

Algorithmic Transit Optimization: Evolutionary Algorithms Applied

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May 1, 2023

Designing a System

- 1 Network geometry
- 2 Frequency Assignment and Timetable Development
- 3 Fleet and Crew Scheduling



Figure: SEPTA Service around Philadelphia [1]

Urban Public Transit Optimization

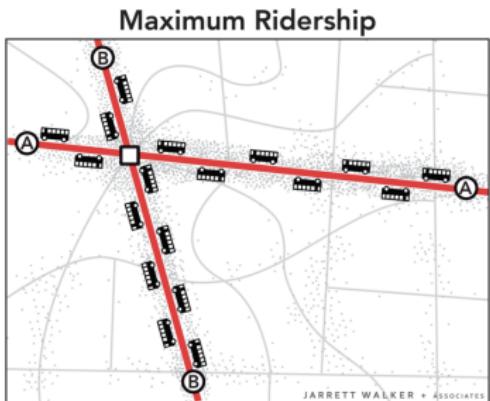


Figure: Optimizing for Ridership [3]

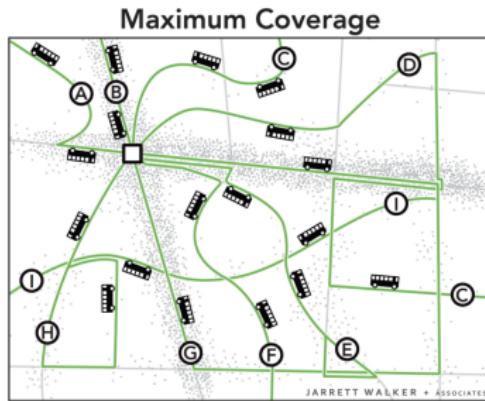
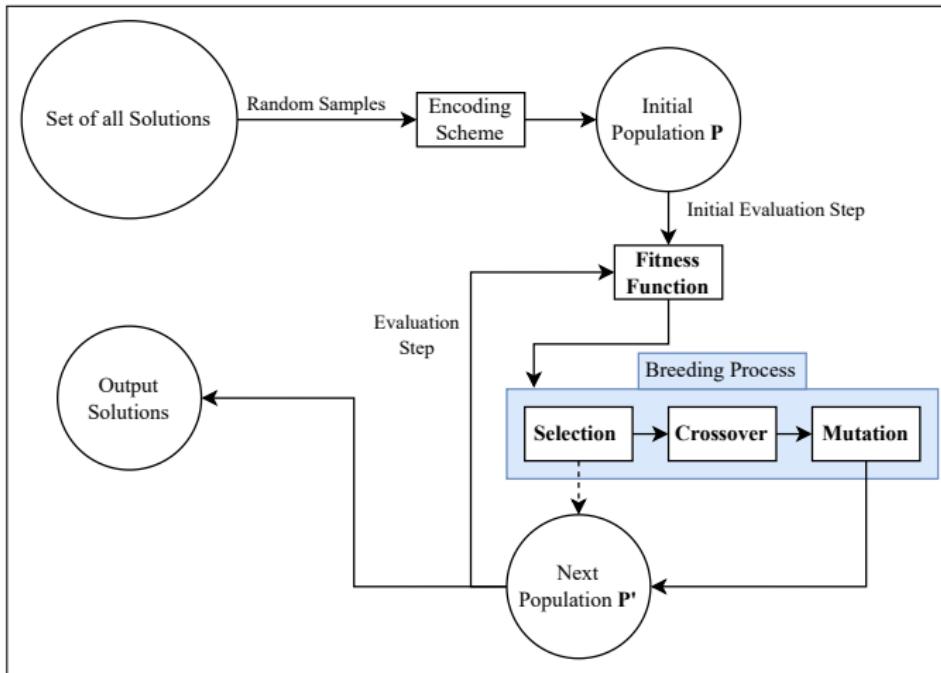


Figure: Optimizing for Coverage [3]

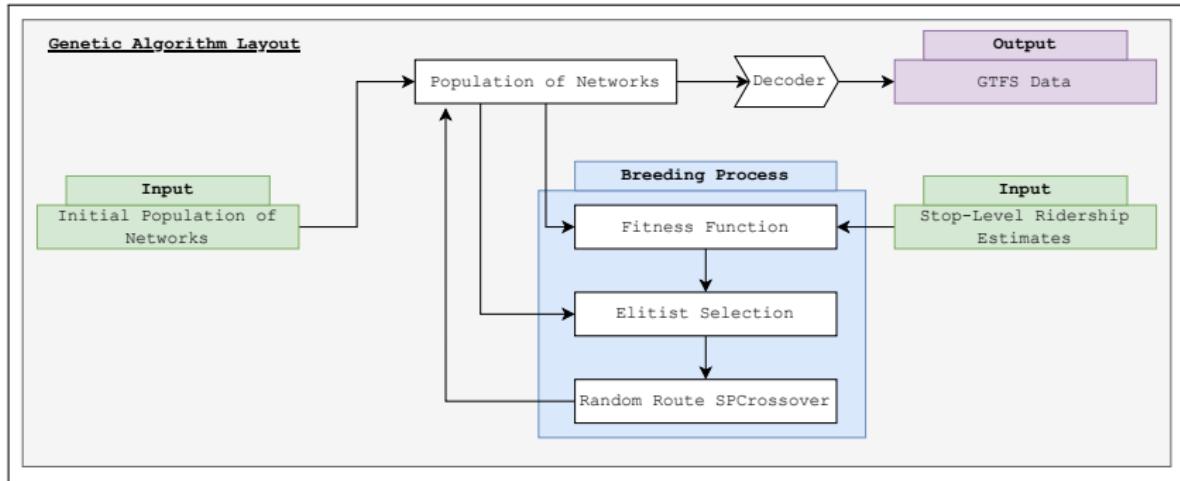
Other examples of trade-offs:

- 1 *User Costs versus Operator Costs.*
- 2 *Network Simplicity versus Functionality.*
- 3 *Direct versus Frequency.*

Genetic Algorithms



Outline of Custom GA



SPCrossover: The Crossover Operation

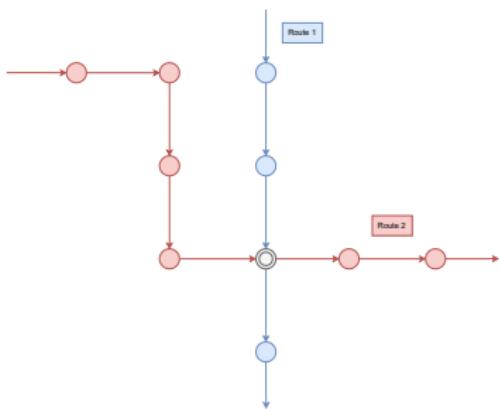


Figure: Original 'parent' routes

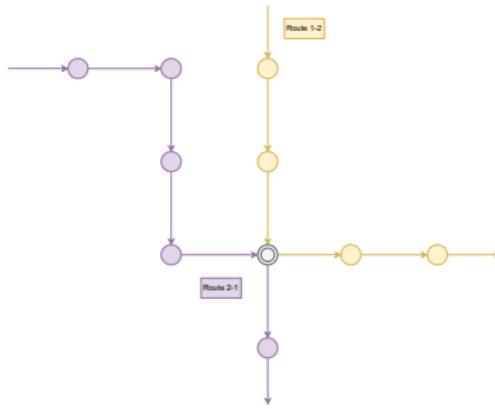
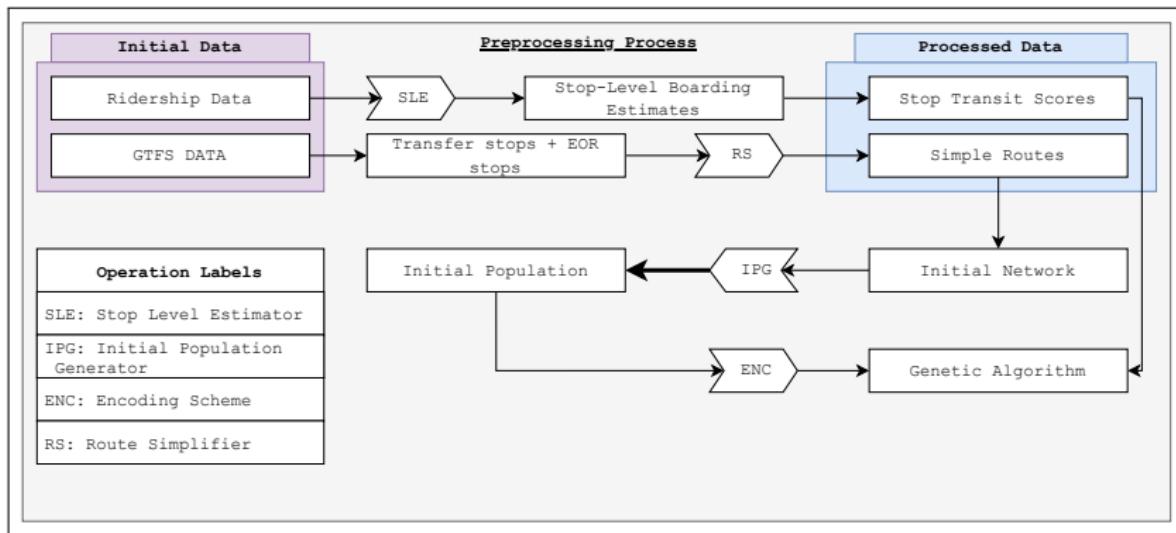


Figure: New 'children' routes

- Focus on **transfer points** as crossover points.
- Work with **simple routes** where only transfer points are considered.

First step: Processing Data



- **Ridership Data:** Average total ridership by month by route.
- **GTFS Data:** General Transit Feed Specification.

Route Simplification

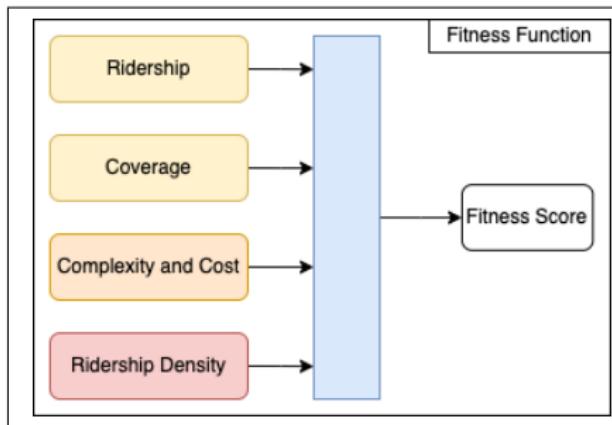


Figure: Original Network

Figure: Simplified Network

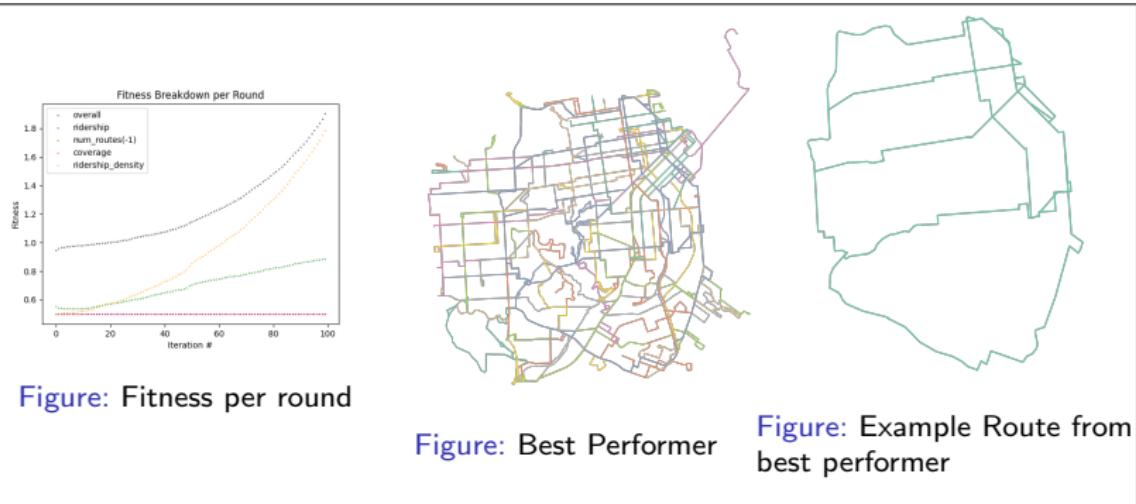
- Reduced number of routes by over 50%.
- Trips from about 50,000 to 106.
- Stops by over 80%.

Fitness Function



- **4 key factors.**
- **Linear Combination** of factors based on experimental hyper-parameters.

Results



- Fitness values **exponentially** growing.
- Best performer creates **unrealistic super routes**.

New Fitness Function and Zone Evaluator

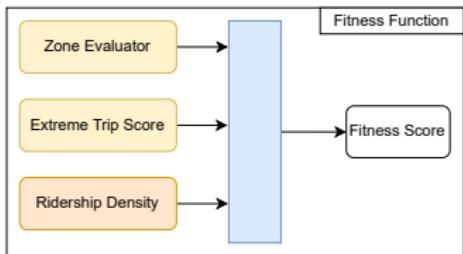


Figure: New Fitness Function

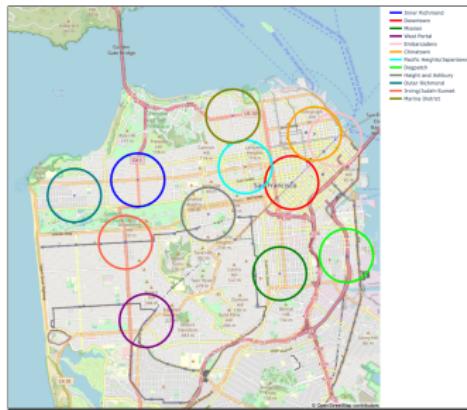
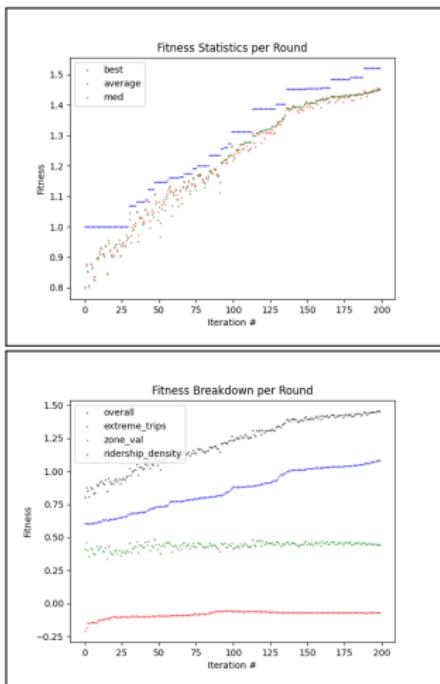


Figure: Plot of zones

- New **Zone Evaluator** metric.
- New **extreme trip** penalty.

New Results: Overview

- Ran **11** different sets of weights.
- Contribution from each element more equal.
- **Convergence** of fitness values.



New Results: Route Level

- Directly connecting zones.
- Bias towards **downtown routes**.
- Creating **redundant** routes.

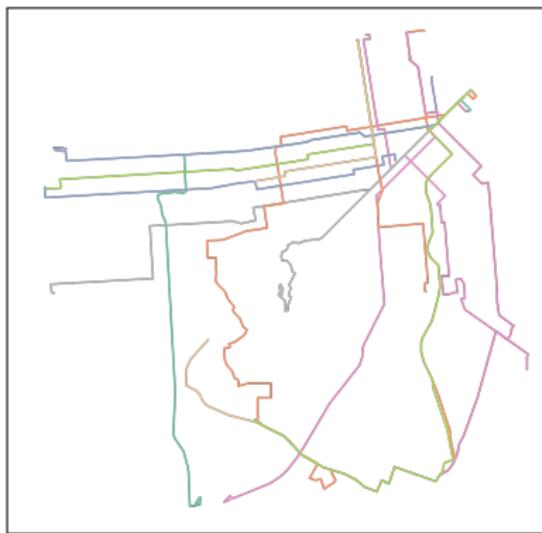


Figure: SPCrossover routes in best performer

Future Work

- Lack of **genetic diversity**.
- Zones are **arbitrary** at the moment.
- Incorporate variable network sizes.
- Code at
<https://github.com/Hweinstock/TransitGA>

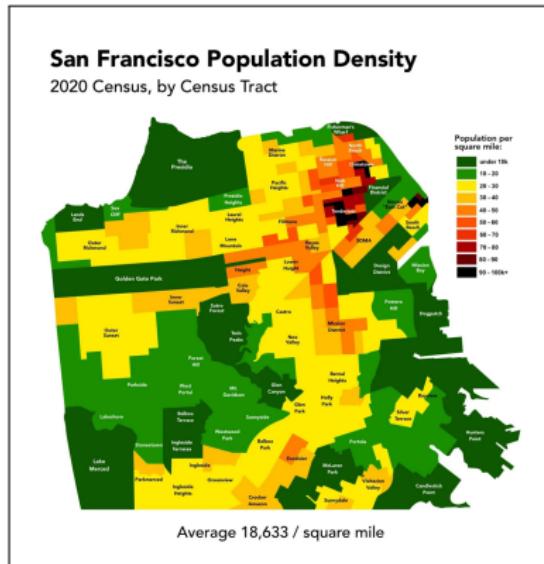


Figure: Population Density Map of San Francisco [2]

Bibliography

- [1] *SEPTA Lines and Routes Information*, SEPTA.
- [2] u/ChaiHigh. *San Francisco Population Density Map*.
https://www.reddit.com/r/MapPorn/comments/vuh1su/oc_san_francisco_population_density/. Accessed: 2023-04-30.
- [3] Jarrett Walker. *Human transit: How clearer thinking about public transit can enrich our communities and our lives*. Island Press, 2012.