# Accessibility Around the Last Mile: Concepts and Tools for Pedestrian-scale Modelling.

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### Two common ways of approaching destinations in the city



G. Caillebotte - Jeune homme à la fenêtre



École Militaire

CAF

While moving around

e.g. on the way to transit

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PAPETH

### **1. Fixed Origin Spatial Accessibility Metrics**



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### **Reach accessibility index**

How many surrounding destinations j can be reached from building i within a given network radius?

$$Reach[i]^r = \sum_{j \in G - \{i\}, d[i,j] \le r} W[j]$$



The map shows buildings that lie within a 10-minute (600m) walkshed from Darwin's café (shaded dark). On Brattle St.



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### Accessibility can be specified to any type of destination



# % population within 1KM of a retail cluster of >25 stores

#### walking distance





### **Towards Amenity Oriented Development (AOD)**

Comparison of urban form and population density metrics across cities that provide a high (top) and a low (bottom) share of populations with walking access to retail clusters.

		Population within 1000m of a							
		retail	Population	Land Area	Residential			Built Coverage	
Rank	City	cluster	2010	(km2)	Density		FAR		
1	New York City, NY	88%	8,175,133	783.0	10,890	km <sup>2</sup>	1.66	35.38%	
2	San Francisco, CA	84%	805,235	121.5	7,174	km <sup>2</sup>	0.43	27.42%	
3	Boston, MA	69%	617,594	125.4	2,700	km <sup>2</sup>	0.71	16.14%	
4	Miami, FL	67%	399,457	93.2	4,866	km <sup>2</sup>	-	-	
5	Honolulu, HI	62%	337,256	156.7	2,236	km <sup>2</sup>	1.50	14.16%	
6	Los Angeles, CA	55%	3,792,621	1,214.0	3,275	km <sup>2</sup>	1.40	18.67%	
7	Washington, DC	54%	681,170	158.1	4,308	km <sup>2</sup>	0.83	16.47%	
8	Oakland, CA	51%	390,724	144.8	2,901	km <sup>2</sup>	0.69	17.04%	
9	Chicago, IL	41%	2,695,598	589.6	4,572	km <sup>2</sup>	-	14.15%	
10	Atlanta, GA	40%	417,735	344.9	1211.17	km <sup>2</sup>	-	-	
	Mean	61%	1,831,252	373.1	4,413.4	km <sup>2</sup>	1.03	19.93%	
31	Omaha, NE	9%	383,964	329.2	1166.35	km²	-	-	
32	Jacksonville, FL	9%	822,050	1,934.7	425	km <sup>2</sup>	0.05	1.23%	
33	Tucson, AZ	9%	520,116	611.7	868	km <sup>2</sup>	0.21	6.52%	
34	Cleveland, OH	8%	396,815	201.2	1,972	km <sup>2</sup>	-	-	
35	San Antonio, TX	7%	1,469,845	1,193.7	1,147	km <sup>2</sup>	-	-	
36	Oklahoma City, OK	7%	579,999	1,556.9	360	km <sup>2</sup>	-	-	
37	Columbus, OH	7%	787,033	562.5	1,399	km <sup>2</sup>	-	-	
38	Fort Worth, TX	6%	854,113	886.3	842	km <sup>2</sup>	-	-	
39	Memphis, TN	6%	646,889	816.0	770	km <sup>2</sup>	0.26	6.42%	
40	Detroit, MI	4%	713,777	359.4	1,900	km <sup>2</sup>	0.25	14.78%	
	Mean	7%	717,460	845.2	1,084.9	km <sup>2</sup>	0.19	7.24%	

# Highest

Lowest

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### Key user inputs for Reach accessibility:

- 1. Origin points
- 2. Destination points
- 3. Optionally weights for destinations (e.g. jobs field for census tracts)
- 4. Search radius (along the network, e.g. 400m)

### **Gravity Index**

Accessibility is proportional to the attractiveness & inversely proportional to the distance of reaching surrounding destinations j (Hansen 1959)

$$Gravity[i]^r = \sum_{j \in G - \{i\}, d[i,j] \le r} \frac{W[j]^{\alpha}}{e^{\beta \cdot d[i,j]}}$$



## Walking distance to bus stops in different cities % transit users



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### Walking distance to bus stops in different cities

% transit users



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### Gravity access from buildings to public transit in Cambridge, MA

T-stops and bus stops (T = 5x bus). Search radius= 1,000m; beta= 0.002



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### Gravity access from buildings to jobs in Cambridge, MA

Search radius= 1,000m; beta= 0.002



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### **Example: Public transit accessibility in SG from each building** Gravity access



### Key user inputs for Gravity accessibility:

- 1. Origin points
- 2. Destination points
- 3. Optionally weights for destination points (e.g. jobs field for census tracts)
- 4. Search radius (along the network, e.g. 400m)
- 5. Beta value for the decay effect\*

i.e. use the following beta values if drawing units are:

"meters" 0.002 "feet" 0.000663 "kilometers" 2.175 "miles" 3.501.

### How can accessibility be improved? **a. Facilitate transportation to destinations**



### How can accessibility be improved? Increase the density of destinations around a location



### How can accessibility be improved? Increase capacity (or attractiveness) of destinations



### How can accessibility be improved? Improve spatial connectivity to destinations



### 2. Mobile Origin Spatial Accessibility Estimation



### **Distribute Origin Weights**

Spatial origins and Destinations



### **Shortest route**

Spacing synthetic points along the shortest route between the O and D at 10m intervals. Overall origin weight remains the same.



### All plausible routes

Up to 20% longer than shortest route



### Key user inputs for Distributing Weights :

- 1. Origin points.
- 2. Destination points.
- 3. Optionally weights for origin points (e.g. people in buildings).
- 4. Observer points, that can count passersby but do not send out or receive any trips themselves.
- 5. Nearest, All, Search radius (determines which destinations are used).

### **Example 1: Planning Commercial Centers in Singapore**

Sevtsuk, A., Kalvo, R. (2017). Patronage of urban commercial clusters: a networkbased extension of the Huff model for balancing location and size. Environment and Planning B: Urban Analytics and City Science. Issue 0(0). pp. 1-21. <u>PDF</u>





### Betweennes: estimated distribution of walks to transit stops





### Gravity access from <u>homes</u> to retail centers

Weighted by store size. Radius= 3,000m; beta= 0.001



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### Gravity access from metro walk routes to retail centers

Weighted by store size. Radius= 3,000m; beta= 0.001



**Punggol, Singapore** 

High

Accessibility



### Estimated center patronage assuming trips start from homes. **Total visits in town 33,211.**



### Estimated center patronage assuming trips start from metro walk routes. **Total visits in town 35,055.**



Estimated center patronage assuming trips start from MRT walk routes. Total patronage in town= 35,055 households.





Model type

Estimate of retail patronage, where existing and future commercial clusters are located according to HDB's current plans. Total quantum of commercial space is 136,500m2.

Total patronage in town: 38,243 households.



Estimate of retail patronage, where the same number of commercial centres are located deliberately closer to MRT walk routes and their sizes reallocated so as to maximize access. Total quantum of commercial stays the same at 136,500m2.

Estimated patronage across all clusters is 41,254 households.







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### Example 2

City Form Lab & Hansen Partnership. (2015). Surabaya Urban Corridor Development Program. The World Bank. <u>PDF</u>

### Surabaya Tram Corridor

Context



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### **Population density at RT level**

South Surabaya



### Estimating foot-traffic from origins to destinations

Betweenness analysis, UNA Toolbox



### Predicted footfall from homes to MRT stations

to stations up to 800m away

### 269 km of paths!



### Prioritize paths with highest footfall >5,000p day

to stations up to 800m away





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### **Brattle Street, Cambridge MA**

Brattle St at Harvard Square has a number of a popular shopping destinations, street cafes and restaurant. The timelapse is captured at about 50 meters from the nearest Harvard Square subway entrance. The space in front of the camera contains a large sidewalk with ample seating areas, which also functions as a public plaza for street musicians and people-watchers.

15:50	Mon	904	783	647	19.2	251571
14/09/2015	Weekday	Footfall per hour	Betweenness	Businesses	Transit	Floor Area



### Upgrade important kampung lanes leading to MRT stations

Drainage, lighting, landscaping, activity generating uses, bike-lanes, furniture...



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### Data...

### **Complex built environment around the last mile**

**AH** 



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### Data we have: road networks



### Data we should have: pedestrian networks and building entrances



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1 truck 4 buses



### Governments maintain good databases on vehicular roads

e.g. US Census TIGER roads data

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### E.g. US Census TIGER roads data

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### The lack of good data is a huge barrier to better walking infrastructure. Denver, a self-styled Vision Zero city, can't eliminate traffic deaths without a safe walking network. And the city can't improve its walking network if it doesn't know where the weaknesses are. And yet, no city department has an inventory of the city's sidewalks and crosswalks.

### **Streets Blog Denver**

### Crowd-sourcing sidewalk data

e.g. Walkscope in Denver



## City governments should maintain equally good databases on pedestrian networks...

OECD ITF to develop standards and recommendations for cities around the world?



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### Conclusions

- It is customary to measure spatial accessibility from fixed locations (e.g. homes, jobs), but people don't necessarily start their trips from these locations.
- Changing our assumption about trip origins, changes our estimates of how frequently and by whom urban amenities can be accessed and are visited.
- When planning accessible environments, we need to not only think about motorized and mechanized transport infrastructure, but also focus on the scale of the *street* which everyone intuitively experiences.
- In order to describe accessibility on streets, we need data about sidewalks and pedestrian infrastructure.
- Could OECD help propose standards and urge cities to collect sidewalk data?
- In order for accessibility analytics to influence city design and planning, analytics needs to move from being retrospective and become projective, applied to synthetic and normative design solutions of the future, shaping decisions about potential built environments.

### Thank you!

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### **Urban Network Analysis toolbox software (FREE)**

The free Urban Network Analysis Toolbox can be downloaded for Rhino3D from http://cityform.gsd.harvard.edu/projects/una-rhino-toolbox and for ArcGIS from http://cityform.gsd.harvard.edu/projects/urban-network-analysis

### **Related Articles**

Sevtsuk, A., Mekonnen, M., 2012, "Urban Network Analysis Toolbox," International Journal of Geomatics and Spatial Analysis, vol. 22, no. 2, pp. pp. 287–305. PDF

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