Gaps in Emergency Preparedness

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We use persistent homology to study the distribution of Community Emergency Hubs in Seattle, identifying gaps in coverage

What are Community Emergency Hubs?

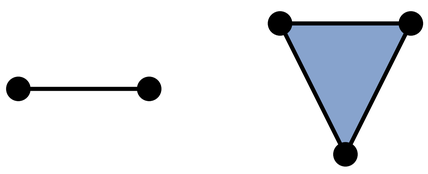
Community Emergency Hubs (CEHs) are locally-organized gathering locations where people can share information and support one another in the event of a major disaster. Regardless of where people are in the city, everyone should be near an accessible CEH. **Thus, we need an equitable spread of CEHs covering the city.**

What is Persistent Homology?

Persistent homology (PH) is a tool from *topological data analysis* that seeks to describe the "shape" of a dataset. **Most importantly, PH can identify and weigh gaps in the spread of data.** Therefore, we can use it to find and determine which neighborhoods have the least accessible CEHs.

Death Values

When applying PH, we generate a collection of simplices (lines and triangles) with an associated *death value*. **The simplex indicates the locations of a gap in our data, and its death value measures how "persistent" the gap is.**



A line is a 1-dimensional simplex, and a triangle is a 2-dimensional simplex. In mathematics, a simplex can be generalized to arbitrarily large dimensions and is related to a bunch of interesting math!

How to Read the Figure

The main figure to the right plots three main features

- The location of organized CEHs
- The location of unorganized CEHs
- The large death simplices and values from PH computations

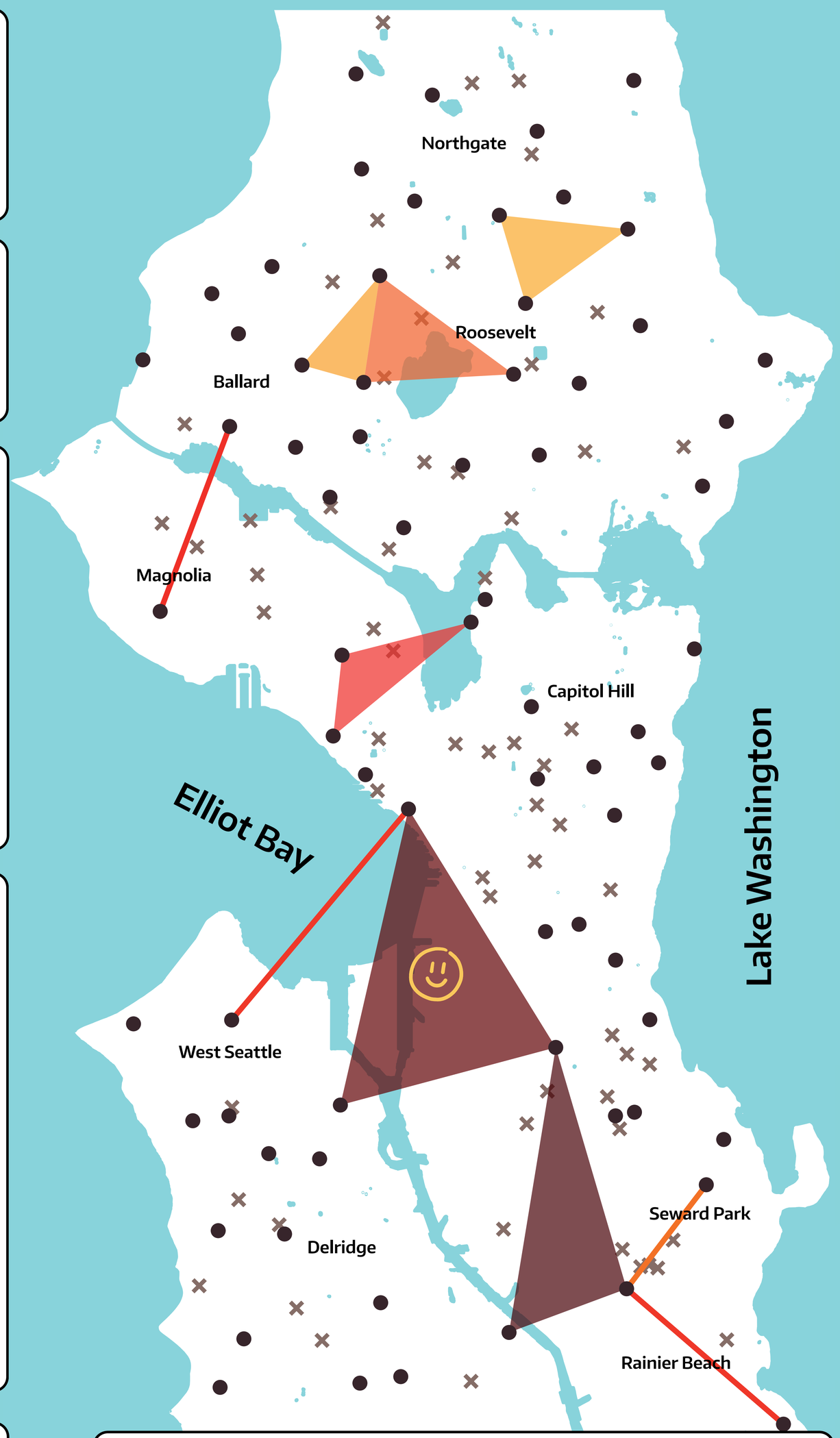
In this context, people in an area containing a high-value death simplex have to walk further to reach a CEH. For example, someone at the center of the ☺ marked triangle on the map could take up to 75 minutes to walk to the nearest CEH.

Two additional notes

- There were other smaller death value simplices, but we omitted them since we are concerned with high-value death simplices
- The unorganized CEHs are used to show where additional CEHs could be established, but are not used in the PH computation.

Results

According to our methods, the greatest lack of coverage by CEHs occurs in South Seattle, partly encompassing the neighborhoods of Beacon Hill, SoDo, and Rainier Beach. Smaller gaps in coverage occur near South Lake Union, Queen Anne, Magnolia, and Roosevelt. Notably, our model does not consider the capacity limitations of each CEH or the population of the neighborhood each CEH serves. We hope future research can be conducted to address these factors and more.



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This project was inspired by the work below on polling site access in the 2020 U.S. election!

Persistent Homology for Resource Coverage: A Case Study of Access to Polling Sites
Abigail Hickok, Benjamin Jarman, Michael Johnson, Jiajie Luo, and Mason A. Porter
SIAM Review 2024 66:3, 481-500