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POI VizNet: New QGIS Tool to Construct Visibility Networks in Cities

Asya Natapov [a,*], Sagi Dalyot [b], Achituv Cohen[c]

[a] *School of Architecture, Building & Civil Engineering Loughborough University – a.natapov@lboro.ac.uk*
[b] *Civil and Environmental Engineering Faculty, Technion – Israel Institute of Technology – dalyot@technion.ac.il*
[c] *Department of Geography, University of California Santa Barbara – achituvcohen@ucsb.edu*

* Corresponding author

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Abstract:

Network science and graph theory offer attractive models to describe urban phenomena and examine cases of urban planning and design. However, none of the existing network analysis tools consider simultaneously human visual perception and locations of urban activities. In this paper we introduce POI VizNet, a new QGIS plug-in that constructs various graphs of unobstructed lines of sight. The plug-in integrates an increasing amount of available GIS-based data of point of interest (POI) and visibility into one readily accessible analytical framework. Graphs are created between two types of decision points during urban travel – street intersections and POIs, origins, and destinations of travel, by connecting these potential observer's decision locations in an open space between buildings. Therefore, the created graphs illustrate hypothetical visual trajectories of a person looking for a particular POI in the city. The graph is termed Integrative Visibility Graph (IVG) as it incorporates both navigational and functional aspects of the city (Figure 1a). IVG examines connectivity of the particular location, i.e., predefined POI within the street network. In addition to IVG, the current version of the toolbox offers two separate modules of analysis corresponding to two additional types of visibility: Street Network Visibility Graph (SNVG) - creates visual connections between decision points of the street network, i.e., street intersections (Figure 1b), and Point of Interest Visibility Graph (POIVG) - creates visual connections between POI that are visible from each other in a given building arrangement (Figure 1c). In addition, POI VizNet provides advanced options to build graphs using a predefined viewing distance and perceptual perspective. Visibility graphs are constructed and visualised as new layers in QGIS and delivered as network files suitable for further exploration, analysis, and visualisation in various network software packages.

In contrast to other vision-oriented analysis methods, such as local isovists or viewshields (Giseop at el., 2019; Benedikt, 1979), POI VizNet translates a city into network-based structure. Network characteristics are global, and therefore they offer a more nuanced picture of urban realm, unique for each building or each POI. Analysing visual patterns with methods from complex network science, we suggest a new link between urban social processes, spatial cognition, and physical theories. A wide range of measures, developed in network and graph theories, could assist in understanding urban evolution – networks' structure, their density, resilience, connectedness, hierarchy, modularity, or clustering (Arcaute et al, 2015; Barthelemy, 2015; Newman, 2010), though not discussed here in details.

POI VizNet combines three historically disconnected approaches - graph analysis, land-use analysis, and visibility analysis, and thereby opens new empirical ground for these fields. It integrates POI, visual perception, and network analytics in one single platform. It expands QGIS with new behavior-oriented exploratory functionality and allows to explore urban environment using interactive visual exploration, as well as to deepen into further statistical analysis, inquiry of individual measures and locations, identification of network core, hotspots, or clustering. Planners, architects, and scholars of the built environment are given a unique tool to incorporate a basic human ability, vision, in their practice. Such practice will rapidly grow with the increasing availability of geospatial and imagery data.

The research community can use POI VizNet in simulations that evaluate wayfinding, pedestrian risks, and route search efficiency. Such simulations will investigate interaction between cities' spatial and cognitive features, e.g., how individuals interact with the urban space, and how this space constantly evolves and transforms from the bottom up in response to behavioural patterns. City performance depends on human behavioral routines - thus, POI VizNet is also highly relevant to the practitioners' community. It contributes to more informed design and assists in understanding factors determining and driving emergence of new amenities or new building uses within certain morphological conditions.

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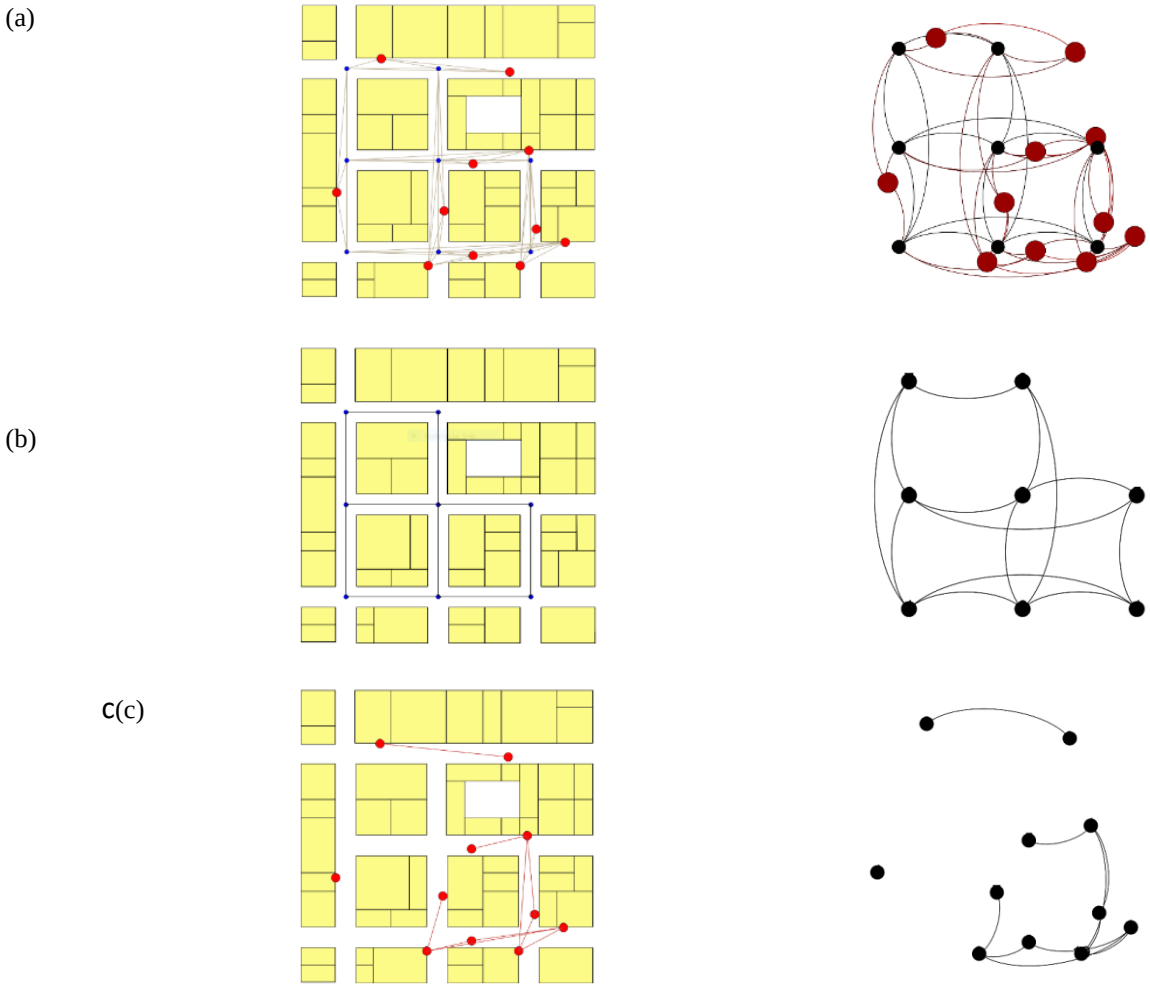

Figure 1. Three types of visibility graphs available in POI VIzNet in geo-referenced and curved visualizations: (a) Integrative Visibility Graph (IVG); (b) Street Network Visibility Graph (SNVG); (c) Point of Interest Visibility Graph (POIVG).

POI VizNet is useful for authorities and stakeholders dealing with the issuance of zoning and building permits for new uses that would alter urban fabric. The use of the new toolbox can prevent withdrawal of pedestrian-oriented commercial uses to the secondary streets, as well as prevent excessive automobilization of city's main streets happening in many planned, modern cities worldwide. Therefore, POI VizNet promotes neighbourhood vibrancy and creates sustainable urban context with mix use desirable for pedestrians.

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