Passenger Counting for Public Transport based on WiFi-Frames

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Status quo

Nightmare in public transportation
Everyone must have been through this...

Source: https://mrpassenger.com/crucial-information-you-need-to-know-when-using-crowded-public-transportation/
Problems

- Max capacity reached or exceeded during rush hour for certain high priority routes
  - Comfort and safety concerns, low quality
- Others have relatively low capacity
  - Low revenue for same operation costs
Building new stations and railways takes too much time and effort...

Uncomfortable, Unsafe, Inefficient.

Is there a way to maximize the use of all facilities that we already have?
Solution
Our Approach

1. Provide other suggestions for popular routes and cooperate with other companies (bike, e-scooter, etc.) to increase the amount of alternatives
2. Rearrange time schedules according to passenger flow
Alternative Route Suggestion

In general, give route suggestions based on current location and the destination

- Shorter travel distance: bikes, e-scooters
- Longer travel distance: metro, bus, tram
- To amusement parks: taxi, Uber
Alternative Route Suggestion

For regularly highly occupied routes:

- Other direct or 1x-transfer routes
- Suggestions based on weather and road conditions
- Suggestions to the public transport company to rearrange the buses from low-priority lines to the high-priority lines
Alternative Route Suggestion

For irregularly low-speed routes:

- Other routes that are not affected
- Vehicles with higher mobility (bikes, e-scooters)
Alternative Route Suggestion

Incentives for passengers

➢ Combi tickets
➢ Bonus Program
Combi tickets

➢ Discounts for vehicle transfer
➢ Monthly or annual packages
Bonus Program

➢ Earn points in exchange for ticket discount or free tickets (base on ticket price)
➢ Extra points for using public transport under bad weather conditions
➢ Extra points for riding bikes (health insurance)
Alternative Route Suggestion

Advantages for public transport operator

➢ Efficient use of all traveling capacities
➢ Higher quality of transportation → price
➢ Increase the frequency of use
➢ Attracts new customers that used to use the services of the cooperation companies
Rearrangement of Time Schedules

- Regularly highly occupied routes
  ➔ Frequency ➪
- Regularly low occupied routes
  ➔ Frequency ➪
In order to achieve this...

Analyze the everyday passenger flow throughout the year

Find out the pattern on regular work days and holidays
Estimation of Passenger flow

- Our Approach:
  Count passengers based on WiFi probe requests through IoT gateway
Estimation of Passenger flow

Advantages

1. Near real-time
2. Efficient
3. Cost-effective
Why do it like this?

- Wi-Fi probe requests are constant and come from all mobile devices
  - 1. A cheap way of capturing these signals
  - 2. Everyone has a cell phone
Solution - Data Analysis
Estimation of Passenger flow

Problems of counting:

1. Devices constantly share signals
2. Frequencies of these emissions are different
3. MAC-addresses of devices are randomized for safety measures
4. Raspberry Pi captures signals from all around the bus
Approach:
1. First attempt was to derandomize the addresses – we figured it isn’t possible to do so
2. Each device shares signals with constant frequency – the second attempt is to catch all these different frequencies throughout one bus trip
Estimation of Passenger flow

Solution - consists of two parts:

1. Filtering – We filter out the MAC-addresses with low strength, as they most likely come from outside of the bus – see picture.
Estimation of Passenger flow

Solution - Consists of two parts:

2. Counting – convolutional neural network based on...
Visualization of Passenger flow

Separate the number of passengers on the bus into categories:

1. Green – The bus is almost empty
2. Yellow – Recommended amount
3. Orange – Fairly crowded
4. Red – Full bus
Bus on the map is moving in real time
GPS-data was used to define its position
See the provided video
Improvements to the model

1. Deeper network, as in the reference paper
2. Add noise to input data, as not to overfit the model
3. Smarter filtering
Conclusion
Thank you for your attention