A Process Model for Route Choice in Risky Traffic Networks
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Motivation
- Traveler’s choice under risk is a key factor of network reliability
- Two different modeling paradigms
  - Econometric: “as-if”
  - Process: actual decision process

Priority Heuristic
(Brandstatter et al., 2006)
A decision maker arrives at the final choice through a series of comparisons of outcomes and/or probabilities.
- Priority Rule. Go through reasons in the order: minimum outcome, probabilities of minimum outcome, maximum outcome.
- Stopping Rule. Stop examination if minimum outcomes differ by 1/10 (or more) of the highest maximum outcome; otherwise, stop examination if probabilities differ by 1/10 (or more)
- Decision Rule. Choose the prospect with the more attractive maximum outcome.

Certainty Effect Example
($4000, 0.8; 0, 0.2) vs $3000
- MinOutcome: 3000 - 0 > 1/10 * 4000, so pick the one with higher minimum outcome ($3000) ($4000, 0.2; 0, 0.8) vs ($3000, 0.25; 0, 0.75)
- MinOutcome: 0 - 0 < 1/10 * 4000, go to the next reason
- Probability of MinOutcome: 0.8 - 0.75 < 0.1, go to the next reason
- MaxOutcome: pick the one with higher maximum outcome ($4000, 0.2; 0, 0.8)

Account for Violations of EU
- The Allias paradox
- The fourfold risk attitudes jointly determined by the domain (loss/gain) and probability (high/low)
- The certainty effect
- The possibility effect
- Intransivity

Probabilistic Priority Heuristic (PPH) Model
(Amax, 1 – Apr; Amin, Apr) vs (Bmax, 1 – Bpr; Bmin, Bpr)
- Add a random noise to the difference between a reason (R = min, max, pr)
- If R is not the last reason
  - Pr(A | (A, B)) = P(A - B > δR * MaxOutcome)
  - Pr(B | (A, B)) = P(B - A > δR * MaxOutcome)
  - Pr(A) + Pr(B) < 1 when δR > 0
- The probability of going to the next reason is
  - 1 - Pr(R | A) - Pr(B)
- If R is the last reason
  - Pr(A) = P (Rmin > Rmax) (similar to random utility model)

Likelihood of Observing Alternative A:
P(A)
(1 - Pr1(A) - Pr1(B)) Pr2(A) +
(1 - Pr1(A) - Pr1(B)) (1 - Pr2(A) - Pr2(B)) Pr3(A)
(reason 1)
(reason 2)
(reason 3)

Estimation Parameters
- 2 aspiration levels for the first two reasons
- 1 scale parameter for the logistics distribution of random noises
- 3 ASCs for three reasons
- ASC for the first reason is normal distributed with an additional parameter of std (panel effect)

Experiment
- Upper route has a deterministic travel time
- Lower route has a stochastic travel time
- Each path segment is clickable
- The label shows total travel time
- 74 subjects from University of Massachusetts Amherst
- Mean age: 24.2 years, 6.9 yrs driving
- 54% male, 46% female
- 1767 route choice observations

Estimation Result
- 6 comparing orders
- 5 out of the 6 PPH models have better fit than Rank-Dependent Expected Utility (RDEU) model (Razo and Gao, 2012)
- The RDEU model has been shown to be superior to EU, and mean-std models
- The best model’s comparing order: maximum delay, minimum delay and probability of minimum delay
  - Sensitivity to large delays
  - Scenarios grouped by probability

Cross Validation
- Generate 10 independent data sets from original full data.
- Within each data set, 2/3 subjects’ route choices used for estimation and the other 1/3 subjects’ route choices used for validation.
- MSD (Mean Squared Distance): Squared Distance (SD) is defined as squared difference between proportion of subjects choosing risky route and the probability predicted by the model in a given scenario. MSD is an average over all scenarios’ SD.

<table>
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<th></th>
<th>RDEU</th>
<th>PPH</th>
<th>SD</th>
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<tr>
<td>Average over 10 data sets estimation</td>
<td>FLL</td>
<td>-561.170</td>
<td>-535.013</td>
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<td>$\rho^2$</td>
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<td>No. of Param.</td>
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Conclusions and Future Directions
- The process model (PPH) fits the data better than the utility maximization model (RDEU) in both estimation and prediction.
- Latent classes for different comparing orders in PPH
- Extension to multi-alternative multi-attribute (including multi-outcome) cases for applications in real traffic networks