Real-Time Optimization of UNH Bike Share System

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Introduction

Bike availability is a key concern in bike share systems. Our project aims to provide the Sustainability Institute's Cat Trax Bike Share system with an effective algorithm for redistributing bikes. After defining a metric for demand, we propose a simple heuristic approach for addressing demand at bike stations. Bike rebalancing is a popular field of research. Modern studies, however, focus heavily on large scale systems and redistribution costs.

In contrast, our project provides a practical, concise, and intuitive method for bike redistribution at UNH. Working with Jennifer Andrews, a Sustainability Project Director, software will be officially implemented within the month. We hope to demonstrate the potential of data science applied to sustainability at UNH.

Data Collection

The Cat Trax Bike Share system is hosted through a third-party company: Movatic**.**

Historical Data

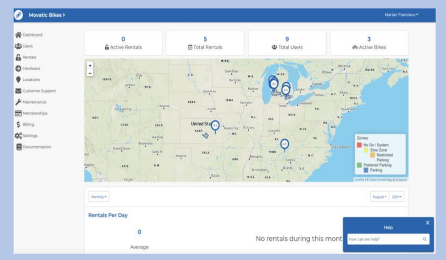
Trip Data Features

| Start Station | Start Time |

| End Station | End Time | Bike ID |

Bike trip data is downloaded from Movatic and parsed into a Pandas DataFrame in Python.

Movatic Admin



Python3

**Open Mobility Foundation prevents real-time trip route data for user anonymity. Thus, we combine historic bike trips with real time station data. **

Real-Time Data

Available bikes at each station queried through Movatic's General Bikeshare Feed Specification API

Authorization errors debugged with:

Exploratory Data Analysis

At the request of the Cat Trax 's team, we developed data visualization for general insight on bike usage. All data visualizations are originally digital and interactive (hovering over specific data provides additional information).

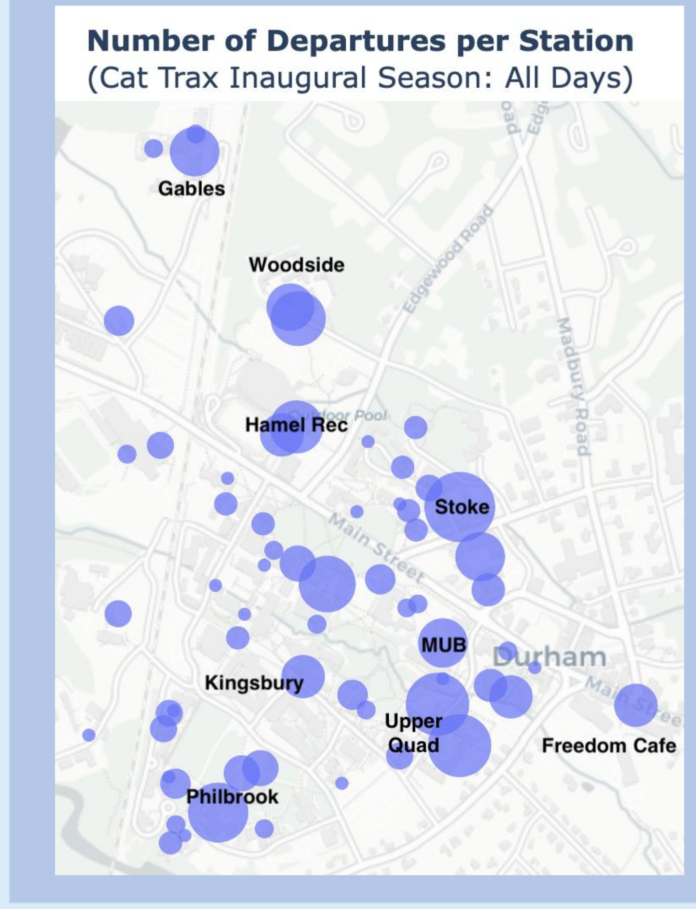


Fig 1 (Left). Departures by station. Bubble size correlates to the number of departures.

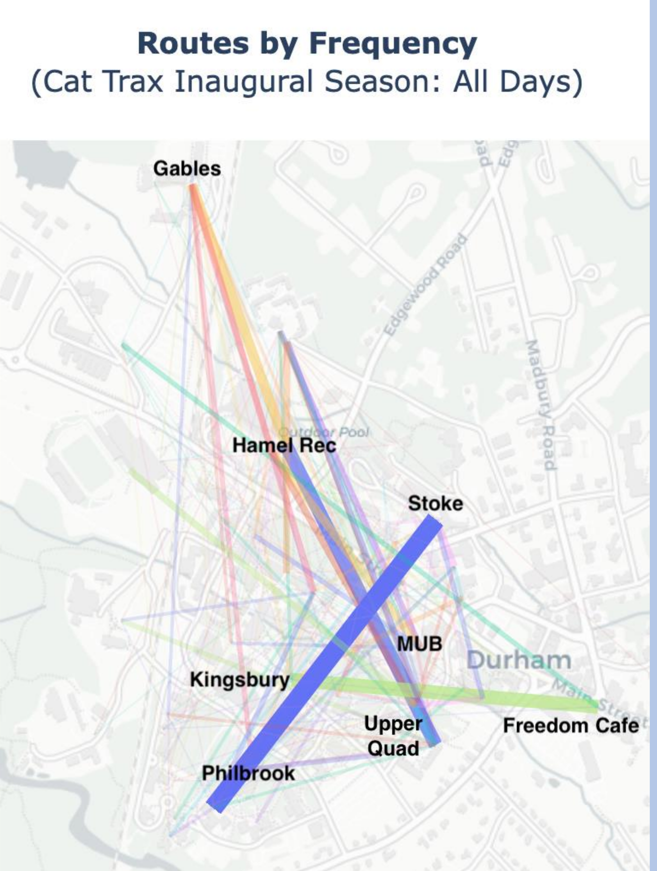


Fig 2 (Right). Routes by frequency. Line thickness correlates to route frequency.

Measuring Demand

We define "demand" at a station as the average number of people per day who wish to check out a bike. Departures are a good indicator of demand. However, if no bikes are available at a station, demand cannot be measured through departures. Thus, we distinguish between states of a bike station. A station is "active" when it has one or more bikes. A station is "inactive" when it has no bikes.

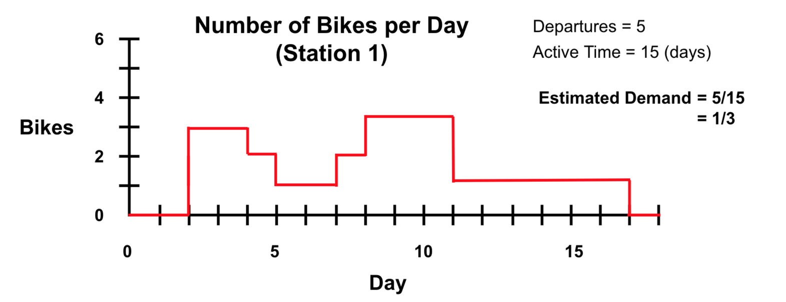


Fig 3 (Left).

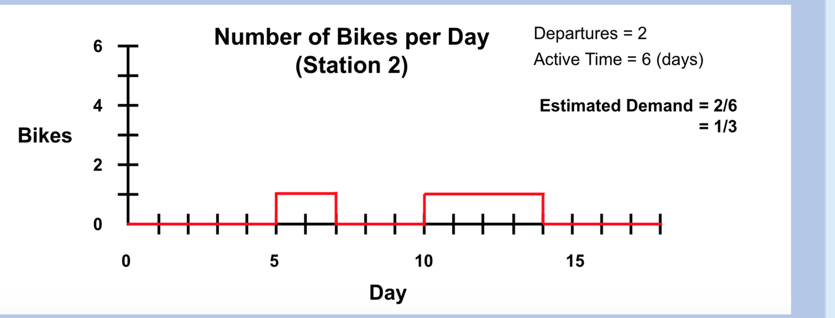


Fig 4 (Right).

To estimate demand at a station, total number of departures is divided by total time active. However, this discounts time in which a station is *inactive* (refer to Fig. 3 and 4, where two different stations have identical estimated demand). Thus, we introduce "uncertainty". Uncertainty is defined as the percentage of time a bike station was inactive. Below, we visualize demand and uncertainty by station for Cat Trax's inaugural season.

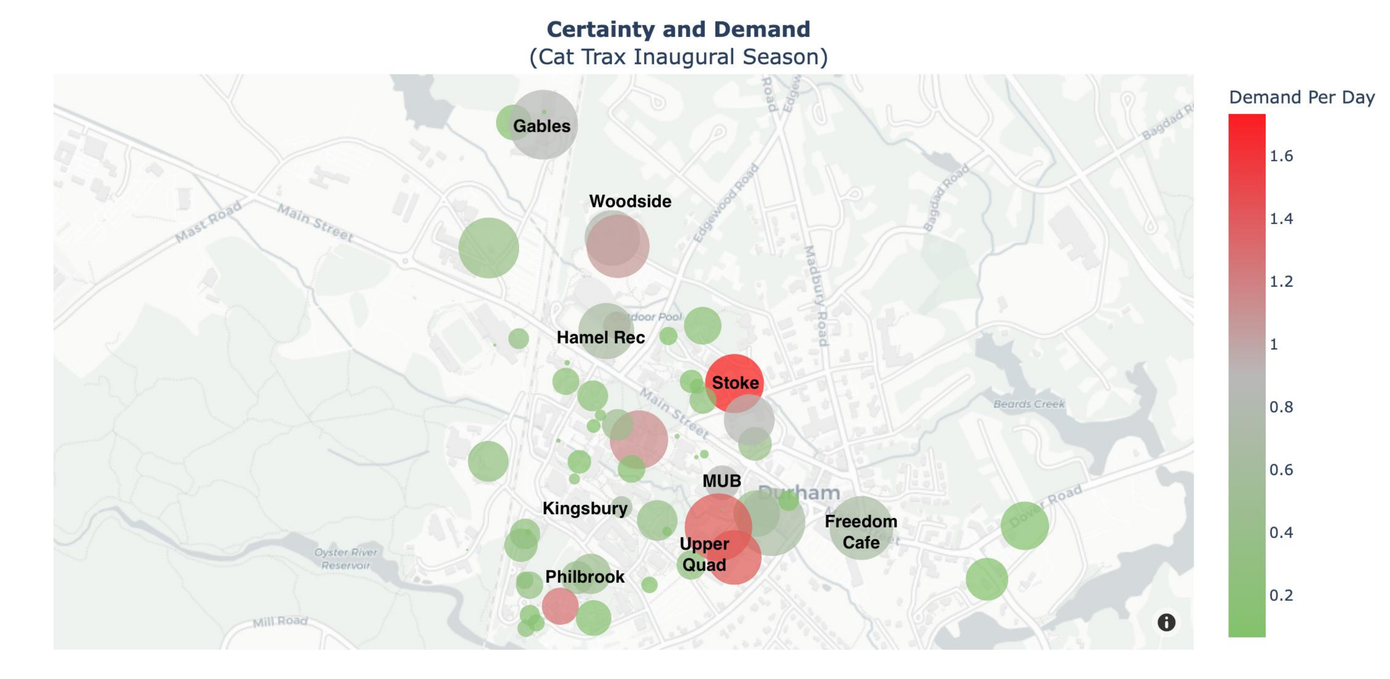


Fig 5. Demand and Uncertainty by Station. Bubble size correlates to uncertainty. Color correlates to estimated demand.

Distribution Algorithm

Cat Trax administrators are prompted for two values:

- Number of bikes to redistribute.
- Floating-point value for "riskiness".

A higher riskiness value favors stations with less certainty.

Next, a "score" for each station is calculated with the formula below:

C = Certainty
D = Estimated Demand
R = Riskiness

Station Score = **(CD + (1 - C) * RD)**

Bikes are then distributed proportionally to station scores. A secondary hidden parameter determines how often the heuristic explores zero certainty stations, where no demand estimates can be made (since no departures have occurred).

Simulation Results

Table 1: Number of Successful Trips

	R = 0.5	R = 1	R = 1.5
5 Weeks	505, 548	**<u>596, 572</u>**	**<u>587, 482</u>**
10 Weeks	1073, 1119	**<u>1178, 921</u>**	**<u>1217, 1032</u>**
15 Weeks	**<u>1873, 1587</u>**	**<u>1804, 1408</u>**	**<u>1816, 1427</u>**

Heuristic Method (Red) **Original Method (Blue)**

Our proposed heuristic method out-performed the status quo for configurations bolded and underlined in Table 1. The heuristic method initially distributes all bikes evenly. The original method, however, contains a priori knowledge of demand. Thus, tuning the heuristic with data from previous seasons may significantly improve results.

Nine simulations were run using weekly redistributions with various riskiness values and durations. Demand was modelled with uniform random variables evaluated in hourly segments, where expected departures per hour were calculated from Cat Trax's inaugural season data. The "Original Method" consisted of placing 5 bikes at the MUB and equally distributing the rest.

Future Work: Sustainability X Data Science

Many possible improvements to this heuristic method exist. Weighting recent data more heavily, utilizing data from previous bike share seasons, modeling demand more realistically during simulated testing, and incorporating arrival data into the heuristic are all promising areas to work on.

We hope this project provides a sneak-peek into the potential of pairing sustainability with data science at UNH. Data science brings an entirely new toolbox to sustainability problems, and computer science students are hungry for resume-building projects. We wish to establish a strong, long-lasting relationship between the Sustainability Institute and the Computer Science Department. Future plans are currently being discussed.

Acknowledgements

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