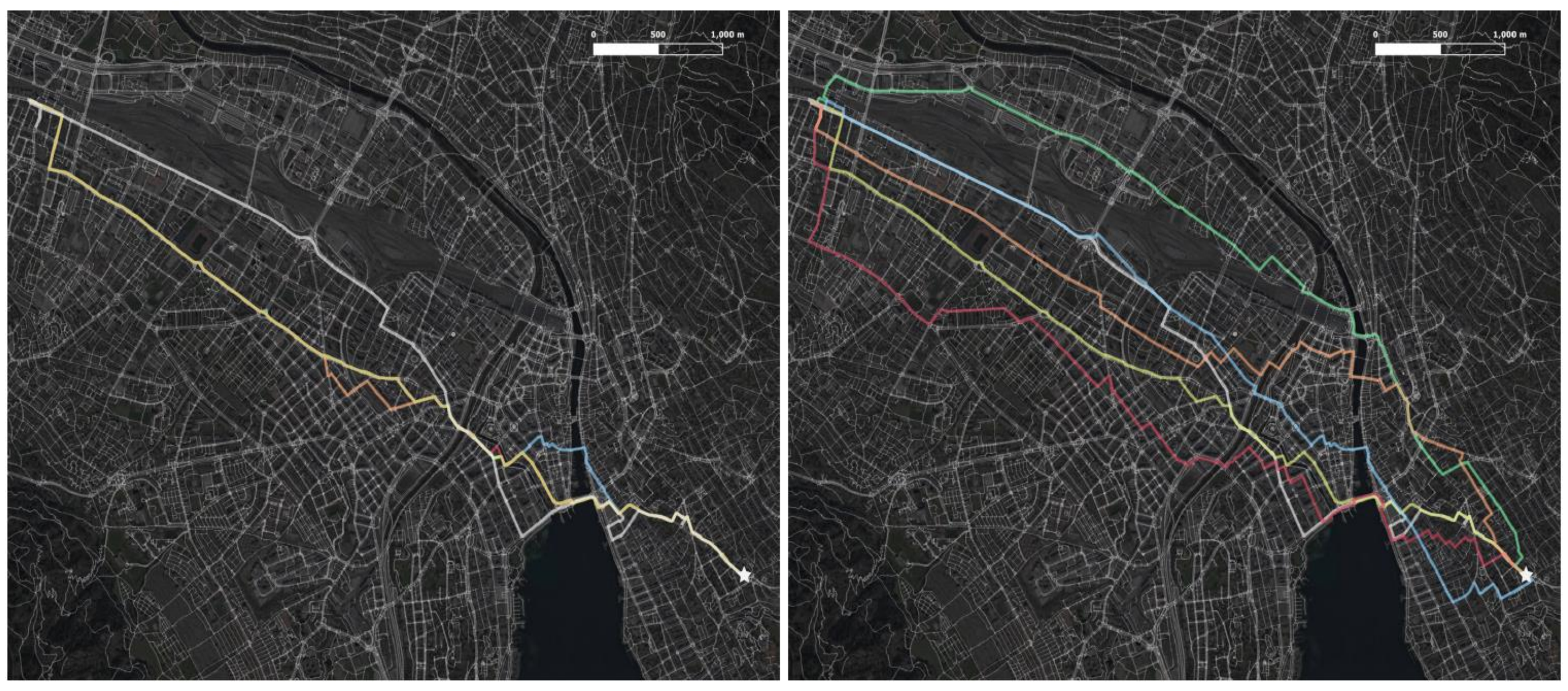

Fig 2: exemplary choice set with and without link-penalty

5 Results

- Parameter estimates are significant and show **anticipated effects analog to existing literature.**
- Positive effects: bike infrastructure, speed limit 30kmh.
- Negative effects: traffic signals, gradients, traffic volumes.
- **Strong and consistent effect of gradients, clear e-bike effect.**
- VoD indicators derived posterior distributions conditional on interaction effects.
- Table 1 example: for avg. respondent, 1km on a bike path is perceived 36% shorter, i.e. like 640m

	avg.	male	female	<30y.	30-50y.	>50y.	bike	ebike
bike path [km]	-0.36	-0.15	-0.42	-0.15	-0.15	-0.15	-0.23	-0.12
bike lane [km]	-0.66	-1.00	-0.27	-1.00	-1.00	-1.00	-1.00	-1.12
speedlimit 30 [km]	-0.16	0.09	-	-	0.07	0.07	-0.13	0.37
traffic signals [n]	0.19	0.42	0.23	0.29	0.31	0.40	0.28	0.53
slope 2-6% [km]	0.55	0.31	0.46	0.24	0.77	-	0.41	0.09
slope 6-10% [km]	3.11	1.69	2.58	3.08	2.44	1.42	2.51	1.01
slope >10% [km]	4.33	2.96	4.38	7.38	-	-	-	2.78
max. traffic 1-10k [0,1]	0.07	0.16	-	-	-	-	0.08	0.27
max. traffic >10k [0,1]	0.11	0.07	0.25	0.09	0.09	0.09	0.01	0.15

Table 1: mean VoD indicators, [-] values are equivalent to avg. column

- **Females:** prefer separated cycling infrastructure (bike path), less gradients, less traffic volumes, analog to literature.
- **Ages:** shows decreasing negative effect of gradients: sample biased towards older e-bikers, effects not fully disentangled.
- **E-bikers:** negative effect of gradients substantially reduced, negative perception of speed limits and traffic lights.

5 References

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