Drawing the '15-minute City' Bubble:

Crowd simulation to detect the size of community-life circle in New York City

GEO503: Geography Seminar - Spatial Simulation

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Presentation Outline

- Problem statement
- Research objectives
- Methodology & Model
- Results & Discussion
- Questions & Answers

15-minute cities?

All residents can access most of their daily needs (e.g., groceries, work, education, shopping, health, exercise, entertainment, etc.) within 15 minutes (up to 20 minutes), commuting from their own doorsteps by walking, cycling, or public transportation.

C40 Cities: "Creating 15-minute cities" where all residents of the city are able to meet most of their needs within a short walk or bicycle ride from their homes.

https://www.c40.org/other/agenda-for-a-green-and-just-recovery#:~:text=C40%20mayors%20have%20collectively%20identified,and%20lifting%20up%20essential%20workers

However…

15-minute city

Urban inequity

$\xrightarrow{\text{Challenges}}$

E.g., people who stay in New York City may be able to gain most of their daily needs within 15-minute travelling, while people who live in the small and midsized cities in US may required more time to get their essentials.

Challenges could vary from different countries in different places

- What is the size of a 15-minute city (community-life bubble) within a travel distance of 15 minutes?
- How is the expanding rate of the bubble size when people travelling during the 15 minutes?
- Does the expanding rate drop dramatically or retain increasing after 15 minutes?
- How much does the size of bubble varies between different places?

The benchmark of quantifying a 15-minute city has not come with consensus

Motivation & Objectives

Agent-Based Model (ABM)

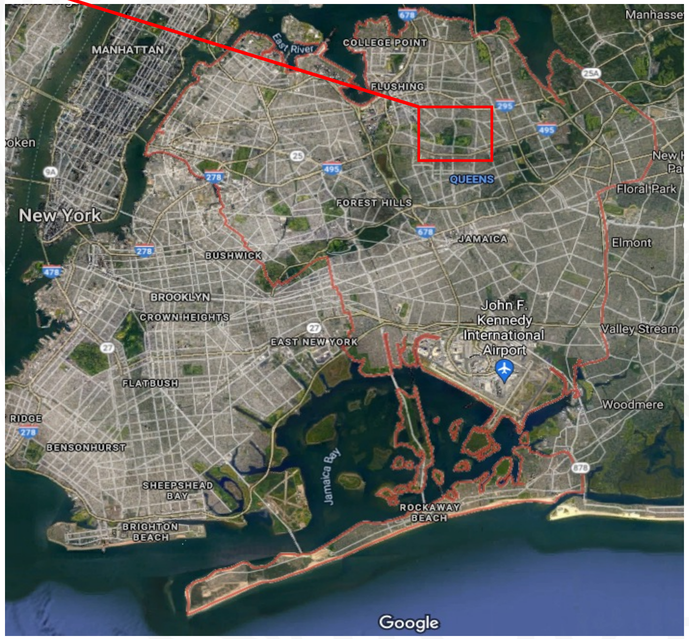
Simulate residential movement

Bottom-up approach

Draw community-bubble of cities

Study Area

- Queens, New York, 2 x 2 km^2
- Bounding box: *[-73.82137, 40.73188, -73.77389, 40.76776]*
- One of the most diverse places in the world
- Home to sports fans, nature lovers and modern-art aficionados

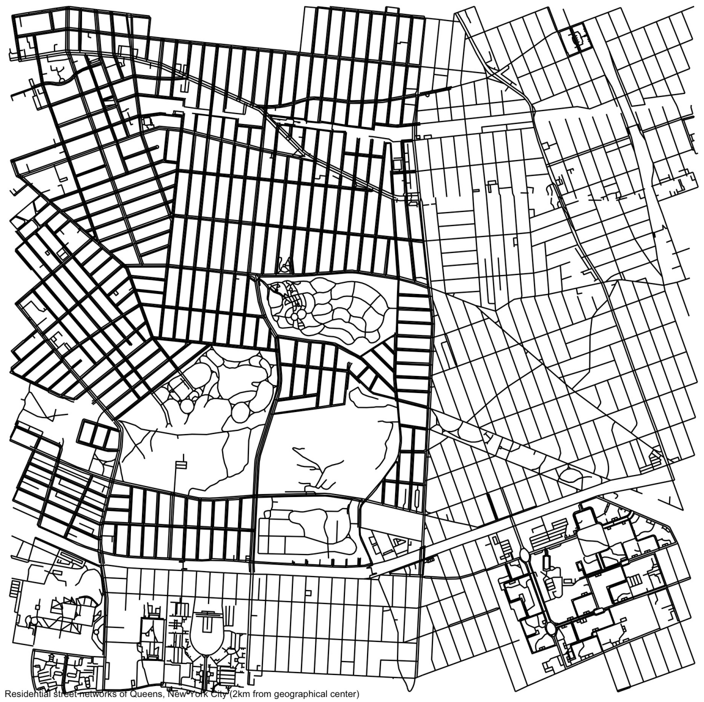


Methodology: Data preparation

Construct street network

OSMnx
(Boeing, G. 2017)

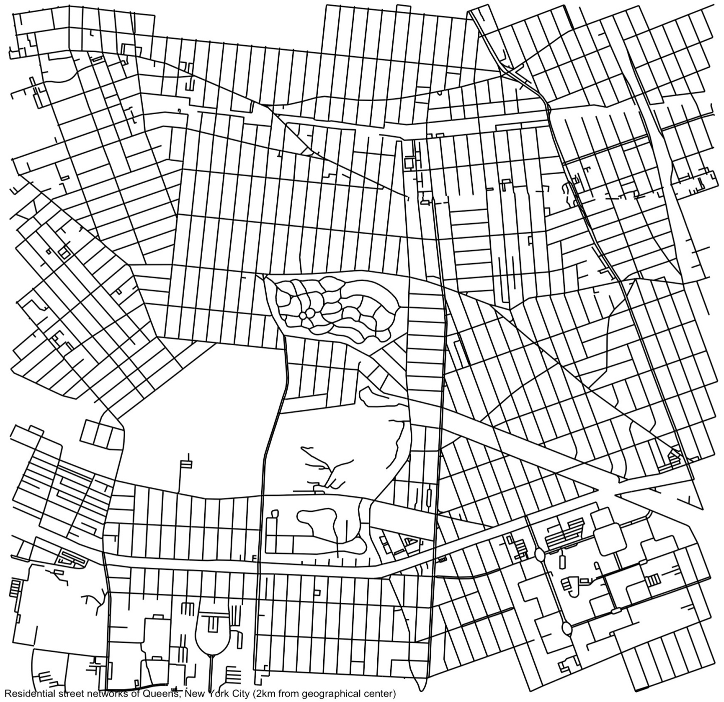
Queens, NY
[-73.82137, 40.73188, -73.77389, 40.76776]



Residential street networks of Queens, New York City (2km from geographical center)

Simplified

Version



Residential street networks of Queens, New York City (2km from geographical center)

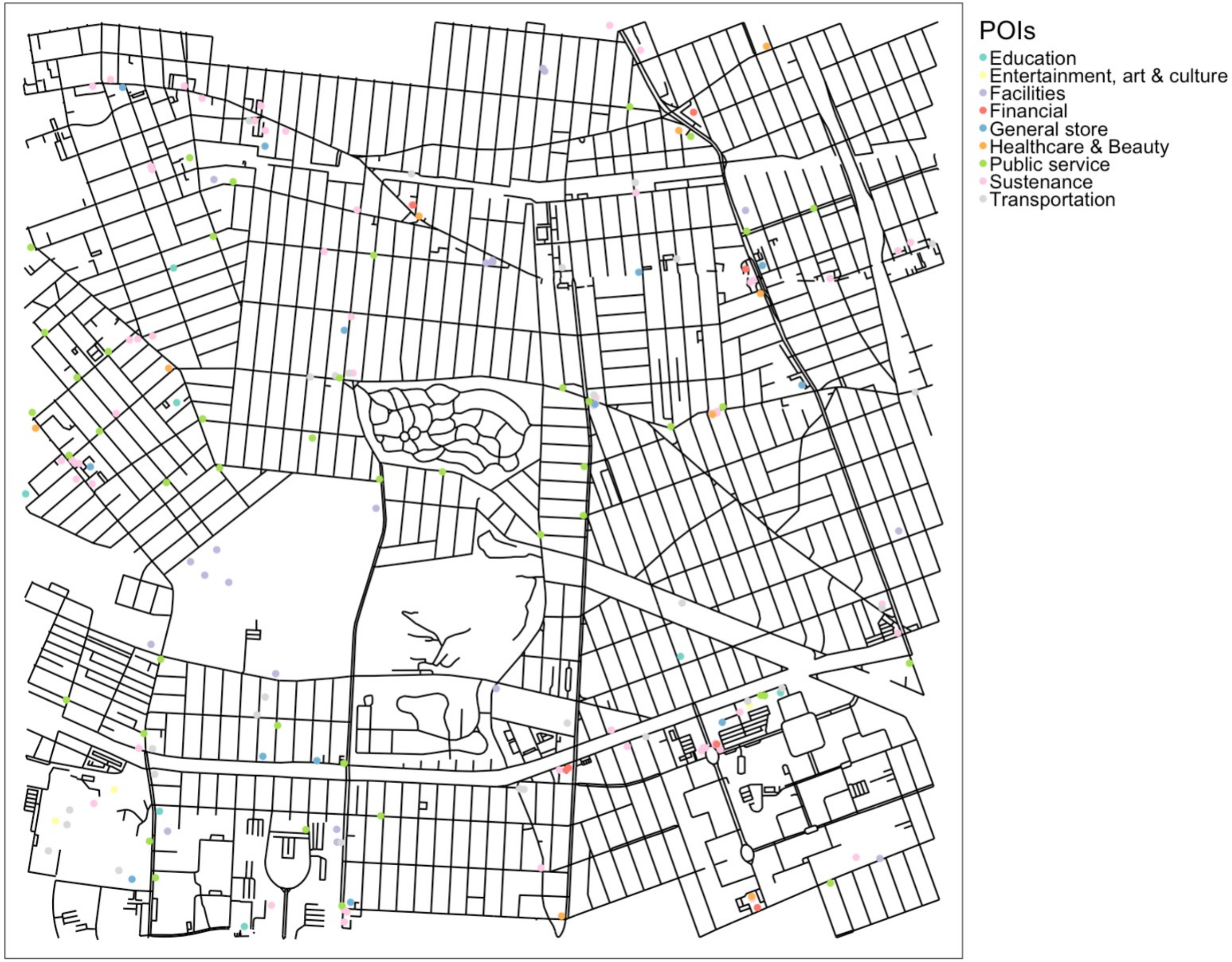
Highway	Description
Primary & primary link	The next most important roads in a country's system (often link larger towns) The link roads leading to/from a primary road from/to a primary road or lower-class highway.
Secondary & secondary link	The next most important roads in a country's system (often link towns) The link roads leading to/from a secondary road from/to a secondary road or lower-class highway.
Tertiary & tertiary link	The next most important roads in a country's system (often link smaller towns and villages) The link road leading to/from a tertiary road from/to a tertiary road or lower-class highway.
Residential	Roads which serve as an access to housing, without function of connecting settlements. Often lined with housing
Service	For access roads to, or within an industrial estate, camp site, business part, car park, alleys, etc.

Methodology: Data preparation

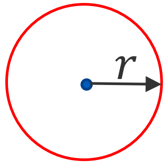
Point of Interests (POIs)

OpenStreetMap

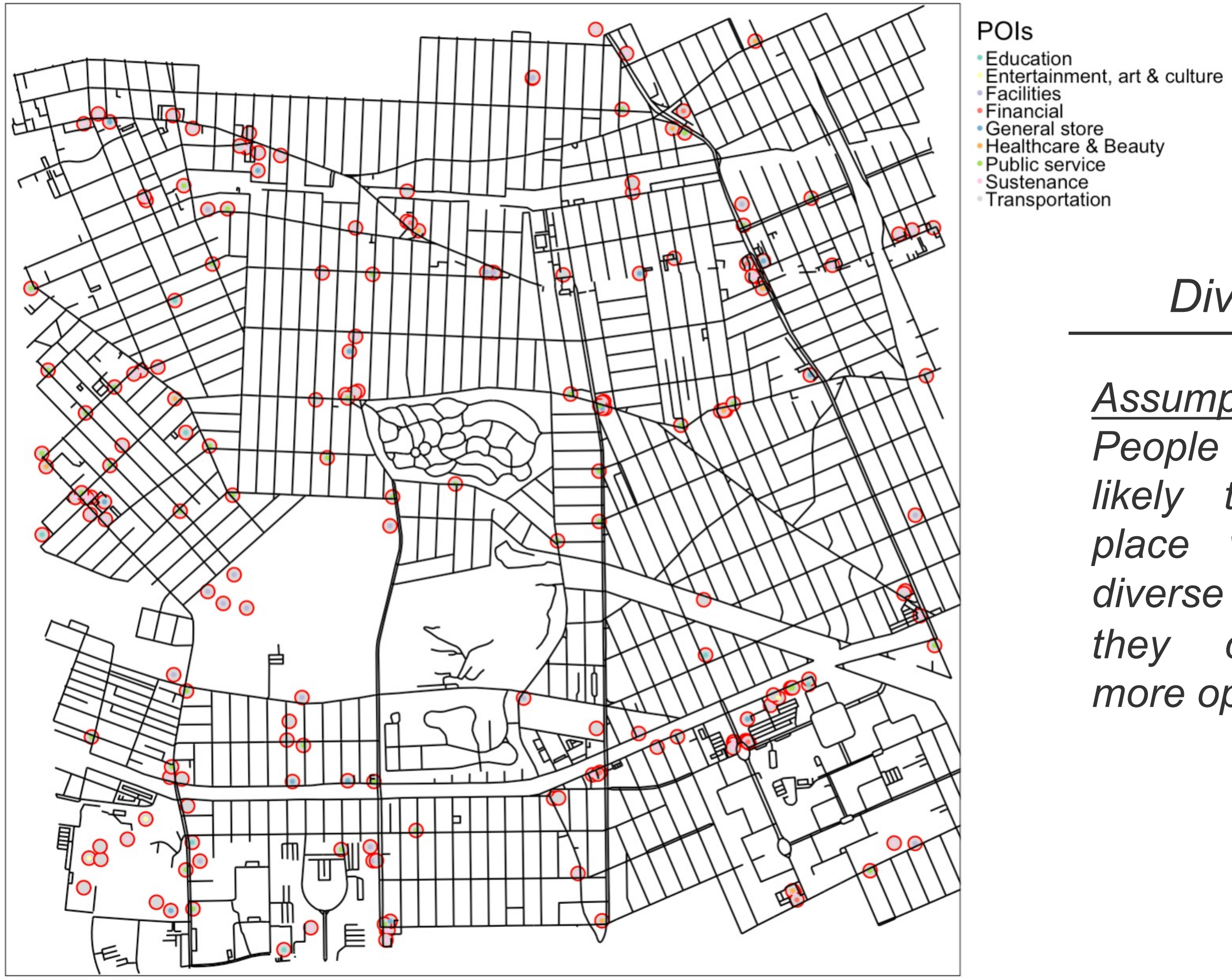
POIs	Count
Education	7
Entertainment, Art & Culture	3
Facilities	20
Financial	7
General Store	13
Healthcare & Beauty	9
Public Service	43
Sustenance	60
Transportation	28



Methodology: Data preparation



r = 30m buffer
around each POI point



Diversity

Assumption: *People are more likely to visit a place with more diverse POIs as they can have more options*

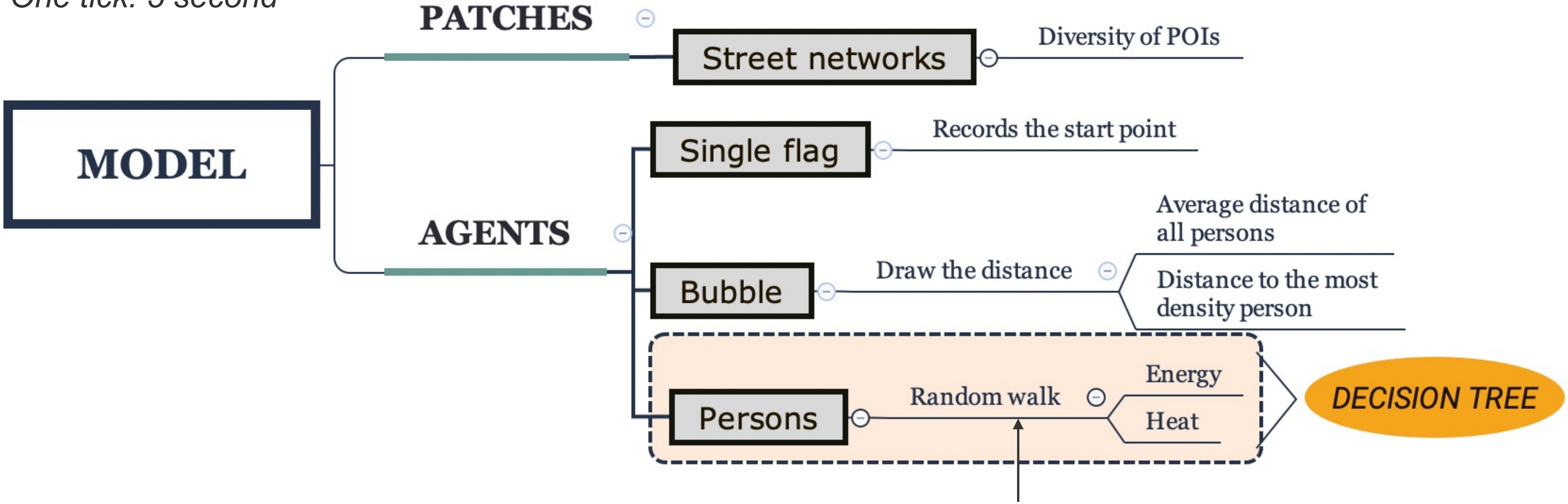
Shannon's diversity index

$$H = -\sum_{i=1}^{s} p_i ln p_i$$

Min-max normalization

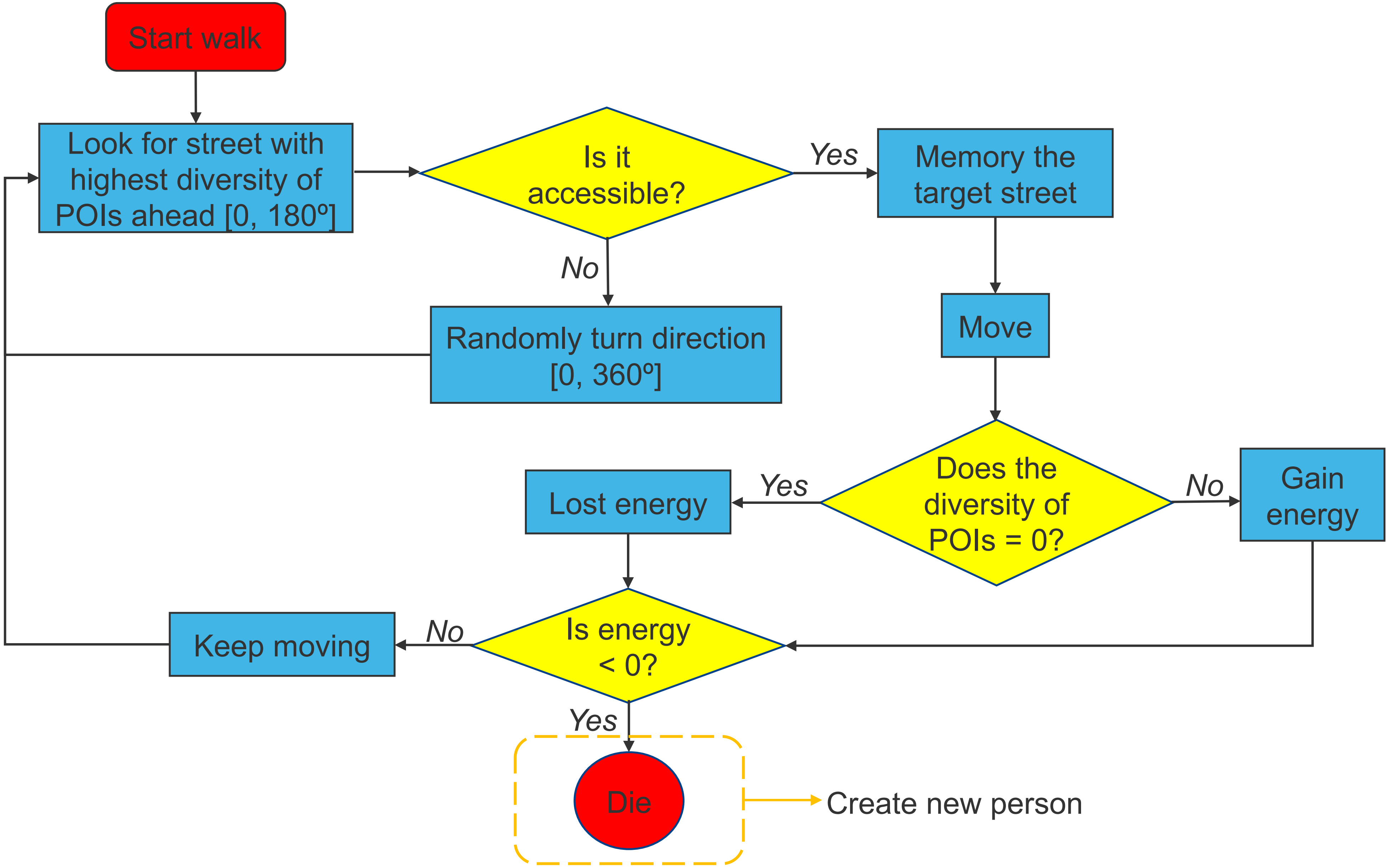
Methodology: Model Structure

Cell resolution: 8 m^2
One tick: 5 second



Walking speed: 1.6 m/s

Methodology: Model Structure



Methodology: Model Structure

Drawing the '15-minute City' Bubble

Pre-setup

Please choose the number of people (default = 100): num-person 103

Do you wanna show people's IDs? On Off show-ID?

Which you wanna show POIs value? base-map show POIs

Do you wanna show rings on the background? On Off show-rings?

How large the rings? (default radius = 50) ring-radius 50

Do you wanna paint the path that people have walked through? On Off show-path?

How do you wanna paint the path? path-type diffusion

Setup | Move | Go

Draw the Bubble

How do you wanna draw the bubble? (default = average walking distance) distance-type average

If you choose 'density', please choose the focus range: density-distance 50

Walking time

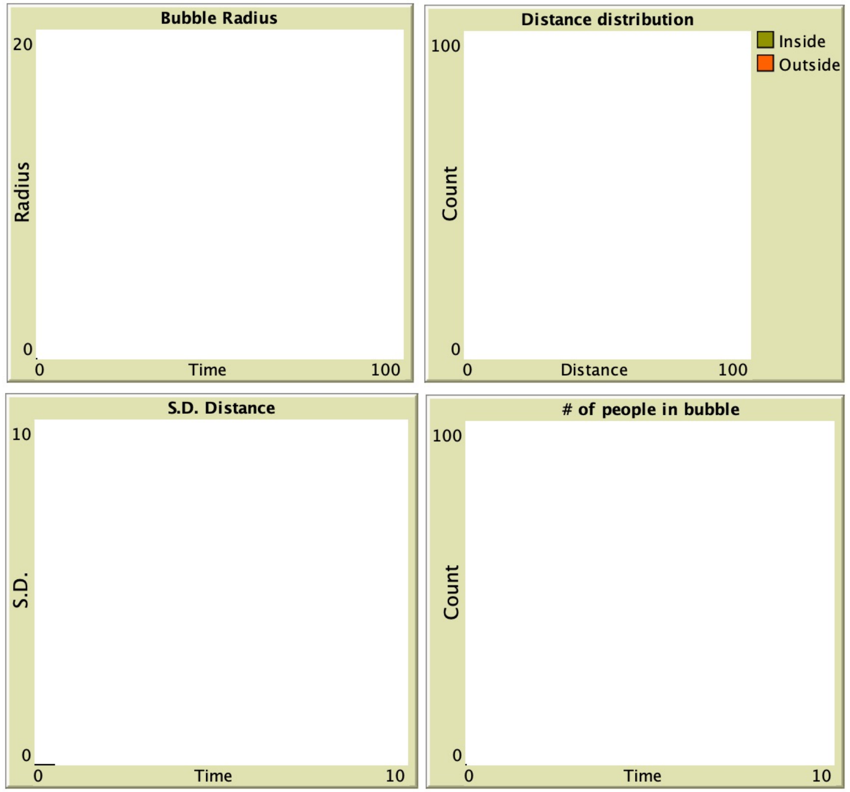
MINUTE 0

SECOND 0

Outputs

Actual bubble radius (m) 0

Actual S.D. Distance (m) 0



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Model Demo

Walking time

MINUTE 0

SECOND 0

Outputs

Actual bubble radius (m) 0

Actual S.D. Distance (m) 0

Show walk path:
No heat diffusion

Show walk path:
With heat diffusion

Conclusion

Strengths

- Integrate GIS with agent-based model.
- Use the real data to reflect certain street features
- The model has the capability to measure the community-life bubble of a city and compare bubble size between different cities.
- The model is flexible to add other indicators that influence human movement behaviors (e.g., transport accessibility, safety, appearance, etc.).

Limitations

- More features need to add to the human (e.g., economic status, demographic characteristics, social networks, etc.) to better reflect the real walk in a city
- More indicators need to consider to construct street features

Reflection

Challenges:

- How to integrate GIS in *Netlogo* and pass value to patches
- How to create recursion function for random walk decision making
- How to store memory of agents
- How to trace model errors
- …

Learning Gains:

- Understand the modeling procedure (e.g., problem definition, dynamic hypothesis, model development, etc.)
- Gain basic knowledge of *Netlogo* software (e.g., create multiple agents, write functions, add properties, integrate GIS, debugging, etc.)
- Use ABM to solve real world problem

About

workflowr ✔

Drawing the '15-minute City' Bubble: Crowd simulation to detect the size of community-life circle in New York City

The recent uptake of '15-minute city' planning ideas sought after by cities around the world (Weng et al. 2019, Pozoukidou and Chatziyiannaki 2021) refers to the idea that all residents can access most of their daily needs (e.g., groceries, work, education, shopping, health, exercise, entertainment, etc.) within 15 minutes (up to 20 minutes), commuting from their own doorsteps by walking, cycling, or public transportation. This notion has been sharply discussed lately during the Covid-19 pandemic, as the pandemic has significantly restricted human movement, forcing people to stay at home and only go out for basic needs (Dinah Lewis Boucher, 2020). Thus, ushering in a new era of integrated urban fabric which combines most of residents' life essentials to each local community is promoted.

However, when the concept of '15-minute city' and the history of urban inequity (Duncan et al. 2012, Douglas S.Massey 2001) encounter, challenges of implementing the idea arise and the challenges could vary from different countries in different places (Feargus O'Sullivan, 2021). For example, people who stay in New York may be able to gain most of their daily needs within 15-minute traveling, while people who live in the small and midsized cities may require more time to get their essentials. So,

- What is the size of a 15-minute city or a community-life bubble (which is referred to as 'the bubble' in the remainder of the paper) within a travel distance of 15 minutes by different traveling modes (e.g., walking, cycling, etc.)?
- How much the size of bubble varies between different places?
- How is the expanding rate of the bubble size when people traveling during the 15 minutes?
- Does the expanding rate drop dramatically or retain increasing after 15 minutes? If the expanding rate reach plateau before 15 minutes, does that mean residents can get their needs in a smaller area?
- What could be the potential factors that affect the size of the bubble?

The benchmark of quantifying a 15-minute city has not come with a consensus in the current state-of-the-art. It is at this junction, we spatiotemporally simulate residential movement on streets from the bottom-up by developing an agent-based model to quantitatively draw the bubble of a city. In this study, we take New York City as the case study and apply the model to the five boroughs. We hope the study could be helpful for detecting the flexibility of defining a '15-minute city' and for investigating the potential factors that affect its definition.

Reference

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