Data-Driven Methods for Balancing Fairness and Efficiency in Ride-Pooling

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Fairness in Ride-Pooling

Study finds racial discrimination by Uber, Lyft drivers

By ERIC NEWCOMER
OF BLOOMBERG | NOV 01, 2016 AT 6:07 AM

Despite changes, LGBTQ+ and racial discrimination persists in Uber, Lyft

Racial and LGBTQ+ bias led to cancelled rides.

By Anagha Srikanth | July 30, 2020

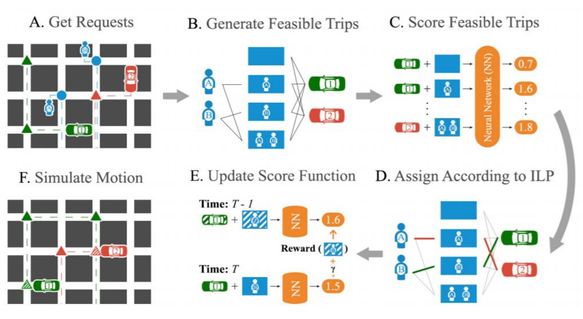
Half of U.S. Uber drivers make less than $10 an hour after vehicle expenses, according to a new study

Seattle's Uber and Lyft Drivers Make $23.25 an Hour—or $9.73

Can we tackle two types of fairness?

1. Fairness in rider pickup
2. Wage inequality between drivers

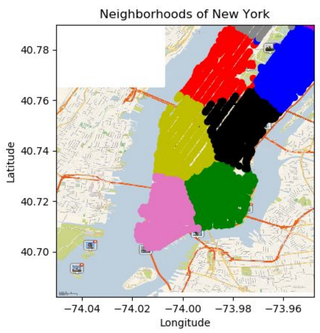
Modelling Ride-Pooling



From Shah et al. 2020

Each rider-driver pair is scored
Then matched according to an integer linear program

Fairness Methods



Divide New York into neighborhoods using KMeans

We define two types of fairness, and create objective functions to try and minimize them

We define two types of fairness:

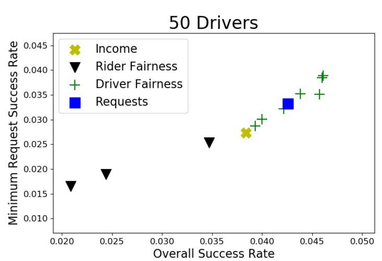
Rider Side Fairness - Variance in acceptance probability across neighborhoods:

$\mathrm{Var}(\frac{l'_{1,t}}{b'_{1,t}} \cdots \frac{l'_{10,t}}{b'_{10,t}})$ Where l represents requests accepted in a neighborhood, and b is total requests

Driver Fairness - Variance in profit earned between drivers:

$\mathrm{Var}(p'_{1,t} \cdots p'_{n,t})$ Where p represents the profit earned by a certain driver

Objective Function: $o(f, r_{i,t}) = R - \lambda(\mathrm{Fairness} - \mathrm{Metric})$

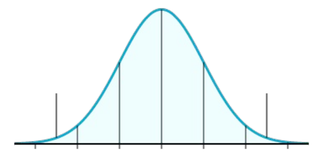


Optimizing for driver-side fairness improves requests serviced in both worst-off neighborhood and overall at 50 drivers

Income Redistribution

Redistribute a fixed fraction R, of the earnings from each driver to reduce income inequality while avoiding the free rider problem

Avoid all work being done by One Driver



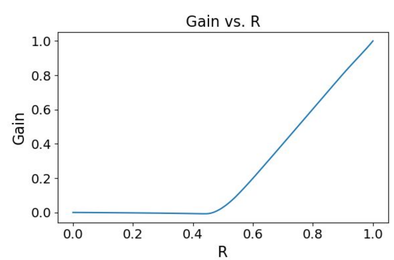
Minimize Income Spread

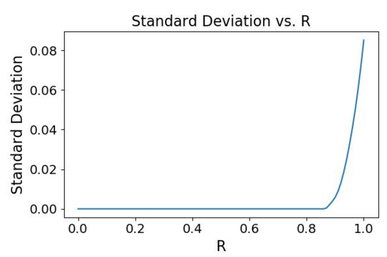
Gain - Quantify if value is proportional to pay

Standard Deviation - Standard deviation of income distribution

$$P_i = r \times A_i + \frac{\min(0, \frac{T}{n} - r \times A_i)}{\sum_{i=1}^{n} \min(0, \frac{T}{n} - r \times A_i)} \times (1 - r) \times T$$

We redistribute according to the formula where:
P_i - Initial Income
T - Total Income for all drivers
A_i - Value of driver; how much of the total income they were responsible for
n - Number of drivers





For R between 0.5-0.8, we can have high gain, while low income spread

Future Question: Do these results hold generally? Can we prove theoretical guarantees?