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PLA2018-2669

# Some Problems of Interpreting Spatial Analysis Results

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This paper should be cited as follows:

**Kaiser, B.** (2019). **"Some Problems of Interpreting Spatial Analysis Results",** Athens: ATINER'S Conference Paper Series, No: **PLA2018-2669.**

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8 Valaoritou Street, Kolonaki, 10671 Athens, Greece
Tel: + 30 210 3634210 Fax: + 30 210 3634209 Email: info@atiner.gr URL: www.atiner.gr
URL Conference Papers Series: www.atiner.gr/papers.htm

ISSN: 2241-2891
24/09/2019

# Some Problems of Interpreting Spatial Analysis Results

**Benjamin Kaiser**

## Abstract

While *spatial analysis* includes any of the formal techniques which study entities using their topological, geometric, or geographic properties [Hsu, 2014, p. 82], various disciplines of urban research describe the city as an architectural product in terms of functionalism. In approaches such as "Space Syntax", methods, which are rooted in the long tradition of spatial analysis and *urban modelling*, are applied to account for spatial settings defined in terms of architecture analytically and propose to interpret them as expressions of socio-economic relations. [Hillier and Hanson, 1984]. However, such an interpretation can only be achieved successfully with reference to precisely those functionalist perspectives that describe the corresponding, spatially relevant socio-economic relations that have spatial impact - i. e. the analysis' normative background. From an epistemological point of view this leads to a twofold conceptual difficulty: On the one hand, the methods seem to apply only where the leading analysis' normative background is well documented. But in this case spatial analysis results are likely to confirm the presupposed analysis' normative background. Circular explanations are a serious threat. If, on the other hand, a detailed account of a specific analysis' normative background is lacking, then interpretations will depend on general correlations between socio-economic relations and their spatial impact. It will be argued that a general social logic of space is not sufficient to justify the interpretations of that scale. Rather, they seem to be based on implicit assumptions which function as *enthymemes* in rhetoric contexts and thus do not suffice scientific standards of argumentation. In order to address these problems, the paper contributes to the development of an epistemologically refined understanding of the correlations between functionalist and formal approaches to architectural design, thus proposing a more precise handling of those well-established tools of spatial analysis that are globally received in present day (digital) analysing practice. To achieve this goal, finally, some primordial requirements are formulated.

**Keywords:** spatial analysis, functionalism, space syntax, urban theory, urban modelling.

## Introduction

"Space syntax is a set of techniques for analysing spatial configuration, and a set of theories linking space and society." [Hillier, 2014, p. 19].

The aim of this approach is to account for built environments in terms of models and to formally describe them in terms of those of its inherent structures articulating socio-economic relations [Hillier et al., 1976].

On the one hand, methods of spatial analysis and urban modelling are used [Marcus, 2018], which examine formal properties of built environments. On the other hand, theoretical approaches are applied that claim to interpret the results of spatial analysis as an expression of socio-economic relations.

While the theoretical approaches attempt to describe correlations between formal and functionalist concepts, the methods of spatial analysis are based on a series of *abstractions* according to Werner Heisenberg.

"Abstraction denotes the possibility of considering one object or a group of objects from just one view-point while disregarding all other properties of the object. The isolating of one characteristic, which in a particular relationship is looked upon as especially important in contrast to all other properties, that constitutes an essence of abstraction." [Heisenberg, 2008, p. 2].

Starting point of the series of abstraction are built environments. In the first step, built environments are limited, internal or external architectures are abstracted to their space-dividing and thus space-defining properties and as such represented in a mathematical environment. Various methods of spatial analysis can immediately be applied to the resulting model. An application of other methods, on the other hand, requires further steps of abstraction. Various levels of abstraction allow for an analysis of number of metric, geometric and topological properties. The results generated by different methods of spatial analysis at different levels can in turn be related to each other in order to obtain further results.

The results of all these analyses consist in numerical values. Their interpretation requires an analysis' normative background. It relates to precisely those functionalist perspectives that describe the socio-economic relations having a significant spatial impact.

Hence, an interpretation of results in spatial analysis can only be achieved successfully with reference to specific functionalist perspectives. From an epistemological point of view, the connexion at issue can be justified as follows:

On the one hand, the relevant socio-economic aspects of the subject of investigation are inherent in the given abstractions. This allows to account for the results of spatial analysis in functionalist terms. However, this results in nothing but a visualisation of the presupposed analysis' normative background and does not generate any new knowledge.

On the other hand, it is possible to use a theoretical and methodical strategy that allows the results of the spatial analysis to be transformed into functionalist perspective independent of the abstracted subject of investigation. However, a strategy of this kind requires the formulation of general correlations between socio-economic relations and their spatial impact.

In most case studies interpretations of results in spatial analysis seem to be successful for the following reasons: Either the corresponding analysis' normative background is well documented from the outset. Or some general, supposedly self-evident functionalist aspects of the analysis results are assumed.

The set of problems to be dealt with results on the one hand from the sequence of abstractions and on the other hand from tacit reference to implicit premises. While the first problem is epistemological in nature, the second one is a rhetorical or argumentation-theoretical problem. In terms of traditional, Aristotelian logic the according structure is described as an enthymeme. Enthymemes are syllogisms whose premises remain implicit.[1]

In the first part of the present paper, the relevant series of abstractions, their presuppositions and consequences are examined in detail. For this purpose, schematic representations will be used. In its second part, the correlations between analysis results and analysis' normative background are illustrated. For this purpose, two examples will be set forth in order to address the aforementioned rhetorical deficiencies in the third part.

Finally, effective requirements are formulated for developing an epistemologically refined understanding of the correlations between functionalist and formal approaches in architectural design.

## Series of Abstractions and their Consequences

At the outset a model - as described above - is created considering only the space-dividing and thus space-defining properties of internal and external architectures. An abstraction in this sense always means a loss [Baumgarten, 1988, p. 145].

To show this loss in detail, the differences between the experienced built environment ("erlebter Raum") and the model ("mathematischer Raum") are characterised with reference to the work of Otto Bollnow [Bollnow, 2011].

Experienced built environment ("erlebter Raum") has the following features:

1. a center given by the experiencing person,
2. a system of axes originated from the human body and its upright posture,
3. differences of quality for which there is no analogy in mathematical space,
4. discontinuities,
5. finiteness,
6. both supportive and inhibitory relations to human beings,
7. meaning of every place,
8. not being detached from its specific relationship with human beings.

[1]This term can be traced back to Aristotle. [Arist. Rh. 2.21] A detailed discussion, however, appears for the first time in the pseudo Aristotelian writing *Rhetoric to Alexander* [Arist. Rh. Al.].

The model ("mathematischer Raum"), on the other hand, is primarily characterised by its homogeneity:

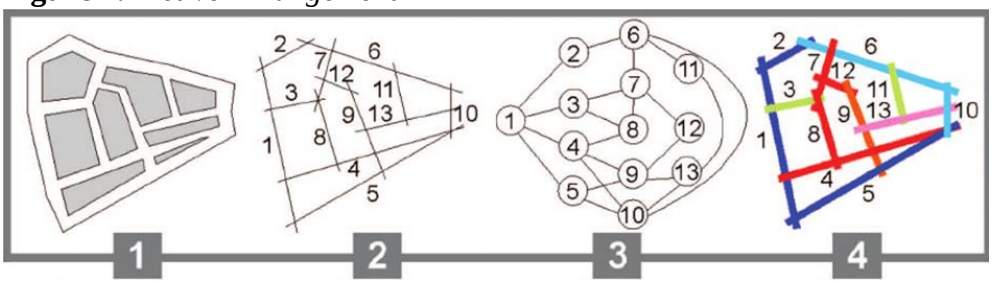
1. Each point can serve as a center.
2. There is no direction given. Any direction in space can be turned into the coordinate axis by a simple rotation.
3. Space extends in all directions into infinity.

Abstraction of the built environment not only leads to a neutralisation of values, but also separated it from socio-economic relations and human perception. This problem is further exacerbated by the fact that the methods of "Space Syntax" [Hillier and Hanson, 1984] are based on the concept of relational space[2] that does not allow for any conclusions about absolute sizes.

In contrast with Euclidean space the concept of relational space dispenses with a fixed system of references in terms of which space can be observed and measured. [Funken and Löw, 2003, p. 187] Rather, it refers to relations of things existing at the same time in space (ordo coexistendi) [Leibniz, 1996, p. 133].

Based on the model and some further abstractions, different methods of analysis can be applied. In what follows, the levels of abstraction and corresponding analysis methods are illustrated schematically.

**Figure 1.** *Fictive Arrangement*



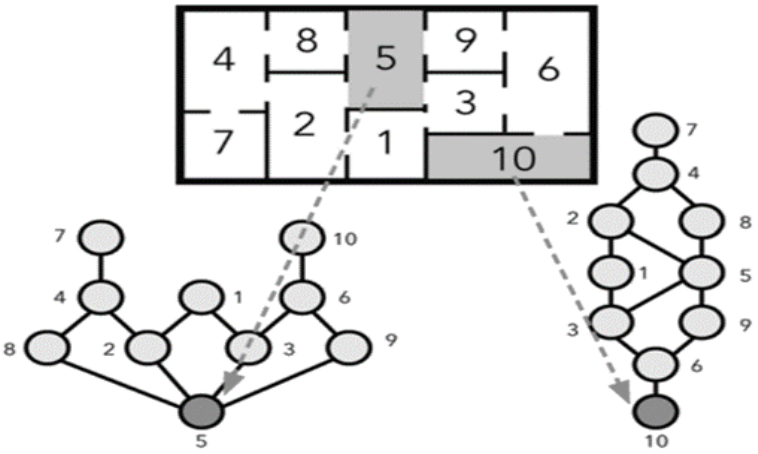

*Source:* [Crucitti et al. 2006, p. 015113-3].

The first part of Figure 1 shows a fictive arrangement of individual buildings or building complexes. This fictive floor plan is already limited and transferred into a mathematical environment. The model serves as the starting point for the analysis procedures for so-called external spatial configurations [Hillier and Hanson, 1984]. Absolute sizes are neglected as well as terrain characteristics. As shown in the second part of the figure, an axial map can be derived from this model. The individual axes of this map are numbered and intersect. As can be seen in the third part of the figure, a graph, more precisely the dual of a graph, can be derived from this map. The axes are assigned to nodes, and the intersections to edges. This graph allows to determine the integration of the

[2]The concept of relational space differs from that of relativistic space insofar as it also considers the temporal dimension, for example with reference to movements. The concept of relative space, on the other hand, assumes that space is bound to the observer's point of view [Macher, 2007, p. 79].

individual nodes in local measurements. In principle, this dual graph is treated as a directed graph and analysed as regards its connectivity. An according value can be determined by corresponding transformations of the graph for each node. In the fourth part of the figure, the results for the individual nodes are projected onto the abstracted axes.[3] This process produces a polychromatic global integration map. The red-coloured axes are highly connected and therefore more integrated, while the blue-coloured axes are less connected and therefore less integrated.

**Figure 2.** *Fictive Floor Plan*




*Source:* [Hillier, 2014, p. 21].

A similar procedure can be applied to internal spatial configurations. As can be seen in Figure 2 the derivation of a graph requires much less definitional effort. The graph can be derived directly from the accessibility of the individual rooms. By this method, however, the connectivity is not determined, though the depth values of the corresponding transformed graphs. In the course of this procedure, the number of rooms to pass through in order to reach each other room is determined. The graph with its root in room no. 5 has a depth of 16, the graph rooting in room no. 10 has a depth of 30.

A closer look at the examples reveals that the seemingly necessary limitation of the subject of investigation to external architectures is arbitrary. Moreover, in both examples it is impossible to rescale the model to the "human scale" [Gehl, 2015]. Rather, in both cases there are suggestions that tend to relate to a number of specific ideas. The polychromatic representation in figure 1 suggests the idea of a city centre. Places with a high integration value can be expected to have facilities or institutions that are depending on a high amount of people passing by. The fictive floor plan also suggests that the depicted ensemble of buildings can be walked through and that the individual buildings can be perceived without any major problems. Further, the figure suggests that the

[3]This projection is not allowed at issue since the connectivity of each point of the axis is different.

spaces between the buildings are streets with a pavement and that axes can be seen by the person experiencing them. The situation is quite similar in the second figure. Although this building has no access, the spatial arrangement suggests a gallery or a building with a comparable purpose. If one assumes the fictive building as a gallery, it can be expected that the objects in room no. 10 will receive less attention than the objects in room no. 5. If, on the other hand, one assumes it to be a private house, a bedroom will probably be expected in room no. 10, since the degree of privacy usually increases in accordance with increasing depth. However, in either case, these assumptions are by no means certain.

Rather, both cases already indicate to what extent the interpretation of the analysis results depends on the corresponding analysis' normative background and how certain expectations serve as enthymemes.

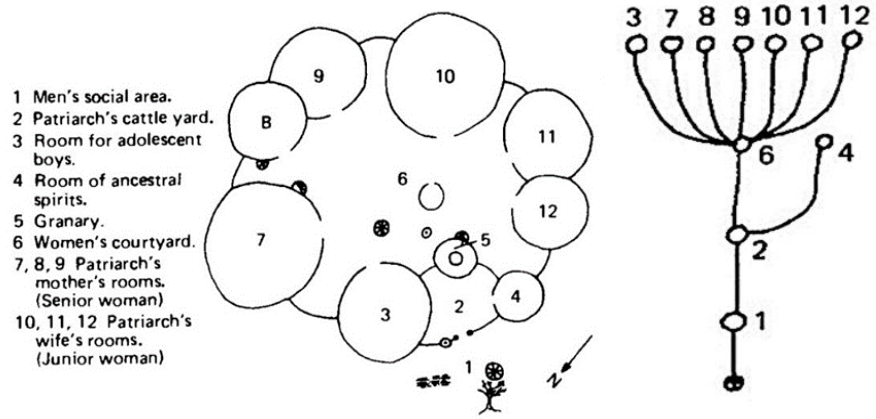
However, no interpretations are permitted. Firstly, in both cases nothing is known beyond formal properties. Secondly, even if good documentations of the analysis' normative backgrounds would exist, according conclusions are not based on a reliable procedure but on assumptions and suppositions.

The following two examples are intended to clarify this ambiguous situation. First, a settlement of the Tallensi tribe is presented. Their socio-economic relations are well documented. This settlement is then contrasted with a fictive example similar in abstract form, but whose exact purpose remains a matter of speculation.

## Two Examples

The Tallensi people live in the north of present-day Ghana. The good documentation of socio-economic relations is mainly due to the works of Fortes [Fortes, 1945] and Riehl [Riehl, 1990]. The Tallensi people live in scattered compounds. Each compound has only one access.

**Figure 3.** *Tallensi Compound*




*Source:* [Hillier and Hanson, 1984, p. 243].

The spatial structure seems to be governed by a strict order. A graph can be derived directly from the ground plan of the compounds.[4]

The graph illustrates the spatial structure of the compound. It can be interpreted as an expression of socio-economic relations. The special significance of the "room of ancestral spirits" is expressed as is the function of the "women's courtyard" in which the granary[5] is also located. The courtyard is the central place of the community. The women and adolescent boys meet there and are protected from the world outside by the "patriarch's cattle yard".

"Just as the male courtyard is the most powerful space governing inside to outside relations, so the senior wife's sub-compound is the most powerful space governing inside to inside relations, in that at this point the compound changes from a unipermeable sequence form to a tree form." [Hillier and Hanson, 1984, p. 243].

The socio-economic relations seem to be reflected in the formal properties of the compound. This example is now contrasted with the figure of a fictive building whose abstract graph corresponds to that of the Tallensi compound. The exact purpose of this building is not known. Different assumptions based on indications or probabilities of the floor plan are possible. By selecting this example, it is possible to argue not from an application-oriented perspective in which the actual or desired purpose is known, but from a theoretical perspective that allows the relationship between spatial analysis results and their interpretation to be investigated in detail.

**Figure 4.** *Fictive Ground Plan*

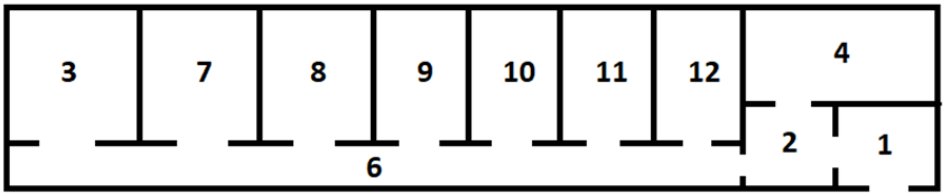



Figure 4 shows the floor plan of a fictive building that could serve as an office building or as a hotel. Rooms no. 3, 7, 8, 9, 10, 11, 12 would be the individual offices or rooms for guests. Room no. 4 could function as the head of department's office or reception. Regardless of the purpose of this building, a graph corresponding to that of the Tallensi compound (Figure 3) can be derived from the ground plan. This allows comparisons to be made independently of the respective analysis' normative background. The differences are immediately clear. While room no. 6 serves on the one hand as a place of community, on the other hand it serves primarily to reach the respective hotel rooms or offices. The same

[4]A closer look reveals that there seems to be no access from 2 to 6. This is due to an error in the map of Fortes. Other figures of Tallensi compounds usually show at least one access. Thus, the derived graph is correct.

[5]The granary is marked in Figure 3 by no. 5. Since it is not a space with a socio-economic relevant function, it is neglected in the graph.

applies to room no. 4, which has a religious-ritual meaning for the Tallensi. In the assumed functions of the fictive building, it serves more as a control room.

The comparison illustrates not only the definitional inadequacy regarding the distinction between internal and external architecture. Rather, it indicates the dependence of the interpretation of the analysis results - in this case the graph - on socio-economic relations and functionalist aspects.

The interpretation of the graph of the Tallensi compound mentioned above would not have been possible without the corresponding attributions in figure 3. The graph visualises, and the analysis of the graph confirms the socio-economic relations. Thus, the results of spatial analysis are circular.

The interpretation of the fictive building depends on its assumed purpose since nothing is known beyond its formal properties. The assumption of different purposes leads to different interpretations.

This is not surprising. The graph is an abstraction of the respective subject of investigation. Abstraction disregards all other objectual features and, in this case, focuses solely on the accessibility of the individual spaces. Different interpretations are possible as the results of the analysis are implicit projected onto different purposes.

The discrepancy between the two examples illustrates the need for general correlations between socio-economic relations and their spatial impact.

## Correlations between Socio-Economic Relations and their Spatial Impact

*The Social Logic of Space* by Bill Hillier and Julienne Hanson (1984) attempted to establish general correlations between spatial order and socio-economic relations referring to Durkheim's distinction between mechanical and organic solidarity:

"[…] organic solidarity required an integrated and dense space, whereas mechanical solidarity preferred a segregated and dispersed space. Not only this, but Durkheim actually located the cause of the different solidarities in spatial variables, namely the size and density of populations. In the work of Durkheim, we found the missing component of a theory of space, in the form of the elements for a spatial analysis of social formations." [Hillier and Hanson, 1984, p. 18].

However, on closer inspection of Durkheim's distinction, it turns out to be ideal-typical on the one hand, since only mixed forms occur. [Vester, 2009, p. 75].

"[…] why mechanical solidarity persists even in the most elevated societies." [Durkheim 1960, p. 186].

On the other hand, the leading question of the work *The Division of labor in society* [Durkheim 1960] is not space related, rather it aims at the question of social cohesion.

"This work had its origins in the question of the relations of the individual to social solidarity. Why does the individual, while becoming more autonomous, depend more upon society? How can he be at once more individual and more solidary?" [Durkheim, 1960, p. 37].

Although the concepts of mechanical and organic solidarity seem appropriate for spatial interpretation, this interpretation contradicts even the examples chosen by Hillier and Hanson and is therefore to be rejected. The comparison in Figure 5 illustrates this rather well.

**Figure 5.** *"G" after Hillier and Oraibi after Mindeleff (Modification by the author)*

*Source:* [Hillier and Hanson, 2014, p. 90] and [Mindeleff, 1891, p. 76].

On the left side of the figure the ground plan of Gassin can be seen. In *The Social Logic of Space*, Gassin serves as a leading example for introducing the various methods of analysis of external spatial configurations. Gassin is situated in the Département Var in the region Provence-Alpes-Côte d'Azur and has about 2500 inhabitants. As a small French town or city inhabited by a modern society, its internal social cohesion can certainly be described as organic in the sense of Durkheim.

On the right side of the figure a slightly distorted representation of a Hopi settlement can be seen. The Hopi are a group of Pueblo Indians living in the north of present-day Arizona. The map is taken from Mindeleff's work [Mindeleff, 1891] and illustrates the distribution of the individual clans or gentes. In Durkheim's sense, the internal social cohesion of the Hopi can certainly be described as mechanical.

Although both communities differ in inner social cohesion the spatial structures they create are quite similar. The spatial interpretation of Durkheim's distinction between mechanical and organic solidarity must therefore be rejected.

The rejection of a general social logic of space now requires a closer examination of the implicit assumptions and their meaning in the arguments.

These projections of the analysis results onto implicit assumptions are important for argumentation theory since they often justify the interpretations

in case studies that do not argue in a circular manner. A syllogism based on unstated premises is called an enthymeme in philosophy. A closer look at this term clarifies the argumentation-theoretical or rhetorical problem.

## Enthymeme

The term enthymeme is used in Aristotelian logic in order to describe various ways of argumentation. Today, it is usually understood to mean little else than incomplete syllogisms. Their premises remain unstated [Schepers, 1972, p. 871]. However, this understanding is not sufficient to clarify the fundamental problem.

In general, three types of enthymemes can be distinguished:

1. Enthymemes with unstated premises or conclusions (truncation):
   Minor premise: Socrates is a human being.
   Conclusion: Socrates is mortal.

The unstated major premise in this case is that all humans are mortal. Only under this (generally known) condition the conclusion is valid.

2. Enthymemes based on signs not on facts:
   Minor premise: Socrates has a cough.
   Conclusion: Socrates is a smoker.

This conclusion is based on signs of illness; a major premise whose general validity can be doubted, because a cough is not a sufficient sign as to whether someone smokes. He could just have a cold.

3. Enthymemes based on suppositions of the recipients:
   Minor premise: Socrates is having a conversation on the Agora.
   Conclusion: Socrates philosophises.

This conclusion assumes of the recipients that Socrates conducts a philosophical conversation in most cases in which he is involved in a conversation on the Agora. In contrast to an enthymeme based on signs, the assumption here is not a major premise, but an assumption of the recipients.

## Discussion

With the term of the enthymeme mentioned above the argumentation-theoretical problems can now be clarified.

Regardless of the specific analysis' normative background, it can be said that room no. 6 in the examples is the place where the probability of encounters is highest, but further statements remain difficult.

If one assumes that this building is an office building based on the ground plan (signs), then this room can be understood as a place of the working group. But these views are based on the assumptions of the recipient. General correlations function as a true major premise have not yet been sufficiently investigated.

If one assumes this building to be a hotel, reaching the rooms will be the primary function of room no. 6, since this assumption relates to the idea that the hotel residents, unlike the employees of the office building, do not form a community. The experiences of the recipients are also addressed here. If one assumes now that this building is used as a brothel, then it could be assumed that encountering in the room no. 6 is sometimes even undesirable.

It becomes clear that to a large extent an interpretation of the analysis results depends on implicit assumptions, which in turn are based on signs and the assumptions related to experiences of the recipients. Corresponding empirical studies usually refer to one subject of investigation. Thus, argumentative results would be circular in this case.

The interpretation of the analysis of the Tallensi compound also amounts to a circular explanation. The results of the analysis are projected onto the underlying socio-economic relations and their spatial impacts and merely confirm them.

However, formulating general correlations between spatial order and socio-economic relations remains a difficult task.

Spatial interpretation of the distinction Durkheim's between mechanical and organic solidarity are to be rejected. Interpretations which are based on a specific analysis' normative background, remain self-referential.

In cases where there is no or insufficient documentation of the corresponding analysis' normative background, the interpretations are based on implicit assumptions functioning like enthymemes in argumentation. Certain ideas or images, certain socio-economic relations and absolute sizes seem to be at issue. They pertain to the relevant interpretation without implicit correlations being sufficiently investigated. Hence, basic scientific standards are not meat.

## Conclusions

In order to face the threat of circular explanations and to satisfy scientific standards, an epistemologically refined understanding of the correlations between functionalist and formal scientific approaches in urban research is required. Such an understanding is initially associated with restrictions in the scope of application. These restrictions should be based on functionalist considerations. Within these limitations, case studies can precisely describe a number of relationships between formal properties and socio-economic relations. Based on these examples, hypotheses can be developed which, as a basis for a hypothetical deductive approach, can explore the possibilities and limits of these correlations.

Some first effective requirements can be proposed on the basis of the previous considerations:

1. A refined understanding should consider the relation between human perception and the absolute sizes in architecture. The terms “pertinence” derived from Boudon’s architecturology [Boudon, 1991] and “human scale” [Gehl, 2015] are promising here.
2. The subject of investigation should be limited in terms of functionalist categories. The concept of community should be reconsidered in this respect. At the same time, it is possible to model further socio-economically relevant properties of the subject of investigation regarding the analysis methods.
3. The heterogeneity of the experienced built environment must be reflected as accurate as possible in the mathematical space. The methods of “Space Syntax” consider at most two entities. This is by far not sufficient in order to depict differentiated uses of space. The introduction of a third entity to mark places that can be overlooked but are not accessible would be helpful. In this way, the places of encounter could be identified more precisely since roads and rivers are currently included.

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