SPATIAL LOGICS OF URBAN COMMUNITY FORMATIONS: PROTOTYPING A GRAPHIC TOOL FOR REASONING ABOUT COMPLEX DATA IN URBAN DOMAINS

ABSTRACT

In this paper we report on some recent, exploratory research towards developing a graphic tool for reasoning about urban community formations. Our objective was to prototype a method for dealing with urban community data collected through a series of participatory workshops with secondary school-age children. This was conducted as part of a wider UCL project 'Visualizing Community Inequalities', (supported by the Leverhulme Trust), where the overall aim is to integrate an urban model of community formations, including their demographic, spatial and semantic (experiential and perceptual) layers. This paper focuses on one section of the research relating to the challenges of integrating diverse and complex materials. To address this challenge, we draw on insights from social and spatial analytical literature, including notions of class categorizations and spatial patterning and ordering.

We sought to test how a set of visual, intuitive and interactive tools may help urban practitioners to construct 'concept graphs' of community formations. To this end we led a participatory workshop, in which participants engaged with research data and explored some ways in which a concept graph could incorporate conceptual and spatial categories to build an urban domain knowledge representation (KR). We do not offer firm conclusions in this paper, but suggest some further work to explore this potentially valuable method for KR design thinking.

1. URBAN SPACE AND KNOWLEDGE REPRESENTATION

To introduce our thinking around the problems of knowledge representation (KR) in urban community domains, we draw out a series of arguments from a diverse range of social and spatial literature. Considered together, these arguments point to a need to 'flatten out' our 'globalized' knowledge of communities and their spaces, to reveal their material forms as well as their conceptual relationships.

Urban practitioners engage their 'design knowledge' in the project process, which has been seen traditionally as belonging to either of two frames: that of rational problem-solving and that of reflective practice (Doorst and Dijkhuis, 1995). The notion of the 'rational' frame suggests that the designer forms an informational process within an objective reality and seeks optimal results from poorly structured problems. The notion of the 'reflective' frame suggests that the designer constructs the 'problem situation' through his or her creative and iterative practice. Design knowledge by professional and non-professional practitioners alike arguably includes both rational and reflective approaches.

Urban practitioners approach urban spaces as highly complex artifacts, which follow functional schemes shaped by the needs of movement and information at local and global scales. They are formed from 'urban images' of boundaries, thresholds and interfaces of everyday activities (Lynch, 1971; Conroy Dalton and Bafna, 2003; Palaiologou and Vaughan, 2012), from socio-spatial integration or segregation (Vaughan and Arbaci, 2011), and from ideological and political distinctions of power and control (Hillier and Hanson, 1984, p.21). When describing the relational complexities of urban spaces, Hillier (2007, p.27-30) has observed differences in the modes and methods of description. Those engaging in urban forms for professional purposes often *think of* space; informed that is by urban analytical theory. Those making everyday use of urban forms *think with* space; informed by local knowledge and natural movements (Al-Sayed, 2014; Hillier, 1999).

Design knowledge requires practitioners to think of urban spaces in terms of their spatial and conceptual associations or implications, or rather their 'spatiality' and 'trans-spatiality' (Hillier and Hanson, 1984: 40-41; Sailer and Penn, 2009). Practitioners categorize urban spaces by combining representations of *cognitive and historical experiences* of artifacts through their associations and implications (cf. Lefebvre, 1991: 294-297), within the limits of spatial and temporal logics (ibid: 195-196). From these experiences and logics they extend categorical 'image schemata' to form representations of their spatial *cognitive and historical knowledge* (MacEachren, 2004, 185-190).

To support our practical thinking, we make use of visual and spatial metaphors such as circles, triangles, planes, globes and scales. However, these metaphors can serve to enframe our thinking, possibly based on the particular viewpoint of the dominant group, for example industrialized, rational, male, literate, and so on (cf. Ingold, 2000: 209-218). Academic discourse in this field has been criticized for its hiding knowledge behind such 'frames' (Hommels, 2010), and arguments have been made to unfold or flatten out knowledge (cf Ingold, 2000: 189-208; 2011, 229-243); to represent an urban environment with all elements unhidden and intelligible (Hillier, 2007, p.67-68), and without the impositions of abstract schemata (Lefebvre, 1991: 301-302).

2. REPRESENTING DOMAIN KNOWLEDGE

In this section we explore the possibility that concept graphs provide a method of representing spatial and trans-spatial knowledge. Working with concept graphs allows us to model semantically rich domains that can include sets of beliefs, desires and intentions among community participants (Sowa, 2008; Kavouras and Kokla, 2007). Logic can be used to model diverse community formations in a consistent and dynamic way[1].

Concept graphs are based on simple logical constructions of domain knowledge, providing an intuitive and portable schema for KR. Graphs as logic tools have been described as 'building blocks' for expressing knowledge in terms of entities. They provided a set of tools for testing (for 'true' or 'false') entities –

[1] A lucid introduction to concept graphs has been provided by Polovina, 2007.

whether facts, goals, implicit or explicit rules – their attributes, conditions and relationships (Chein and Mugnier, 2009: 22).

A set of standard statistical methods in graph analysis allows us to analyse relationships among entities based on conceptual distances, measured by degrees, densities and centralities. Similarly, a set of established layouts allow us to represent these relationships based intuitively on patterns of flow, force, orientation and geometry, as well as colouring and labelling. Employing these methods may reveal the functional significance of an entity or cluster of entities within the network model, which may also reveal the significance of conceptual entities whose roles may not be readily apparent from real-world domains.

Concept graphs can represent entities and relationships using generalized or categorical concept nodes and relation nodes. Every concept has an abstracted type, which can be either specified or non-specified. Concept graphs can be used to configure and test assertions by 'projecting' or 'simplifying' sets of abstract concepts into specific instances (and *vice versa*).

Conceptual graphs represent this schematization using arcs (or edges) that connect concepts to relations.

[Concept_1] -> (relation) -> [Concept_2]

Concept and relation types are arranged hierarchically based on a generalization order, meaning that one type can subsume another. For example, *girl* (type) would bear the same characteristics as *person* (type); in other words *person* subsumes *girl*. The universal type is marked by the sign T.

Alice < Girl < Person < Human < Organism < Entity T

Sleeps < Resting activity < Activity < Action < Event T

Multiple type structures can support semantic conjunctions (e.g. 'the girl Alice sleeps in the park which is sunny and pleasant).

[Girl:Alice] -> (Sleep) -> [Park:Sunny:Pleasant]

Graphs can be projected in the sense that their nodes can be changed into specific sub-types or general super-types and then tested for logical composition. Projection also supports graph unification whereby sets of nodes between graphs are generalized (preserving their arguments and values), and then compared with similar graphs to identify their similarities (isomorphisms).

The example conceptual graph in so-called Linear Form (below), demonstrates how the generalized graph projects into the specialized graphs. This shows how agents interact with entities (and their themes), and also their position within the conceptual hierarchy: {*} demarcates the top supertype and *x the bottom sub-type (being the specific instance; sometimes called the 'absurdity'), while ?x can demarcate uncertainty:

Generalization:

[Person:Name {*}] <- (Agnt) -> [Activity:Resting] -> (Thme) -> [Space:Weather:Feeling]

Projections:

[Girl:Alice *x] <- (Agnt) -> [Sleep *x] -> (Thme)-> [Park:Sunny:Pleasant *x]

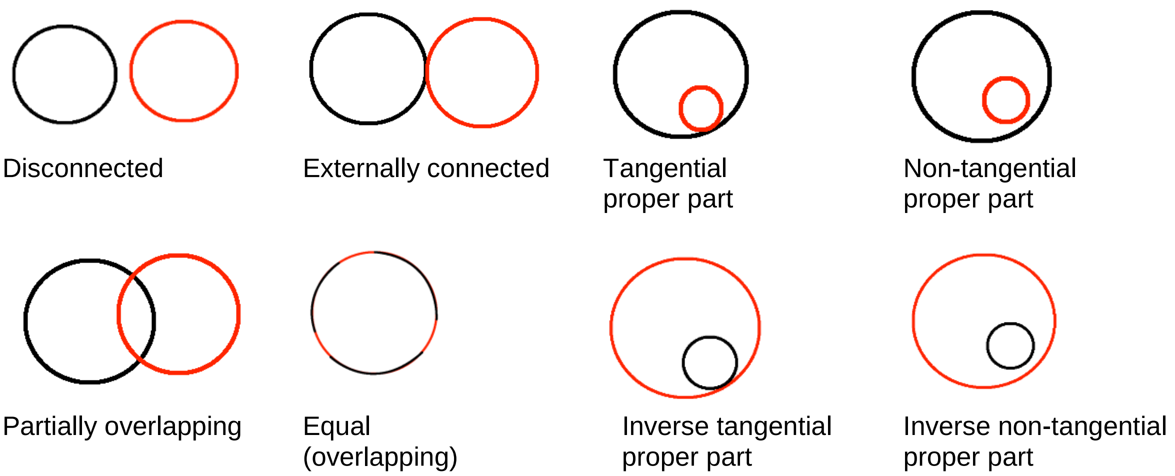
[Boy:Billy *x] <- (Agnt) -> [Shelter ?x] -> (Thme) -> [Park:Raining:Cold *x]

Using these and other logic tools, conceptual graphs allow high-level generalizations to be agreed among a community of domain practitioners, and specialized with more specific or concrete instances of those general categories. Conceptual graphs may be constructed through a top-down (general-to-specific) or bottom-up (specific-to-general) process. Importantly, a 'middle-out' extension to this well-established graph process has been developed by Berta et al (2016) in the field of 'urban ontologies'. Here (to paraphrase), the specifications of relational concepts (ontologies) are extrapolated through domain practices. The extrapolation process is limited selectively according to the *scale of representation*, the *historical significance* and the *'relational functionality'* (in terms of logical composition) of the urban elements under analysis. The ontologies are shared as a compositional template, which includes spatial and functional classes, spatial data properties and their logical relationships from a given set of domain phenomena.

3. REPRESENTING SPATIAL LOGICS

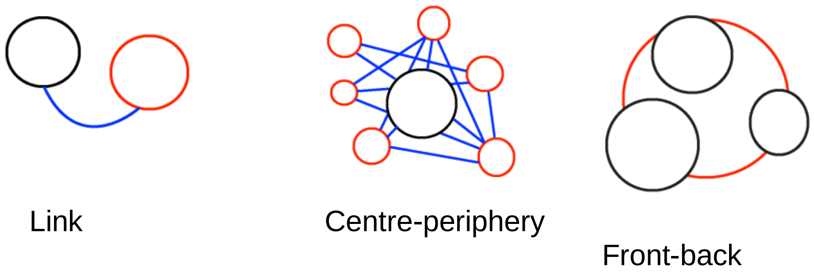
Spatial logics of urban configurations have been described in various urban domain contexts, in terms of both Euclidean (abstract) and topological space. For example, urban spaces have been shown to bear structural and geometrical patterning based on metric and topological distances and local-global relationships (Hillier, 1999; Hillier et al, 2010; Hillier and Vaughan, 2007). In another field, the Region Connection Calculus is based on a set of eight basic (abstract) relations of connection, intersection and contact (Randall et al 1992). These can be used to describe part-component relationships (A and B is *part-of* C, or C is *made-of A and B*), including meronymic relationships[2] where entities coincide within their parent class (Berta et al, 2016).

The language RCC8 is a formalism to describe eight basic spatial relations, which can be rendered visually:



We may also offer icons for Lakoff's (1987) image schemata of spatial relationships that are not available in RCC8:

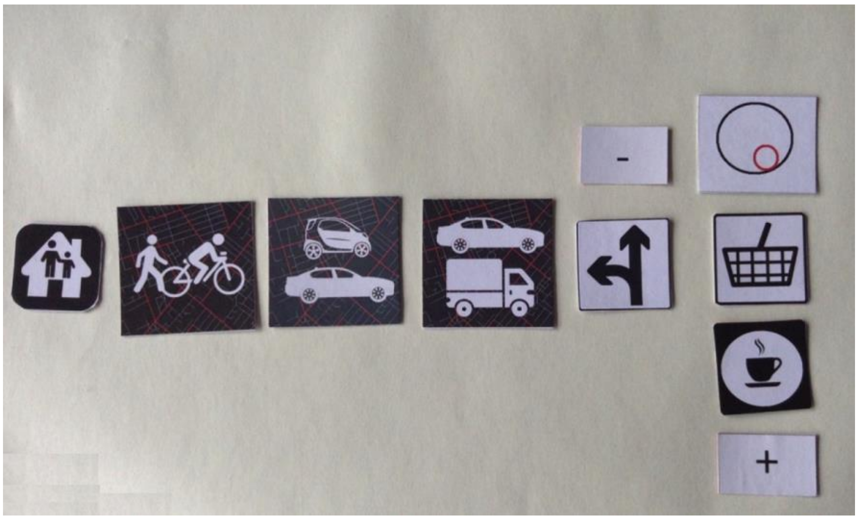
[2] Meronymic refers to parts being joined to the whole via a structurally functional connector (Berta et al, 2016)



4. PROOF-OF-CONCEPT WORKSHOP

Our aim in this research exercise was to test the practicable viability for urban domain KR of incorporating spatial logics using RCC8 into a concept graph schema. Towards this aim, we conducted a prototyping workshop involving a small group of planning and design practitioners[3]. They were invited to engage with mapped data visualizations from an earlier data-gathering exercise with secondary school-age children across Liverpool (O'Brien et al, 2016), which was part of a broader study at University College London, 'Visualizing Community Inequalities', (supported by the Leverhulme Trust). The participating children had 'mapped' their local urban communities by selected significant features, and weighting these by applying emoticon stickers to local maps. These maps and emoticons where digitized with a GIS and the points data were manipulated to produce the visualizations.

The urban practitioners were then presented with a set of graphic icons that represented the range of structures, scales and other features selected by the school participants. The participants also presented with graphic representations of spatial logics (as above) to describe ways in which these structures and scales might be arranged. The participants were then invited to build a basic (roughly defined) concept graph to describe any discernable patterns community formations within the mapped data. Here we present just one example of the concept graphs produced by the participants:



The participant's concept graph, above, represents a possible journey from home (left) to a supermarket (right), which crosses busy roads carrying local (pedestrian/velomobile), city-wide (light/heavy authomative), and regional (heavy automative/transit) traffic. The journey has a negative dimension involving a road junction (e.g. for hindering pedestrian access). The supermarket contains a café as positive dimension (e.g. for social life), represented here using an RCC8 icon for 'tangential proper part' (TPP). From

[3] An illustrated description of the workshop is available here **http://tinyurl.com/hqkv7jv**. The authors are grateful to staff at Urbed Ltd, Manchester (UK), for supporting this workshop.

this illustration we can construct a generalized and specified concept graph:

Generalization:

[Origin:Name] <- (Agnts) -> [Activity] -> (Thme) ->
[Urban entity:Type] -> [Movement:Scales] -> (Thme) ->
[Urban entity:Type] -> [Logic relation:RCC] -> [Destination:name]

Projections:

[Home-shop] <- (Parent+child) -> [Cross road] -> (Neg) ->
[Junction] -> [Traffic:Local+Citywide+Regional] -> (Pos) ->
[Shop] -> [RCC8:TPP] -> [Café]

Other participants in the workshop were able to use RCC8 icons to describe urban community relationships in terms of being 'externally connected', 'disconnected' and 'tangential proper part' and 'non-tangential proper part' (NNTPP). Interestingly, the latter instance of NNTPP was used to refer to an activity taking place in a public park, which perhaps speaks to the production of a local social-space (a sporting activity) that is part of, but not physically integrated with, the public open space. From this and other examples of successful graph constructions, we feel confident in developing and refining this prototyped technique.

5. DISCUSSION

The proof-of-concept exercise described above demonstrated the viability of incorporating spatial logics schema in a concept graph. Participants' engagement with a set of graphic icons (representing urban spatial entities, movement scales and spatial relationships), provided an intuitive method for representing their observations of complex data. However, we acknowledge that this has not yet produced a practicable tool for KR in urban domains. Towards this objective, we next need to test how the graphic icons can be organized into a meaningful 'flow' to support domain diagnostics and decision-making.

One possibility in this area is to arrange these icons within an argumentation schema. Arguments often derive from expert opinion, from metaphors, analogies or precedents or from practical reasoning (and, negatively, from ignorance, misinformation or prejudice). Challenges to an argument can be made by posing critical questions that serve to interrogate the argument's assumptions, premises and logical formulations (Walton, 2013, p.28). The field of argumentation provides a range of informal logic schema for enriching and testing representations of domain arguments.

[NOTE TO REVIEWERS: work in this area will be completed in advance of the symposium]

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