# Being in space and space in being

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The subject matter of this short essay is the technology of space syntax. The two particular technologies I wish to discuss are axial analysis and agent-based analysis, as tools applied to urban analysis, in relation to what at first appears to be a single epistemology of spatial evaluation. In order to enliven an otherwise dry exposition, let us first imagine the situation of this urban analysis, a street scene as it unfolds in the few minutes of our space syntax observation, in the manner of Jane Jacobs.

We are perhaps on a university campus, or maybe we are observing a university campus, and on the path we occupy, or watch, there is a bustle of student life; three smart young women on their way to a physics lecture in one direction, three sloppy men slouching towards an engineering lecture in the other; as they approach, they take note of each others' presence: the young men and women stand up straight, exchange glances and pass one another. A lecturer trails behind one group, observing the fine figure of one of the young men, or women, while a cleaner sweeps the path ahead of the other group, in turn observing the people who pass him or her daily. Everyone in our mildly nostalgic scene[1] is moving, reacting and enacting, and since it is sunny but not overly hot, perhaps they are contentedly enjoying this activity.

Back in the light and airy lab, its fans spinning dutifully, we can represent the space in which the path is located as a network of axial lines, or as a dense grid of isovists. These two representations will probably be familiar to the reader. Both can be generated automatically from plans of the area under consideration, which I will describe briefly below. The automatic generation of either representation is fairly straight-forward, although subject to various caveats. The caveats should not concern us overly in the context of this essay, although I will mention them in order to reassure the reader that I am aware of them. What will concern us instead is the analysis we will perform on the representations, as the analyses are, under close inspection, quite different in nature, and the difference in nature will lead us to a curious modification of traditional phenomenological thought, if we start from the premise that we locate ourselves within a tradition of phenomenology. Others have attempted to do so; in turns through the close reading of Space is the Machine (Seamon, 2003) and comparison with the work of Norberg-Schultz. From such a perspective, we cannot fail to notice the structuralist enterprise of space syntax. The axial line, by its very nature - and grammatical conception - must appeal to an underlying structure, hidden among the sensations of space. Seamon writes:

> "As a phenomenologist, let me emphasize that Hillier is a structuralist using largely positivist methods to demonstrate the ways in which spatial configuration both generates and arises out of social pattern and organization." (2003, page 6)

[1] There also appears to be a distinct sexual frisson in the air.

Note that Seamon does not condemn Hillier's approach; instead, he translates the thesis of space syntax into the language of phenomenology: "that person is world, and world is person."

To generate a fewest-line axial map, as generally used in space syntax, one can start with an all line map (Penn et al, 1997). That is, draw essentially (but not exactly) every line that connects two corners in open space, and extend it until it hits a solid object. This task is necessarily complicated by the number of corners one can draw, and so the number of corners must be restricted in some way. At some point, a decision on sensible resolution must be made, where 'sensible' resolution is determined by the possible human interactions that may be observed in the space. This is not entirely satisfactory, as by doing so, we may delete a crucial line, that just links to another line, the combination of which would cover the space in a more economic fashion, but let us leave this for now as we have not even arrived at what might be an economic fashion. The set of lines may then be reduced using a technique called subset elimination. That is, a line whose connections are the subset of another line may be deleted, until only the core lines remain (Turner et al., 2005). Two guidelines must be followed in this task: one, ensure that all open space may be observed by the combination of lines, and two, that all topological loops are completed, that is to say, that all islands of built form are cut off from all other islands of built form (Peponis et al, 1998). After this task is completed, a skeletal map of the configuration remains, which, with the exception of dead-ends, is equivalent to the hand-drawn axial map (Turner et al, 2005). For now, we will take it on face value that the axial map is a good representation of the space (in two dimensions though it is) and that measures of it will be in some way meaningful.

The generation of a grid of isovists is subject to the same sort of considerations as the generation of an axial map. An appropriate scale must first be chosen for the grid. Then the isovists may be constructed at each grid location, either by shooting out rays, or growing a circle out from the centre, or by testing the visual connection to boundaries in distance order from the grid location. Whichever method is used, an appropriate resolution for construction must be chosen. This might be an angular resolution, or an approximation of the isovist itself, for example, by pixelating it as in the construction of a dense-grid visibility graph, or through limiting the number of boundary lines to test. To reach the decision of appropriate scale - as with the axial map - the use of the grid of isovists must be considered. For this essay, we require them as a basis for visual input to agents. Since the agents will represent people, once again, our decisions are guided by the scale of possible interactions of people with the environment and with each other (Turner et al, 2001). Furthermore, the isovist map is also a two dimensional entity, and, at this stage, we must assume that this representation is good for purpose, despite the fact that the precise purpose is currently undefined.

From a strictly technological point of view, the purpose initially seems to be the prediction of the number of people passing through a notional line arranged across the path, or rather, to quantify the effect, ceteris paribus, of the configuration of space on the number of people passing through a notional line arranged across the path. However, this purpose is clearly lacking in regard to a phenomenological account of the path and its occupants. The final purpose of this analysis must be in order to understand the life of the path itself (as a whole, including occupants). This is true not only from a phenomenological perspective, but also from a sociological perspective. If we really are to understand the social significance of the space of the path, we must go further than simply an account of the number of people found within it. Be this as it may, let us first turn to numbers of

people.

The axial map is analysed by the assessing the number of steps it takes to get from one line to all other lines in the system. If the number of steps is low, then the line is considered integrated. Well integrated streets correspond to relatively high levels of movement (Hillier et al, 1993). There is an ongoing debate as to why this might be the case. We can posit two naïve position statements, which I shall label Hillier and Peponis, for simplicity of reference. The Hillier position is that the axial structure corresponds to an underlying physical property of space, so that any movement must be constrained to work according to it, that is, the structure is of the space. The Peponis position is that the axial structure corresponds to an underlying cognitive understanding of the space in the subject, so that movement is correlated on the grounds that it is the means by which the subject navigates the space, that is, the structure is of the (situated) being[2]. In both these position statements, the axial structure is not accessible directly, rather it is hypothesised to exist through the observation of occupants. In other words, the position statements do not assume that the axial line as it is drawn is primary to the representation, merely that there is an underlying structure either in the space or in the being. However, various authors have placed an emphasis on 'the line' as being paramount to the structure, arguing that it is a fundamental and economic representation of space. It seems to me that recent research has shown that this is an erroneous belief. The recent research has modified the analysis so that it relies on the angular step depth from one location to all others. An integrated segment (rather than axial line), is one that is shallow to all others in terms of the angle one must turn through to get to each other line. The angular measures of the segment correlate with observed movement as well, or better, than standard axial analysis (Hillier and Iida, 2005). However, the correlation remains if we simply substitute the axial lines with road-centre line segments (Turner, 2005). Therefore the underlying structure is simply a skeletal network (perhaps any skeletal network) drawn between blocks.

The transfer of the axial network to a generic network does nothing to denigrate the structuralist position statements; in fact, I believe it makes them superior. The axial structure is now read as an underlying and pure topological map of the space. That the experience of space is bound to its topological structure is much more pleasing a statement in its mathematical simplicity than to a specified line-based representation (though perhaps no more true). The enhancement is pleasing both in the context of the Hillier position, where we see topology of space as a fundamental and inescapable quality of the environment, and to the Peponis position, where we see the topology as the minimum cognitive information required to guide one through an environment (see Kuipers et al, 2003).

In some senses there is a false dichotomy between the naïve position statements. Recent works by Penn and Hillier have made reference to John O'Keefe's essay on Kant and the Seahorse (O'Keefe, 1993). O'Keefe takes the Kantian perspective that space itself is only space in as much as may be conceived by the subject; his take is in terms of his background in neurophysiology. He uses the example that we are unable to conceive of space in more than three dimensions, and suggests that the reason for this is grounded in the shape and structure of the brain, in particular the part of the brain associated with navigation, the hippocampus. It is here that O'Keefe suggests that the subject's cognitive map resides (if there can be any one location). Thus, his argument is that (spatial) cognition is space, and space is as it is cognised; in other words, the being is not in space, but the space is

[2] In more philosophical terms, the 'situated being' might be read as Heidegger's da-sein.

actually in the being. This brings us back to Seamon's translation of Hillier, but it does not free space syntax from its structuralist constraints. Seamon continues: "[For Hillier,] environment is experience, and experience is environment in the sense that particular environmental features (for example, a pathway network's particular spatial configuration) contribute to and reflect the particular human worlds manifesting in a particular place". But how can we perform space syntax - that is, how can we assess the contribution of the spatial configuration to the human world - if not through some abstraction of the space?

The agent-based analysis of a grid of isovists is as follows. Agents, computational simulants of people, are given a location within the grid and may choose a destination from any other location that they can see (within a certain field-of-view, experiments suggest that 170° is optimal for correlation with human action at gates), walk towards it for a few steps (experiments suggest 3 steps), and then choose another destination (Turner and Penn, 2002). The impetus for the method of analysis is Gibson (1979), who proposes a theory of natural vision. In natural vision, the subject is drawn through a configuration not by planned decisions, but by the available affordances of objects within it. The classic summary of the theory is this:

> "When no constraints are put on the visual system, we look around, walk up to something interesting and move around it so as to see it from all sides, and go from one vista to another. That is natural vision ..." (1979, page 1)

With Penn, I have suggested that there is an element of 'natural movement', which hinges on the phrases 'we look around' and 'go from one vista to another' (Turner and Penn, 2002). In this model of natural movement, perception is direct: the affordance offered, in terms of a point location, or a line-of-sight (more correctly, a ray of light incident on the cornea of the being), is given to the agent. It possesses the ability to move, and the ability to sense, but no more. The connection between sensation and move we have programmed as a direct link. The sensation, we claim, is exosomatic, or out of the body, in the environment (Penn and Turner, 2002). This corresponds to Gibson's formulation of an ambient optic array, the light pattern within the world without the being, which is broken as the being passes through it. We assume that it is reasonable to suggest that the being can identify a location, or, more recently, can identify a length of line-of-sight in a range of directions available to it from this ambient optic array. In fact, we show that selection of a destination location, and selection of a line-of-sight to follow based on length are mechanistically equivalent (Turner and Penn, 2005). Our experiments parallel those in early evolutionary robotics. In evolutionary robotics, the decision of action between sensation and ability to move is not programmed, but left to evolve, through possible connections from input to output. Wheeler (1996) suggests that evolution within these constraints leads to a hermeneutic dialogue between the robot (or agent in our case) and the environment it inhabits. That is, the being in space is connected directly to the space of its being, which, if situated in time, leads to a dialogue, which contains a hermeneutics, in that the understanding of the robot of the environment is built up through its direct interaction with it. In terms of natural movement, we might say that the agents represent a set of possible dialogues with space. This is a fairly weak hypothesis, in that there must surely be many possibilities connected to a particular configuration of space. Foucault, in conversation with Rabinow in 1982 (Foucault, 2000), suggests that the structure of the space, as bounded by walls, or some other immediately impermeable surface, can take on many meanings. His example is of the Familistère of Godin at Guise. He claims that

panoptic qualities of Guise make it just as viable prison as an instrument of freedom. Foucault must undoubtedly be correct: in the space of all possible societies is there one that may treat the Familistère as a prison. Indeed, there must be, in the space of all possible societies, a usage that to an external observer is exactly the usage of Familistère, yet to its inhabitants it signifies a prison. However, if we treat the surface meaning of a place, then it must only exist in the sense of the interactions that occur within it. In this, more facile sense, it is reasonable to say that there is a set of constrained dialogues[3]. The evidence of experimentation backs this up: in terms of aggregate numbers, these dialogues compare well with actual usage. However, aggregate behaviour is what Seamon argues against, and aggregate behaviour is not the whole story.

If the 'natural movement' of axial analysis and the 'natural movement' of agent-based analysis are compared, they turn out to be different things. The natural movement of the agents is directly based on line-of-sight. However, the line-of-sight does not correspond to the axial analysis. Although axial analysis concerns itself with long lines, which may be lines of sight, it is the topological structure that matters, or more precisely (following Hillier, 2004) the topology as it is constrained by geometrical considerations. It is the turn away from the current direction that implies 'cost' in axial analysis, or dissipation of movement. This is not the case for the agents: there is no cost of transfer from the current direction. The difference is probably best illustrated by recent experiments in angular segment analysis of topological networks, although it should be noted that the objection applies equally to axial analysis. In segment analysis, there is a formal model of movement: that it follows the shortest angular path between origin and destination. If all combinations of origin and destination are considered, then this measure becomes 'choice' (or betweenness). If simply origin or destination is considered, then we can build an argument that integration also gives a direct model of movement (Turner, 2001), by considering dissipation of flows according to network branching. In both cases, the network itself is primary, not the immediate perception of the network. Indeed, we are forced to consider the possibility that the naïve Hillier position is incorrect: starting from the locus of the agent, there is no way that the structure of the space simply guides it - for it to movement to branch in different directions, the branches must not only exist, but also be perceived as direction of routes, that is, there must exist a cognitive choice between different paths. If we are to force agents to move with cognition, they need to have an idea of where they are going. At its most simple, this is implemented as a general direction to follow (a method of navigation known as path integration). However, any researcher who has worked with agents knows that if you apply knowledge of a 'general direction' to agent movement, the agents get stuck in dead ends, or simply at corners in the road. Thus we must introduce a second, or third level of cognition. The second level is place recognition, specifically, recognition of a junction, and the third level topological navigation (Bachelder and Waxman, 1994). At each level, our model of movement obtains cognitive structure. As we race to the goal of movement, our agent model loses all it had. Although it will probably happen to correlate very will pedestrian movement, it is compromised by the fact that it

[3] This is not intended as a critique of Wheeler, who would not be so naïve as to claim access to meaning. However, his paper takes as a theme the interaction of a putative robot and Rothko's art, which cannot fail to imply a deep emotional connection. In fact, the dialogue (exchange of information between robot and artwork), may not in itself be 'meaningful', and our access to it, the understanding of the process of understanding, neither includes the semantic content of the exchange nor the experiential quality of it. In contrast to Wheeler, the dialogues (in Wheeler's non-verbal sense) on the university campus path are fleeting and capricious.

is no longer a direct perception model, its directions are no longer out in the environment, but internalised in a cumbersome and ultimately arbitrary internal structure.

So what should we do? I suggest we should watch other people. Or rather our agents should watch other people[4]. It is the movement of other agents that gives the clue as to how the geometry of the city is laid out, to where one can go. To take a topic of many papers, if one is to escape the Tate Britain Gallery using visual perception, one merely has to move towards other people in order to find a route back to the entrance, or at least, a route away from the dead end. The advantage of this method is that it does not presuppose a structure of any kind; the cognitive choices are out in aether of the changes of direction of others according to the geometry of space. Rereading the life of the campus path, it is relations between people that make this brief passage come alive.

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**Literature**

Bachelder, I. A. and Waxman, A. M. (1994) Mobile robot visual mapping and localization: a view-based neurocomputational architecture that emulates hippocampal place learning, *Neural Networks*, 7, 1083-1099.

Foucault, M. (2000) Space, knowledge and power, in: *Hays, K. M. (ed.) Architecture Theory Since 1968*, MIT Press, Cambridge, MA. p. 428-439.

Hillier, B. (2004) The space-time city as a self organising city: the emergence of the living city, presented at International Conference on Complex Systems (ICCS2004).

Hillier, B. and Iida, S. (2005) Network effects and psychological effects: a theory of urban movement, in This proceedings.

Hillier B., Penn A., Hanson J., Grajewski T. and Xu, J. (1993) Natural movement: or, configuration and attraction in urban pedestrian movement, in: *Environment and Planning B: Planning and Design* 20, p. 29-66.

Kuipers, B., Tecuci, D. and Stankiewicz, B. (2003) The skeleton in the cognitive map: a computational and empirical exploration, in: *Environment and Behavior*, 35(1) p. 80-106.

O'Keefe, J. (1993) Kant and the Seahorse: An Essay in the Neurophilosophy of Space, in: *Eilan, N., R. McCarthy and B. Brewer (eds) Spatial Representation*, Cambridge, Blackwell Publishers, p. 44-65.

Penn, A. (2003) Space syntax and spatial cognition: or why the axial line? in: *Environment and Behavior* 35(1), p. 30-65.

Penn, A. and Turner, A. (2002) Space Syntax Based Agent Simulation, in: *Proceedings of the 1st International Conference on Pedestrian and Evacuation Dynamics*, University of Duisburg, Germany, (Springer, Berlin), p. 99-114.

[4] I leave this idea unattributed. Although it is not an idea of mine, further reading of my contemporaries shows that none of us appears to have said it explicitly. If one of us has, then I apologise unreservedly for not paying enough attention.

Peponis, J., Wineman, J., Bafna, S., Rashid, M., and Kim, S. H. (1998) On the generation of linear representations of spatial configuration, in: *Environment and Planning B: Planning and Design* 25, p. 559-576.

Seamon, D. (2003) Review of Bill Hillier, Space is the Machine, in: *Environmental and Architectural Phenomenology* 14(3) p. 6-8.

Turner, A. (2001) Angular Analysis, in: *Proceedings of the Third International Space Syntax Symposium*, Atlanta, Georgia.

Turner, A. (2005) Is the axial line a road-centre line in disguise? in This proceedings.

Turner, A. and Penn, A. (2005) Evolving direct perception models of human behavior in building systems, to be presented at Pedestrian and Evacuation Dynamics 05, Vienna Technical University (TU-Wein).

Turner, A., Penn, A. and Hillier, B. (2005) An algorithmic definition of the axial map, in: *Environment and Planning B: Planning and Design* 32 (in press).

Wheeler M. (1996) From robots to Rothko: the bringing forth of worlds, in: *Boden, M. A. (ed.) The Philosophy of Artificial Life (Oxford University Press, Oxford)*, p. 206-236.