An Urban Walkability Assessment Model

Based on Network Distance Metrics and Topographic Features

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What is meant by walkability[1]?

It is an integral part of a computational model (Nourian, P., Sariyildiz, S., 2012) for measuring the pedestrian accessibility of vital services and locations from urban blocks and through urban street networks.

1- Taking account of topographic landscape in calculation of network distance, as well as the topological structure of the network. (Google does not show the walking distance according to topography.)

2- Consideration of an inter-subjective aspect of vitality as the relative importance of places: this makes the model interactive and yet mathematically consistent

Walkability from the point of view of "urban morphology" **(Moudon, 2003)**

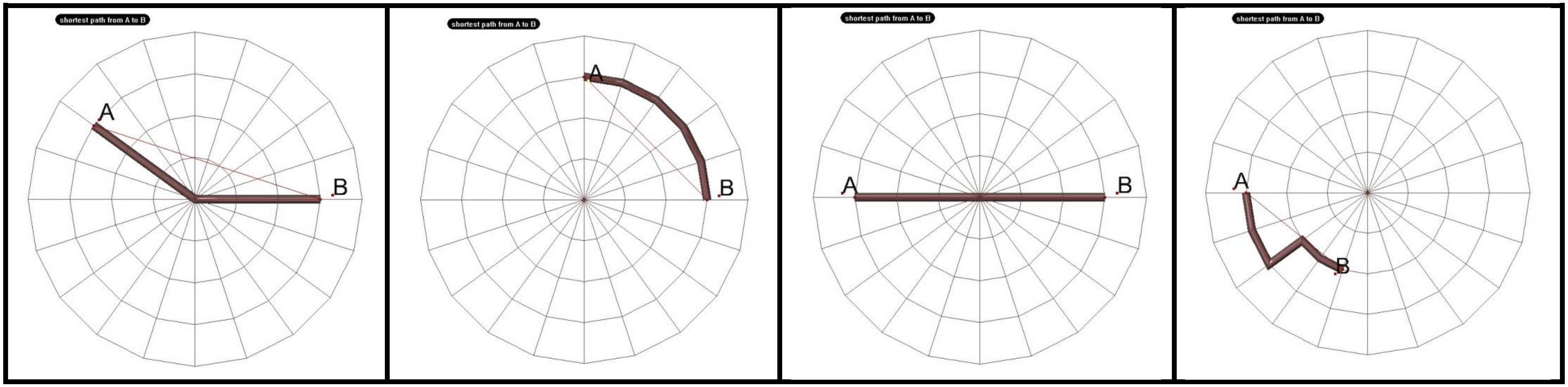
How to measure the average pedestrian access of a place to a group of important locations?

HOW TO MEASURE WALKABILITY			
	1	STREET NETWORK TOPOLOGY	HOW THE STREETS ARE CONNECTED TO ONE ANOTHER: NETWORK DISTANCE
	2	TOPOGRAPHIC FEATURES	HOW DIFFICULT TO WALK A CERTAIN ROUTE IS, BECAUSE OF ITS UPS & DOWNS
	3	ATTRACTION POINTS	WHERE IMPORTANT SERVICES ARE PROVIDED & ONE NEEDS TO BE CLOSE BY
	4	VICINITY & AGGREGATION	HOW CLOSE ONE IS TO AN ATTRACTION POINT, OR ALL OF THEM ON AVERAGE
	5	RELATIVE IMPORTANCE OF POINTS	HOW IMPORTANT AN ATTRACTION IS, COMPARED TO OTHERS

[1] A measure of walkability potential: the actual walkability might be quite different due to many other features of streets not taken into account such as noise level, safety, pavement quality and alike, which might have a great influence on the actual walkability of a neighborhood. This is to say what can be calculated by this model is basically the walkability potential of a neighborhood, regardless of the abovementioned factors.

- **(Metric) Shortest Path Algorithm by Edsger Dijkstra (Dijkstra, 1959)→ USED IN THE MODEL**
- **(Angular) Shortest Path by Alasadir Turner (Turner, 2007)→ TO BE USED AS AN ALTERNATIVE IN FUTURE DEVELOPMENTS**

Table 1 Euclidean Shortest-Path versus (Metric) Shortest Path between a pair of origin-destination (drawn using "Shortest walk" component, made by Guilio Piachentino)

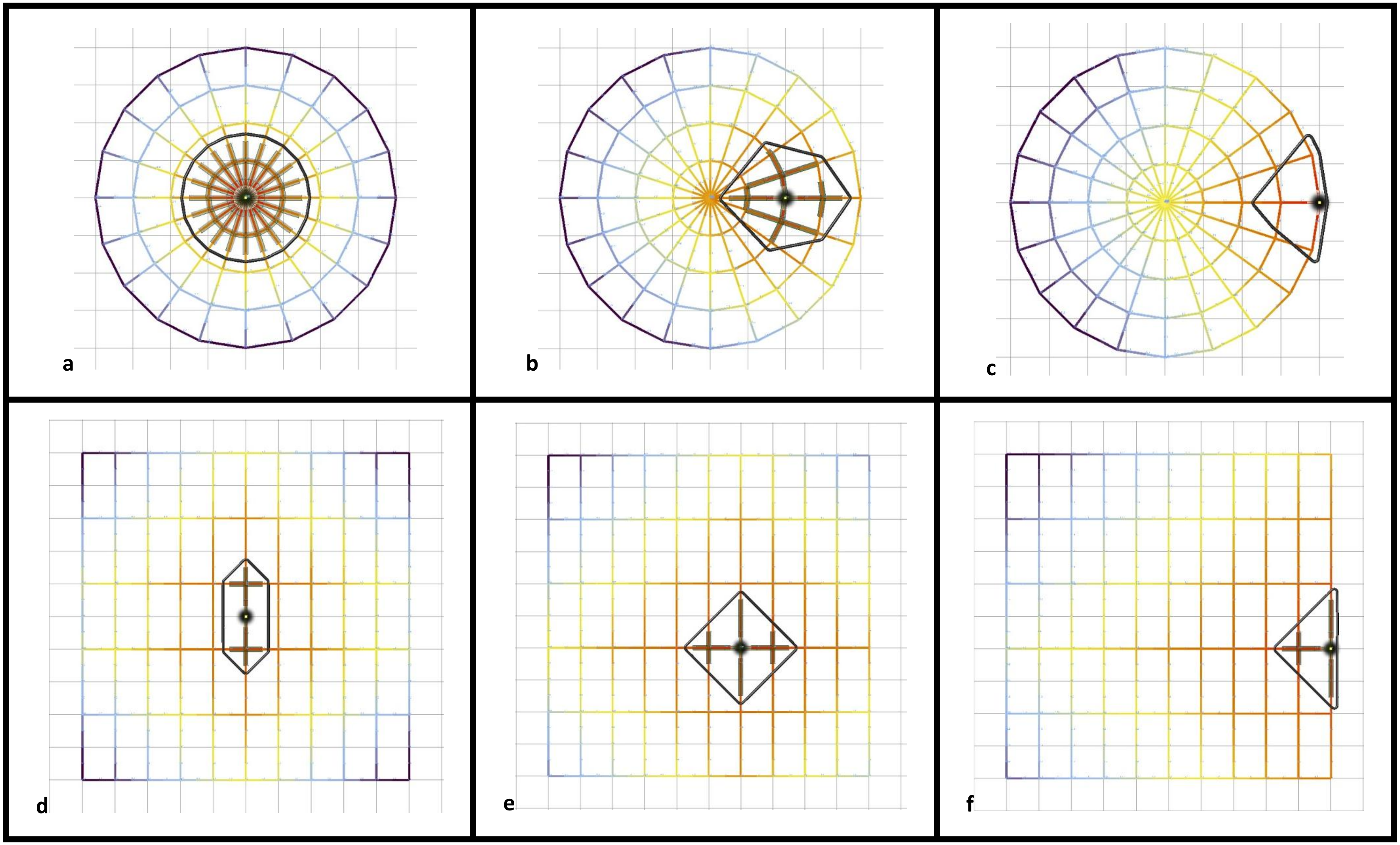


- **Catchment Radius**

The distance of an origin towards its catchment enclosure, delineating the furthest accessible points for an agent moving in all possible directions for an equal range of distance termed as *catchment radius*. It can be expressed in terms of spatial distance (meters, for instance) or temporal distance (minutes of walking).

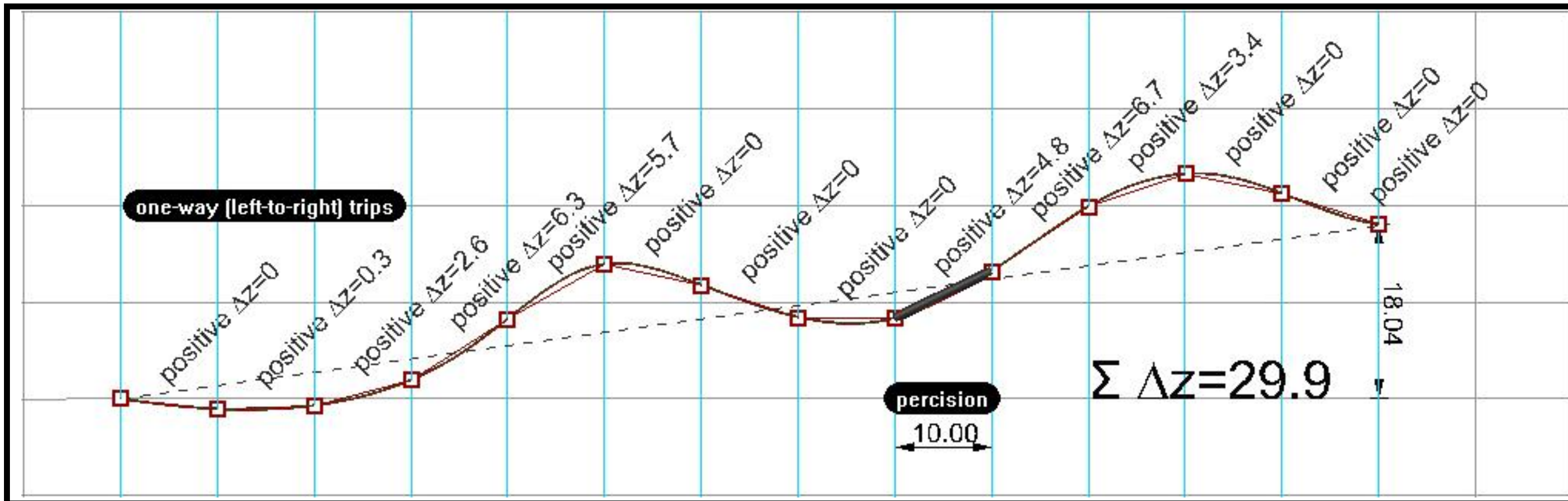
Walking Distance/Network Distance Gradients & Catchment Enclosures

Table 2 Catchment Radii in two particular networks, radial and rectangular, around an arbitrarily chosen point.



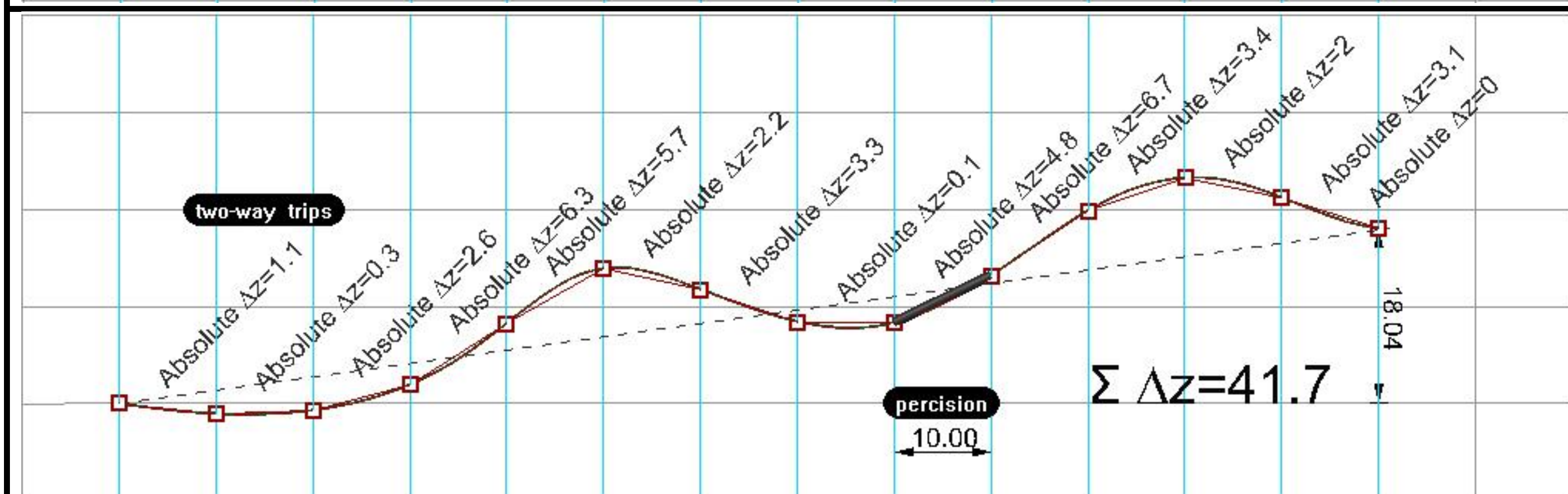
Walking Impedance Calculation

Table 3 Walking impedance measurement for one-way directed trips and for two-way trips



On a curvy route for a one-way trip from left to right

Only ascending pieces impede walking; thus positive altitude differences count.

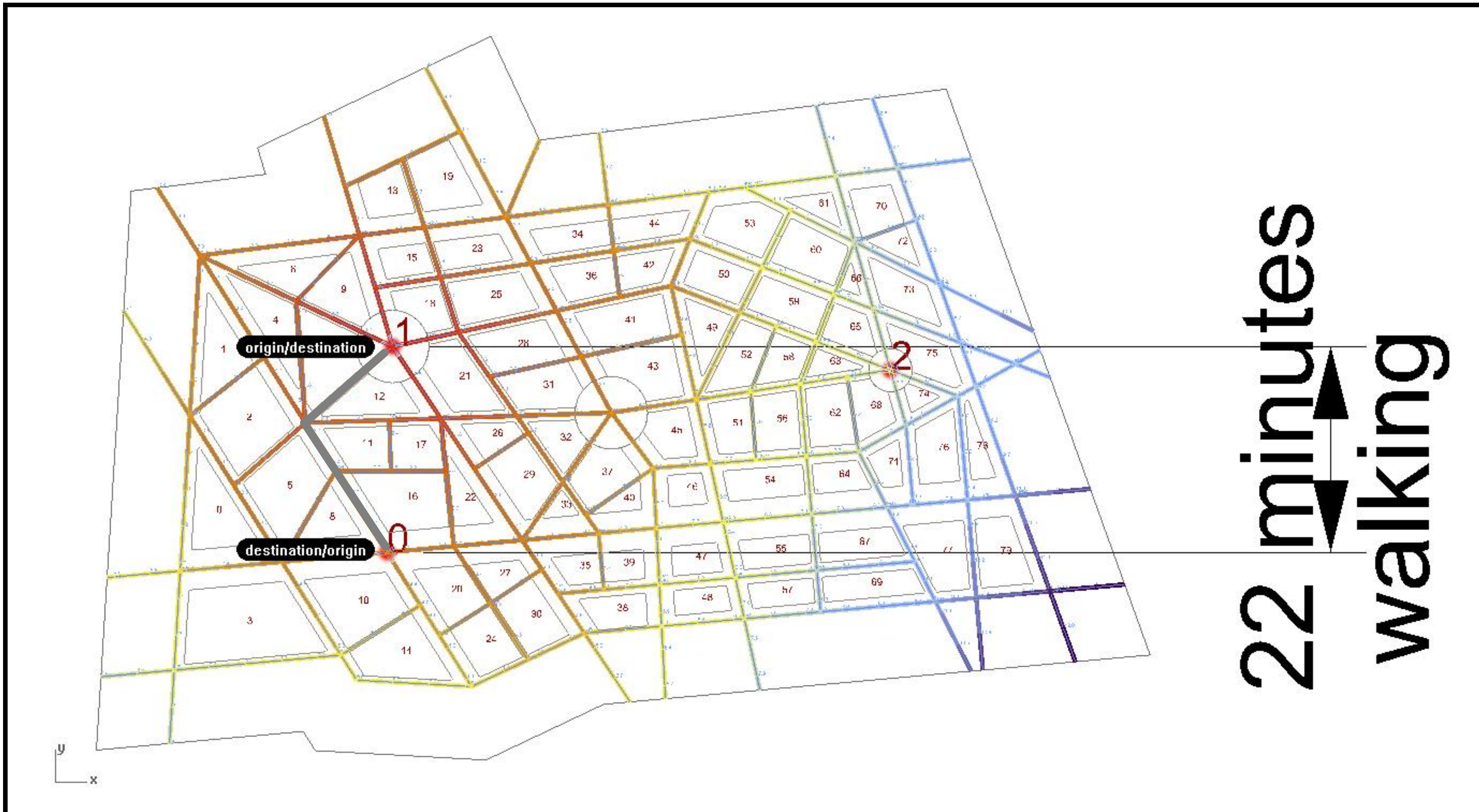


On a curvy route for a two-way trip

Every descending piece will be an ascending one in the return trip; thus absolute altitude differences count.

Walking Impedance Calculation: without taking topography into account

Table 4 Gradient of network distances from attraction point number one, considering a flat landscape; The bluer the color the farther the distance



Walking Impedance Calculation: with taking topography into account

Table 5 Gradient of network distances from attraction point number one, considering a hilly landscape; The bluer the color the farther the distance

Location of vital services

The choice of location for an attraction point is arbitrary for the user	Every location has multiple distances towards attraction points

Table 6 from left to right (a) a typical imaginary neighborhood; (b) street centerlines (c) network distances from an attraction point

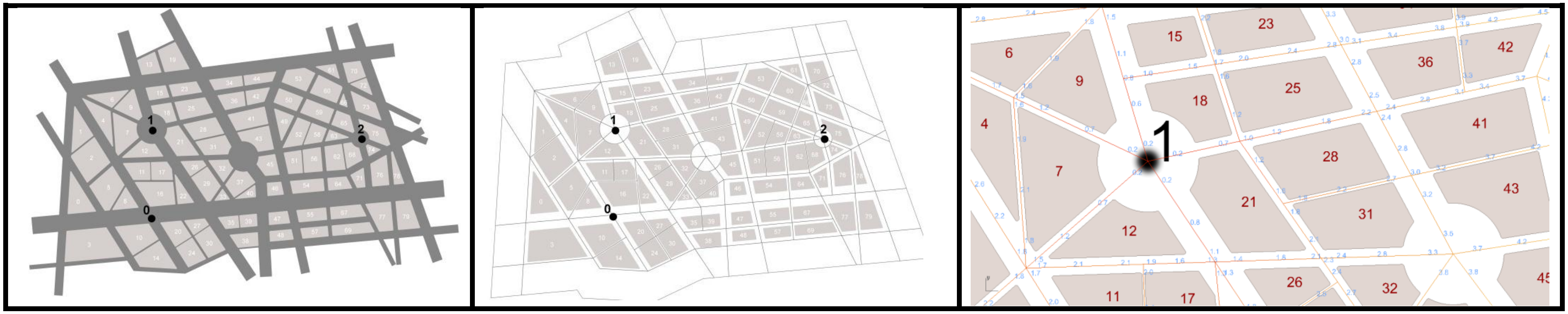
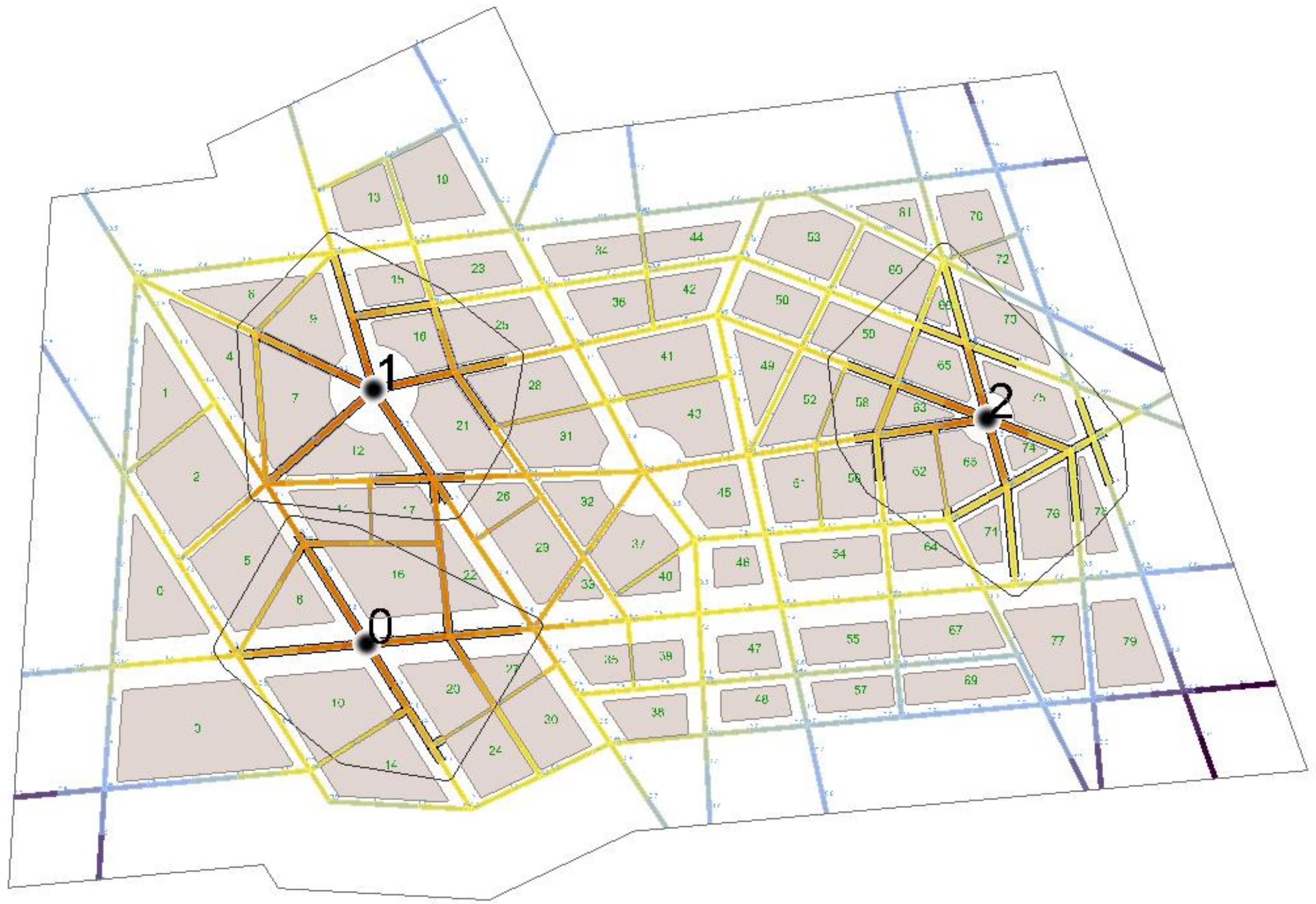


Table 7 network distance gradient measured from different attraction points

Close (enough) to an attraction point?

Table 8 Catchment analysis of attraction points



- **vicinity analysis; vicinity of attractors and catchment radii combined**
- **catchment radii based on network distances and 20 minutes of walking**

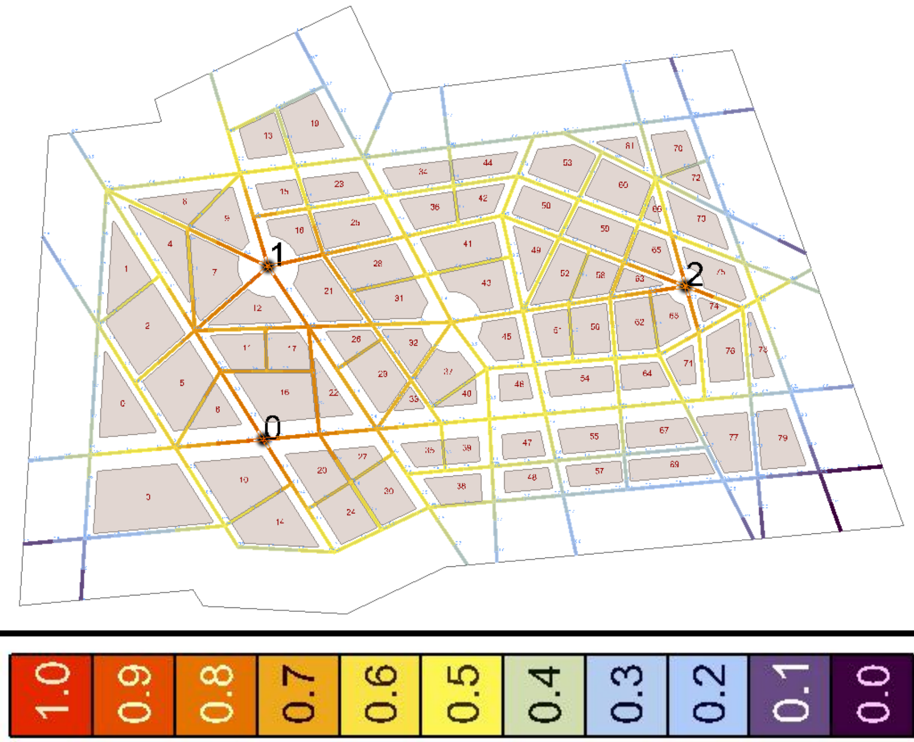
Vicinity versus Walkability as aggregate measures of distance

D_{ik}: The shortest distance of location* number i to attraction place number k through the street network, calculated by the Dijkstra shortest path algorithm.

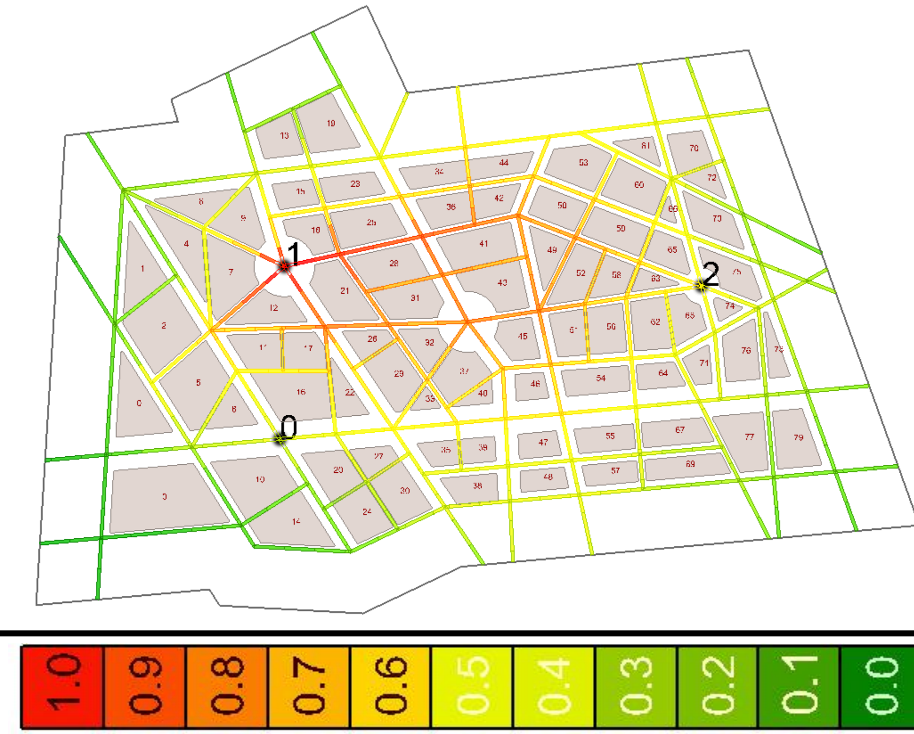
D_i: Aggregate distance measure corresponding to a single location index i.

Table 9 Aggregate measures of distance: vicinity and walkability

VICINITY: proximity to point 0, point 1, OR point 2



WALKABILITY: proximity to point 0, point 1, AND point 2



Inter-subjectivity

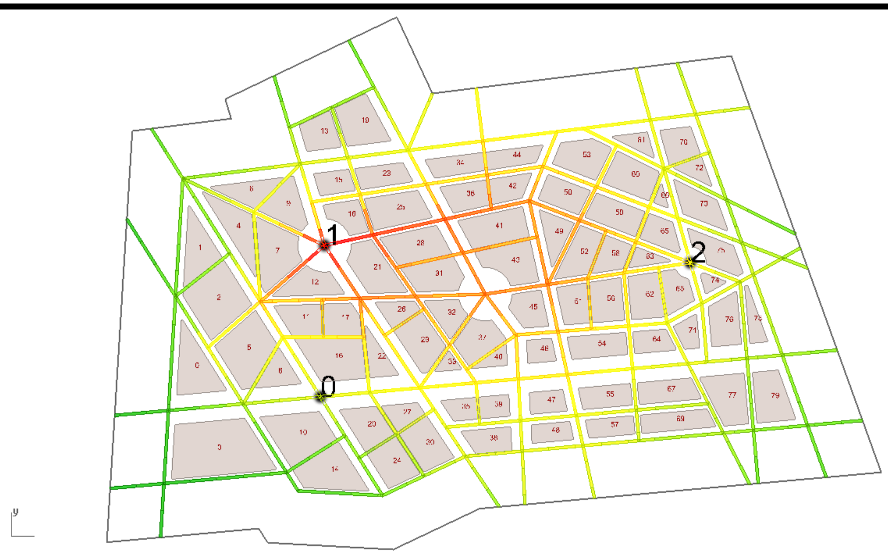
Table 10 In each image one point has the highest relative importance, three times bigger than the other two.

0

1

2

Table 11 Gradient of walkability on street network with the equal relative importance of attraction points



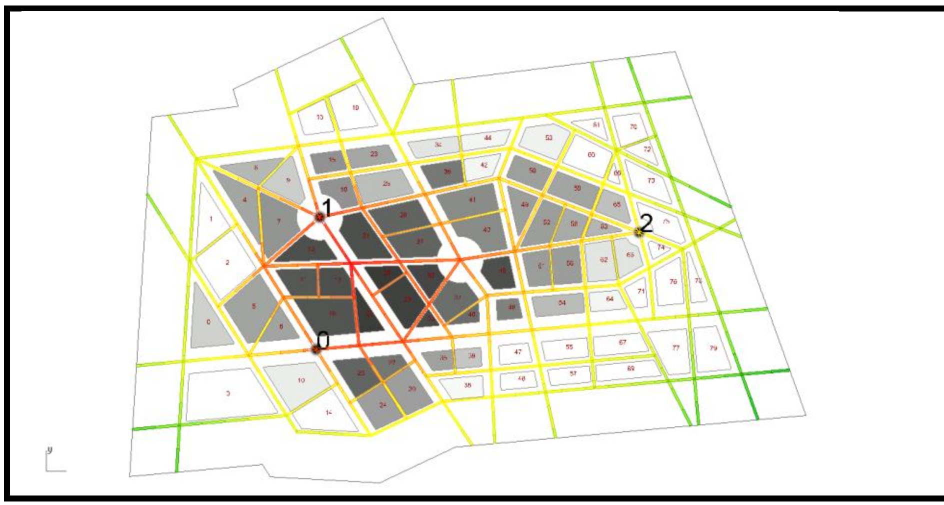
- ***All attraction points have the same relative importance***
- ***Point 1 has a slightly more central location, due to its topological situation***

Fuzzy Definition of Walkability

$$Near\ (walkable) \xleftrightarrow{Fuzzy\ Membership\ function} Far\ (not\ walkable)$$

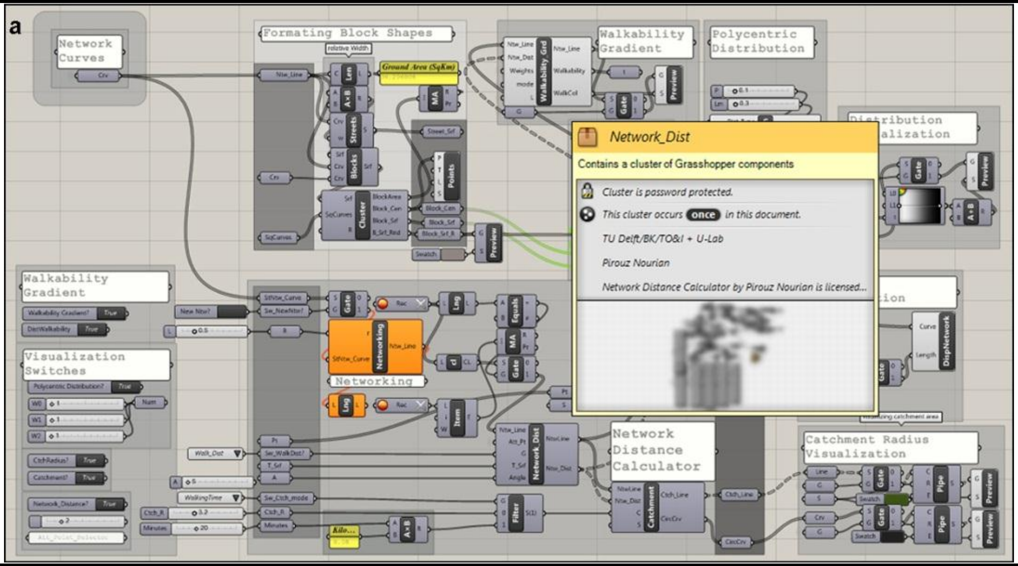
Table 12 The greener the color, the less accessible the location; the blacker the color the more walkable the urban block (0) polycentric distribution of walkability, with the maximum weight of point #0; (1) with the maximum weight of point #1; (c) with the maximum weight of point #2

Table 13 Polycentric distribution of density, with equal weights of importance



- Polycentric distribution of walkability
- A distance decay phenomenon
- Modeled as a "fuzzy membership function"
- A maximum of 700-800 meters/10 minute walk?

Table 14 Structured flowchart of the computational model



The computational model implemented in Grasshopper®, a plugin for computational design tightly coupled with the CAD platform Rhinoceros®.

- This system accepts any kind of network pattern
- The system is completely modular
- All the major module have been developed by Pirouz Nourian
- The algorithms are to be reported in a forthcoming journal paper.
- The modules will be distributed as a tool suite for Grasshopper® soon.

Works Cited

Dijkstra, E. W. (1959). "A note on two problems in connexion with graphs". *Numerische Mathematik, 1*, 269-271.

Lawson, B. (1980). *How designers think* (4th, 2005 ed.). Burlington: Architectural Press, Elsevier.

Moudon, A. V. (2003). A Catholic approach to organizing what urban designers should know. In A. C. (Ed.), *Designing cities: critical readings in urban design* (pp. 362-386). Oxford:Blackwell.

Nourian, P., Sariyildiz, S. (2012). A configurative approach to neighborhood design promoting pedestrain mobility. *ISUF: NEW URBAN CONFIGURATIONS* (p. forthcoming). Delft: ISUF.

Turner, A. (2007). From axial to road-centre lines: a new. *Environment and Planning B*(34(3)), 539-555.

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