Mapping has progressed from a hand-drawn image to one that could be moved around the world, almost at will. It is obvious that over the centuries, a revolution has occurred in cartographic design, map production, delivery and consumption (or use).
The City Form Lab at the Singapore University of Technology and Design, in collaboration with MIT, has created a new Urban Network Analysis (UNA) toolbox that enables urban designers and planners to describe the spatial patterns of cities using mathematical network analysis methods. Network analysis is widely used in the study of social networks, such as Facebook friends or phonebook connections, but so far fairly little in the spatial analysis of cities. While the study of spatial networks goes back to Euler and his famous puzzle of Königsberg’s seven bridges in the 18th century, there were, until recently, no freely accessible tools available for city planners to calculate computation-intensive spatial centrality measures on dense networks of city streets and buildings. The new toolbox, which is distributed as free and open-source plugin-in for ArcGIS, allows urban designers and planners to compute five types of graph analysis measures on spatial networks: Reach, Gravity, Betweenness, Closeness and Straightness.

The Reach measure, for instance, can be used to estimate how many destinations of a particular type—buildings, residents, jobs, transit stations etc.—can be reached within a given walking radius from each building along the actual circulation routes in the area. It offers an intuitive metric to accurately describe how the surrounding built fabric or pattern of economic activities appear differently to an observer from one building to another. The Betweenness measure, on the other hand, estimates the number of trips between the other surrounding destination pairs in the area that pass by a particular building. It can be used to quantify the number of potential passersby at each building. These and the other three indices—Gravity, Closeness, and Straightness—characterise spatial accessibility to each particular location in a number of different and complementary ways.

These indices have numerous practical applications. They help explain, for instance, on which streets or buildings one is most likely to find local commerce, where foot or vehicular traffic is expected to be highest, and why city land values vary from one location to another. They offer a powerful toolkit to study spatial relationships between urban activities under the actual geometric constraints of building, parcel and street networks, which have been largely ignored in spatial analysis.

With the new UNA toolbox, studying spatial configurations of cities, and their related social, economic, and environmental processes has become easier than ever.

**Urban network analysis simplified**
economic models in the past.

The tools incorporate three important features that make them particularly suited for spatial analysis on urban street networks. First, they can account for both geometry and topology in the input networks, using either metric distance (e.g. Miles) or topological distance (e.g. Turns) as impedance factors in the analysis. Second, unlike previous software tools that operate with two network elements (nodes and edges), the UNA tools include a third network element—buildings—which are used as the spatial units of analysis for all measures. The spatial graph thus consists of three basic elements: edges, representing paths along which travelers can navigate; nodes, representing the intersections where two or more edges intersect; and buildings, representing the locations where traffic from streets enters into indoor environments or vice versa. Buildings are represented as points, positioned at the centroids of actual building footprints or entrances, and are assumed to connect to streets (edges) that lay closest to them along the shortest perpendicular connection. Two neighboring buildings on the same street segments can therefore obtain different accessibility results. And third, the UNA tools optionally allow buildings to be weighted according to their particular characteristics—more voluminous, more populated, or otherwise more important buildings can be specified to have a proportionately stronger effect on the analysis outcomes, yielding more accurate and reliable results to any of the specified measures.

The tools are aimed at planners, urban designers, architects, geographers, and spatial analysts who are interested in studying the spatial configurations of cities, and their related social, economic, and environmental processes. The UNA toolbox allows researchers to accurately quantify the two- and three-dimensional network characteristics of different spatial and economic networks in neighborhoods world-wide. Though primarily designed for the study of urban building- and street-networks, the toolbox is equally suited for analyzing other types of spatial networks, such as utility networks, highway networks, or building layouts. The toolbox is built for easy scaling—it can be used for small-scale and detailed network analysis of dense urban areas, as well as sparser large-scale regional networks. It requires ArcGIS 10 software with an ArcGIS Network Analyst Extension and it can be freely downloaded from the City Form Lab website (http://cityform.mit.edu/projects/urban-network-analysis.html).

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