

A Graph-Based Spatio-Temporal POI Ranking Measure for Pickup and Delivery Platforms

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Introduction

- Demand in pickup and delivery platforms fluctuates due to a variety of spatial and temporal factors
- Limitations of current POI ranking models:
 - Graph-based metrics fail to capture temporal variation
 - Machine learning models fail to provide reasoning
- We propose ZoneRank, a new spatio-temporal POI ranking measure that encodes spatial relationships, mobility flows, and temporal transitions while maintaining explainability

ZoneRank

$$ZR(v, t) = (1 - \delta) + \delta \sum_{u \in adj(v)} \frac{ZR(u, t + dist(v, u)) - Delv(u, t - dist(v, u))}{|adj(v)|}$$

the total weight (time distance) of the shortest path from u to v

anticipated deliveries at vertex u at time $t - dist(v, u)$

a dampening factor on the effect of spatial neighborhoods on the rank of the vertex

vertices adjacent to v

- Initial values are set to anticipated pickups predicted from historical traces
- Ranks are repetitively recomputed until the average marginal difference in values from one iteration to the next is smaller than some threshold

Evaluation Method

Data:

NYC TLC Yellow Taxi Trip Data (Jan–Jun 2016)

Baseline Algorithms:

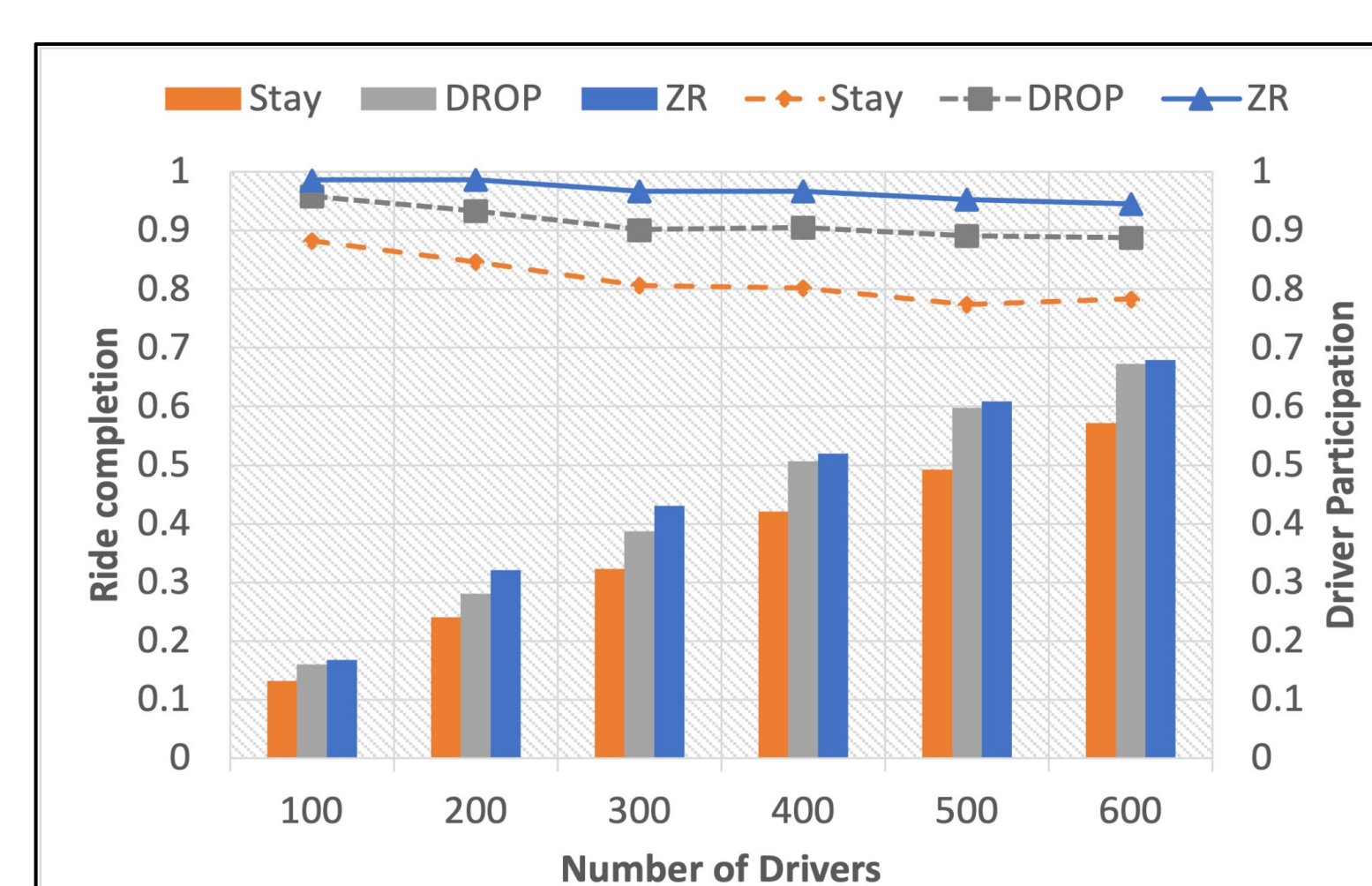
- Stay-in-Place (Stay)
- DROP repositioning algorithm

Simulation:

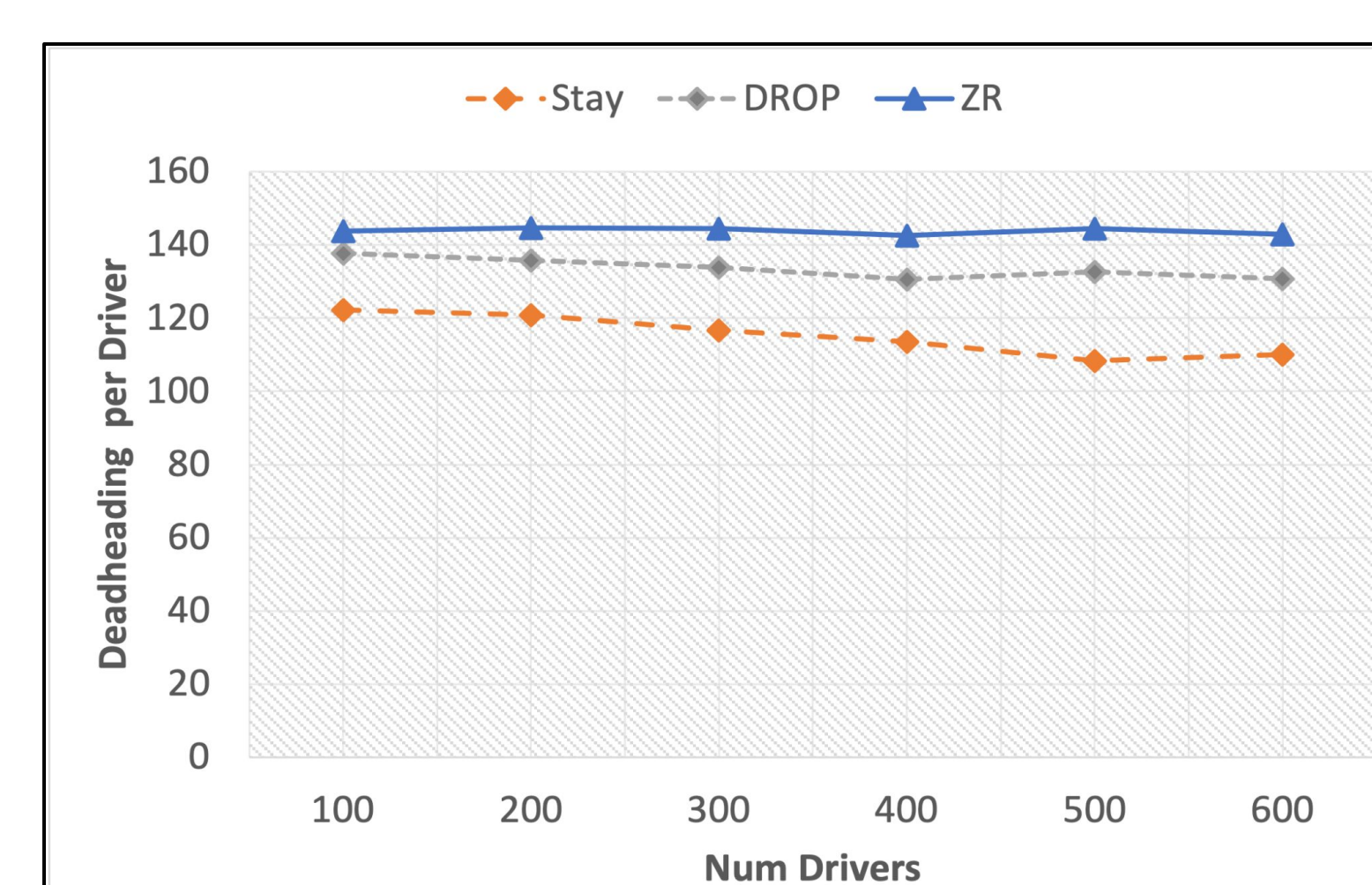
Run Simulator varying (1) **driver density** under fixed demand and (2) **ride frequency** under a fixed number of drivers

Effect of Varying Drivers

ZoneRank allows for better repositioning of idle vehicles leading to higher driver participation rate overall with minimal increased deadheading



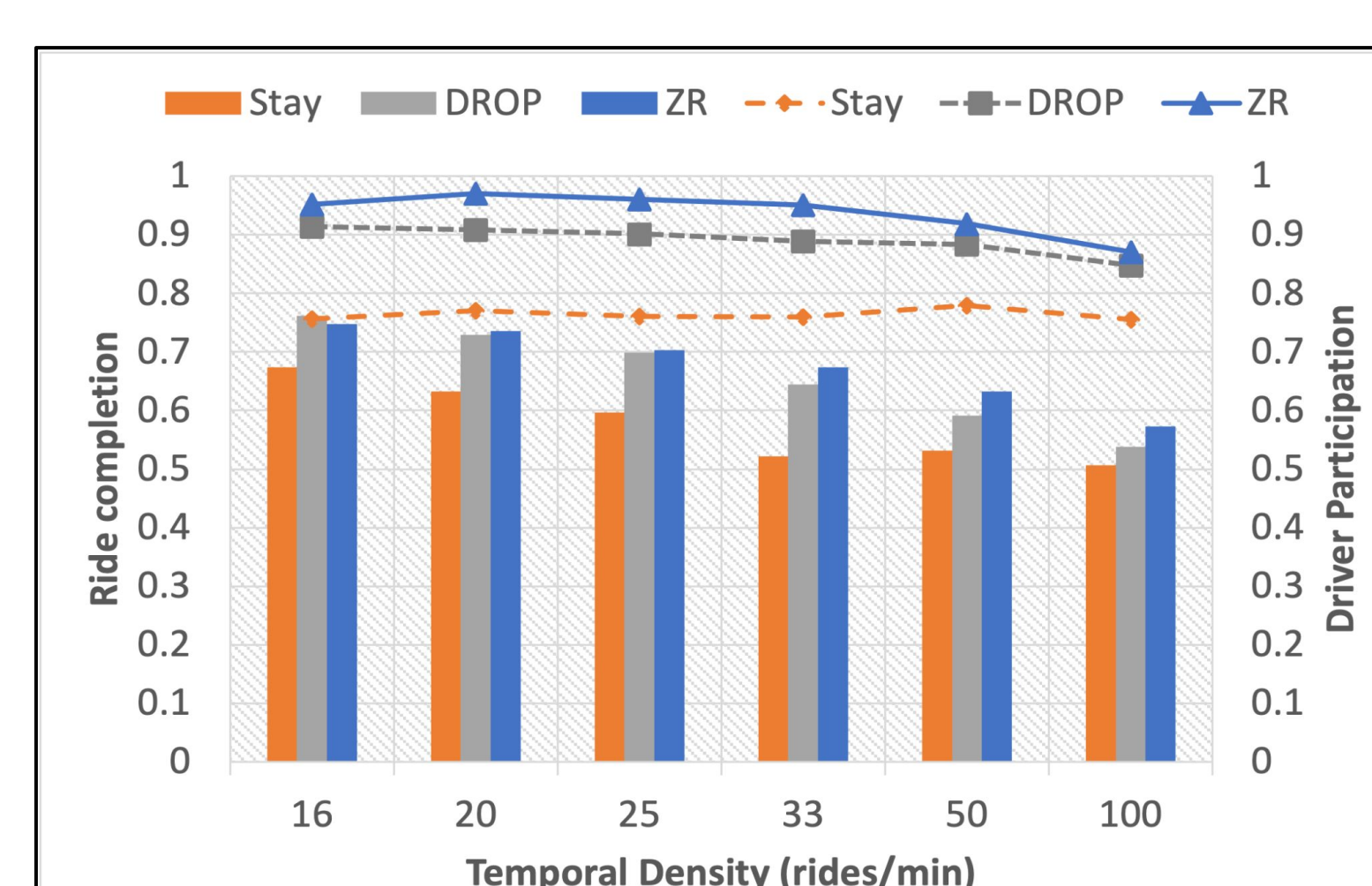
Ride Completion and Driver Participation



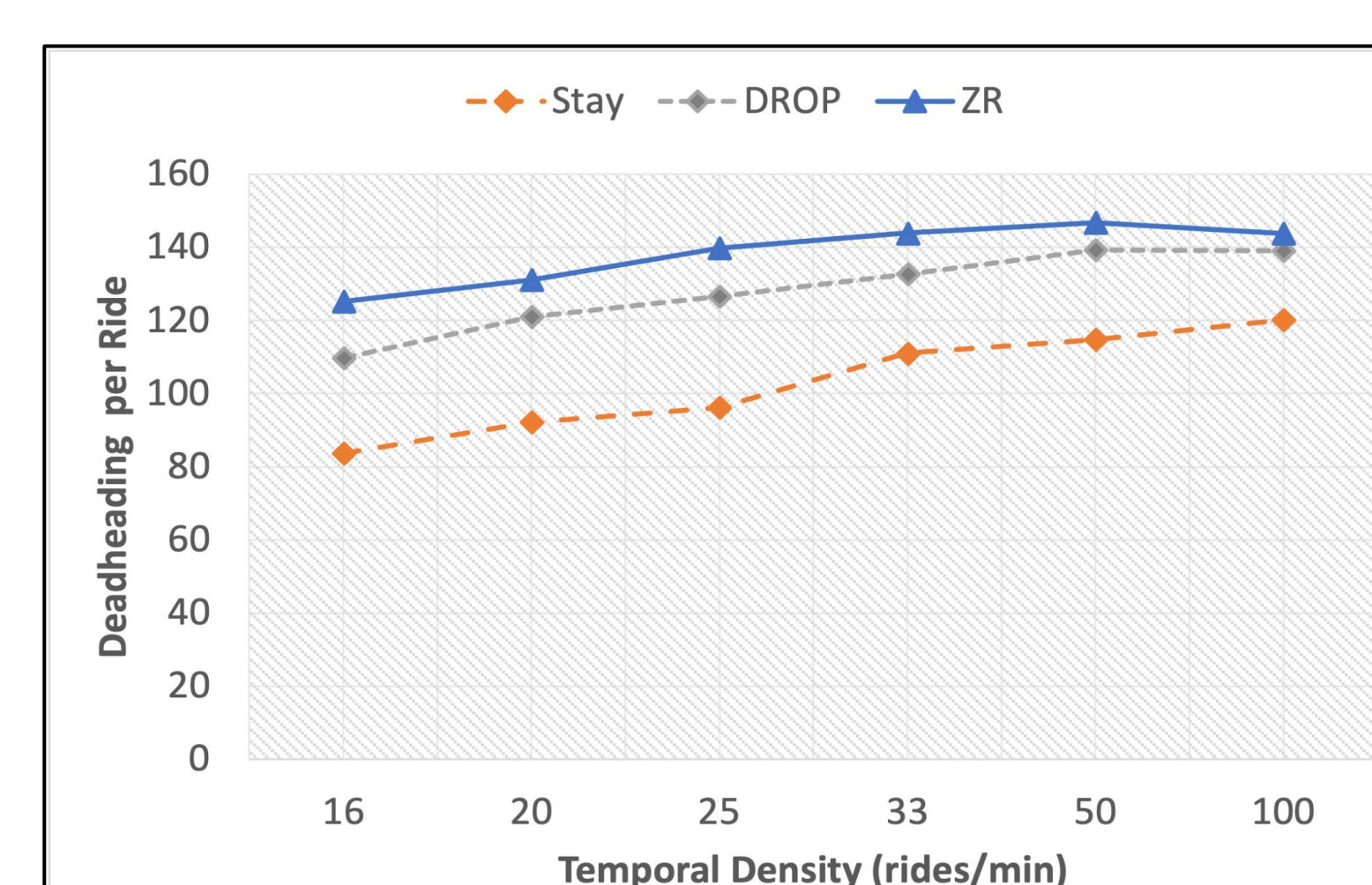
Average Deadheading

Effect of Varying Rides

ZoneRank out-performs other metrics as it leads drivers closer to zones with anticipated pickups



Ride Completion and Driver Participation



Average Deadheading

Key Takeaways

More drivers engaged, fewer idle vehicles, and smoother service coverage across zones



ZoneRank enables smarter, scalable driver repositioning: more completed rides with less wasted motion

Future Work

- Broader validation with **additional repositioning models**
- Test generalizability on **different cities, time periods, or delivery platforms**
- Evaluate **sustainability** and **operational impact**