Interaction between Boundary Shape and Circulation Structure in the Built Environment

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Abstract/Summary of the Presentation

The built environment is considered at two distinct scales: the boundary condition exemplified by building shells and urbanized territories, and the embedded circulation system of corridors and streets. Analytical models that consider interrelations between the two scales are especially important for the study of building types where the two have different life spans. In cities, the boundary condition is often influenced by external constraints of terrains and bodies of water. An analytical model is proposed to understand this complex relationship, consisting of three main parts:

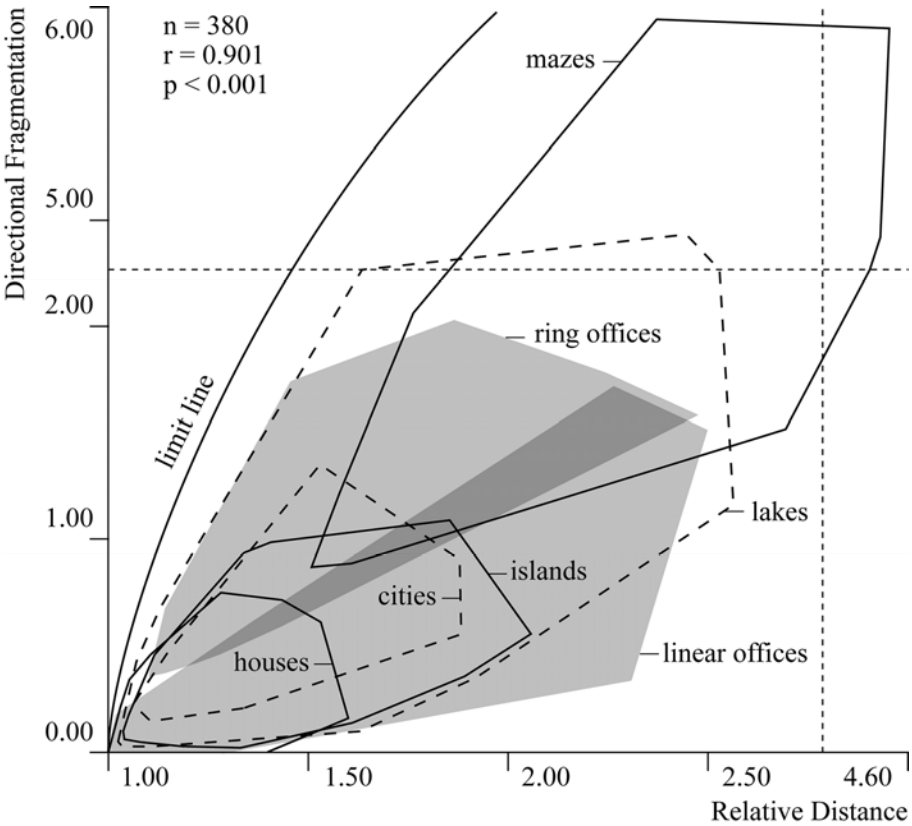

Figure 1: The position of boundary shape classes in morphospace.

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First, a configurational method for describing shape is proposed based on two measures that gauge two elemental human experiences of moving through space: covering distances and changing direction of travel. The first measure, Relative Distance, is an index of universal metric distance. It corresponds to the potential energy needed to cover distances between locations inside a shape. It is calculated by normalizing the overall distance for the entire shape by the overall distance in an equal area square. The second measure, Directional Fragmentation, is an index of the universal change of direction of travel between locations in a shape and corresponds to the kinetic inertia of movement. It is calculated by normalizing the overall visibility graph distances by the area of the shape. A 2D morphospace is proposed based on the joint use of the two measures, defined according to the scatterplot between RD and DF values of shape. It is shown that various boundary shapes from the built environment and physiography occupy specific positions in morphospace.

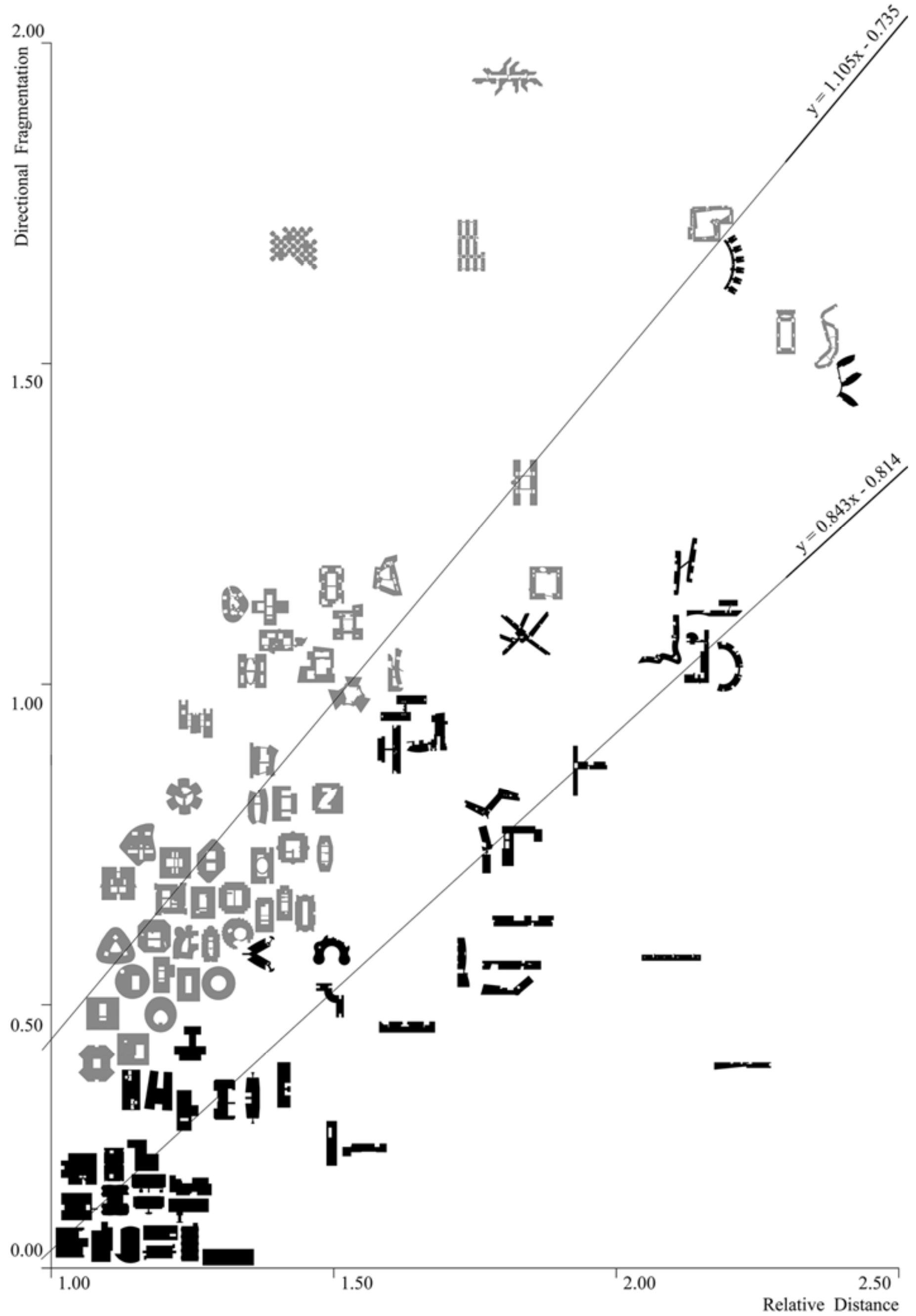

Figure 2: Fifty ring office floorplates (gray) and 50 linear office floorplates (black) compared according to relative distance and directional fragmentation.

Second, boundary shapes are considered according to a balanced diagram of forces, of which the internal forces exerted by circulation systems in buildings and street networks in cities is given priority. Three building types with distinct topological structures of circulation are considered: houses, exemplifying elementary circulation, in both topological and metric terms; office buildings with ring circulation; and office buildings with linear circulation. House floorplates show a weak correlation between two shape measures suggesting that elementary circulation systems are associated with a wide range of conditions of boundary shape that lack a clear relationship between compactness and fragmentation. In contrast, the two classes of office building floorplate, with ring and linear circulation, show high correlation between the two shape measures, while in addition they occupy distinct positions in morphospace with a minimal overlap.

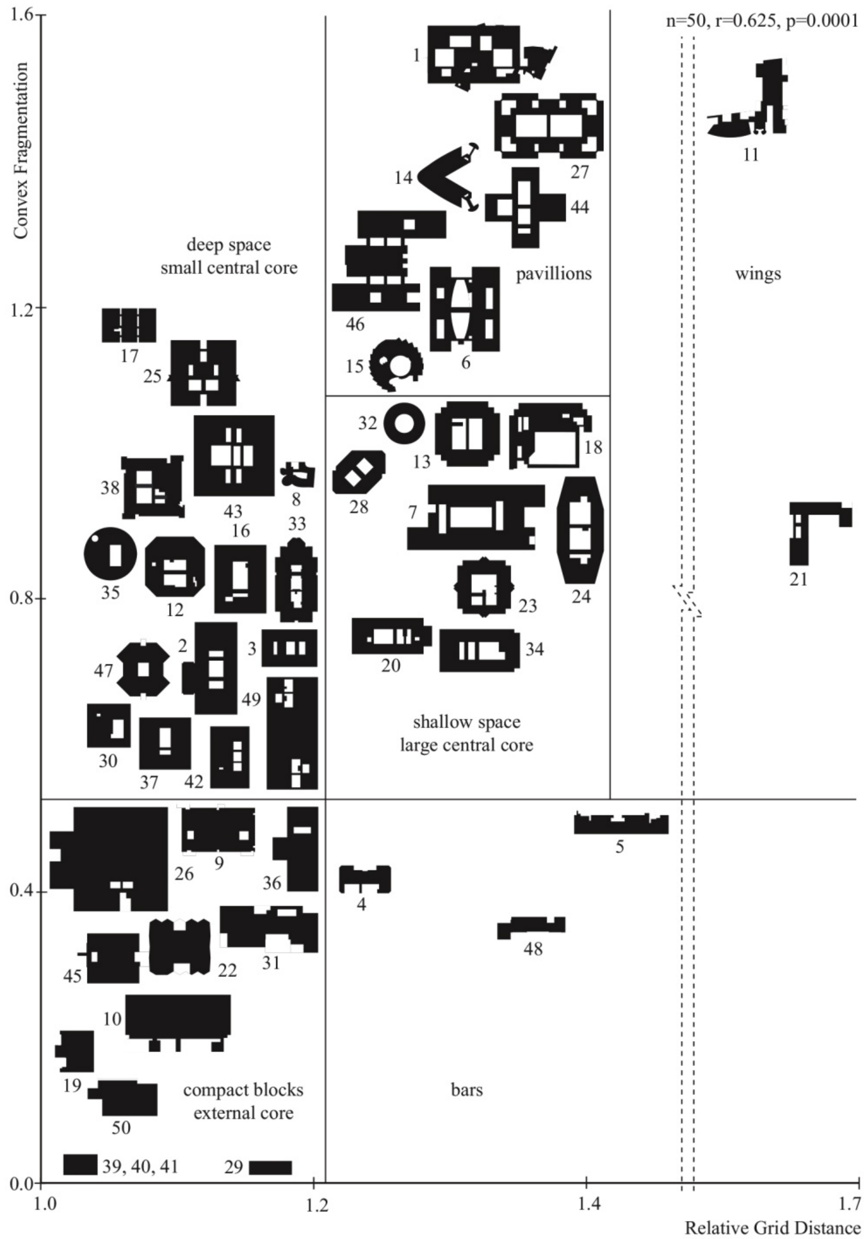

Figure 3: Fifty footplate shapes compared by relative grid distance and convex fragmentation.
The numbers refer to the offices listed in table 1 in Shpuza & Peponis 2008 (r à 0.625; p à 0.0001).

Third, the effect of boundary shapes on the embedded circulation is studied by analyzing two kinds of theoretical layouts generated in a sample of office building floorplates. The two layouts are synthesized based on the analysis of real office layouts: grid layouts exemplify high mean connectivity and low bias; fishbone layouts exemplify low mean connectivity and high bias. The more layout circulations are characterized by dense patterns of connectivity and low bias, the more their integration is predicted by the floorplate shape fragmentation. The more layout circulations are characterized by sparse connections and high bias, the more their integration correlates with the floorplate shape compactness.

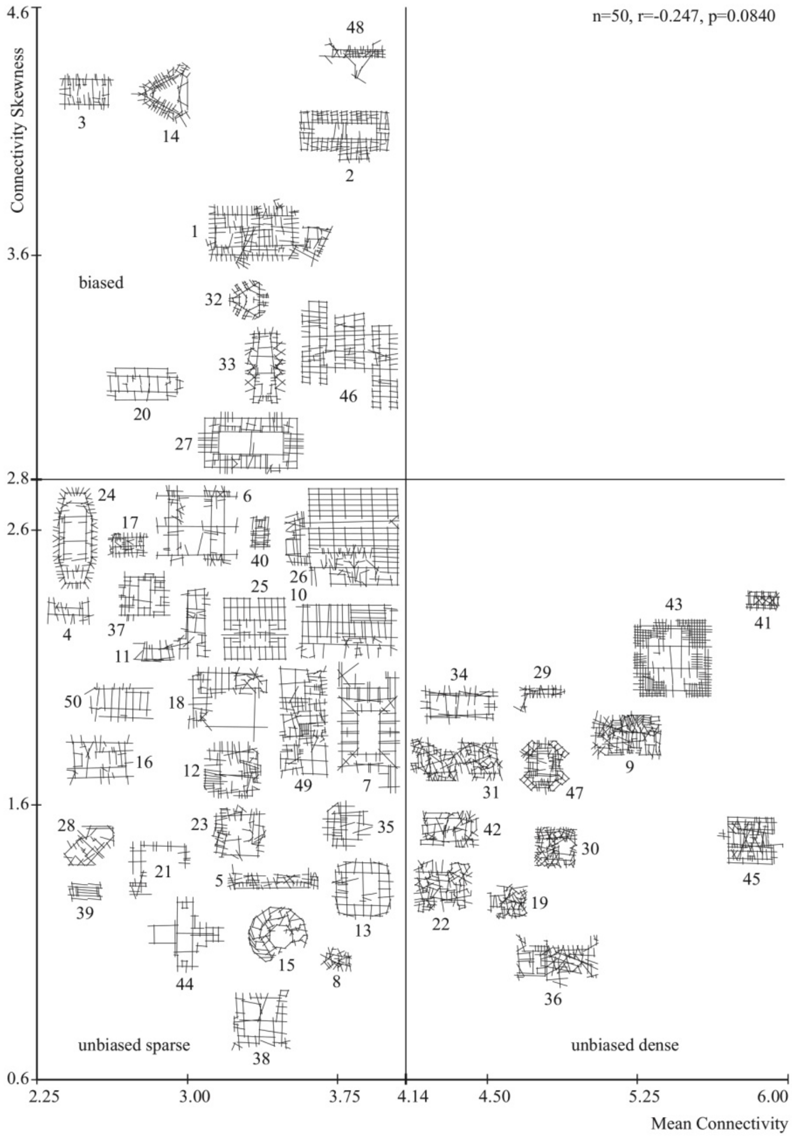

Figure 4: Fifty line-representations of office layouts compared by mean connectivity and connectivity skewness. The numbers refer to the offices listed in table 1 (*r* à 0.247; *p* à 0.0840).

References

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Ermal Shpuza is Associate Professor of Architecture at Southern Polytechnic State University and Visiting Professor at Art History Department, Emory University. His research interests span across architectural and urban morphology, allometry in the built environment, urban history, and design computing. His work is focused on the interaction between boundary shape and circulation network in buildings and cities, development of descriptive measures of shape, urban evolution in Adriatic and Ionian coastal cities, impact of physiography on street networks, and effects of floorplate on daylight and acoustics. He presently teaches design studios focusing on urban renewal and passive environmental systems, and courses on research methods, morphology and design, urban design theory, and environmental technology. He is a registered architect with several years of practice on workplace projects. He received his architectural degree from PU Tirana, and completed post-graduate studies at the Bartlett, UCL and Georgia Institute of Technology