Intention-Aware Routing of Electric Vehicles

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Electric Vehicles

Electric vehicles (EVs) reduce:
- CO₂ emissions and
- dependence on fossil fuels.

However, EVs have a limited range (typically <100 miles).

Public charging stations are scarce and charging is slow (at least 15-30 minutes), leading to potentially long queues and delays.

Routing Problem

Traffic network is modelled as a graph:

Edges represent roads…

… or charging stations.

Travel and waiting times are probabilistic and depend on time of day: $P(t|s, j)$

Optimal policy maximises user’s expected utility $E(U(t,s))$:

$t$: time of arrival at destination
$s$: state of charge at destination

Solution is a routing policy (state-dependent plan):

$P(t|s, j) = e_{j}$

Waiting Time Distributions at Charging Stations

Step 1: Compute probability $P^{*}(c, i)$ of vehicle $i$ arriving at station $e$ at time $t$, using historic information or intentions, when available.

Step 2: Approximate waiting time distribution by sampling from $P^{*}(c, i)$ and simulating waiting times using a queueing model.

Results

Deviations from Logit:

Logit($A$, True/False): As Min(True/False), but with random deviations (using logit function with parameter $A$).

Incentives to adopt IARS

Min(False): Shortest path without considering historical waiting times.

Logit($A$, True/False): As Min(True/False), but with random deviations (using logit function with parameter $A$).

Min(True): Shortest path considering historical waiting times.

IARS: Intention-Aware Routing System

Conclusions

- Proposed new routing model for the EV charging setting.
- This incorporates intentions by:
  - Combining known EV policies with historic information.
  - Using a principled approach for approximating waiting time distributions based on a queueing model.
- Evaluation shows significant reduction in overall journey time, compared to approaches using only historic information.
- IARS benefits all agents, even those not using the system.

Future Work

- Evaluation on real road networks and traffic data.
- Comparison to reservation-based systems.
- More advanced queueing models, including variable charging times.