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Exploring representational issues in the visualisation of geographical phenomenon over large changes in scale.

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1. The Challenge

It is only at small scales that we get a synoptic view of the world. That synoptic view is composed of highly characteristic forms – these forms representing 'ideas' or concepts, and their location. In the example (Figure 1) a mix of text and a highly generalised representation of the road network are used to delineate the concept 'city' – in this case London.

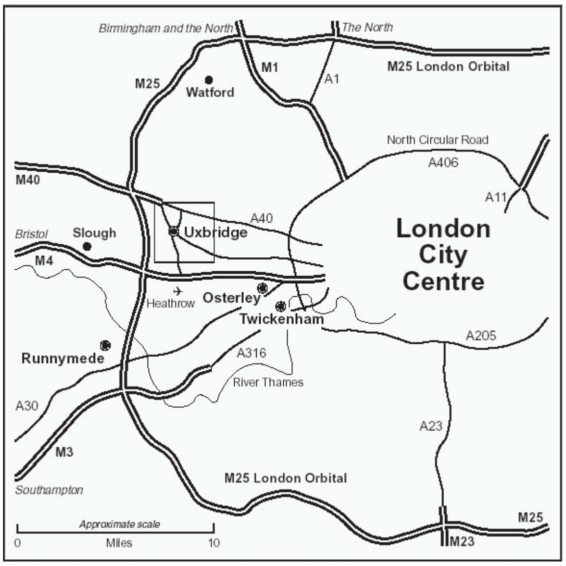

Figure 1: Small scale mapping at 1:1,300,000 – critical to the synoptic view.

The contextual information combines to emphasise the location of a set of places and a river, on the western side of London. We borrow specific properties of an entity, and symbolise it in a manner that both best enable its immediate identification and clearly separates it from other features. In Figure 1, one can see how symbolisation has been used both to capture the sinuous nature of the river Thames, and separate it from the hierarchical inter connectedness of the road/motorway network. In general what we see are a collection of caricatures of various concepts – exaggeration of a trait to reinforce the efficient transmission of an idea.

Beyond the visual, (ie from a database perspective), information recorded at this scale can be used in spatial analysis – for example comparing spatial extents of UK cities, or in broad brush journey planning. Finally we note that there is vagueness in the representation of these concepts. The boundary of London is inferred, the river and roads leading into London behaves like pieces of dropped cotton thread.

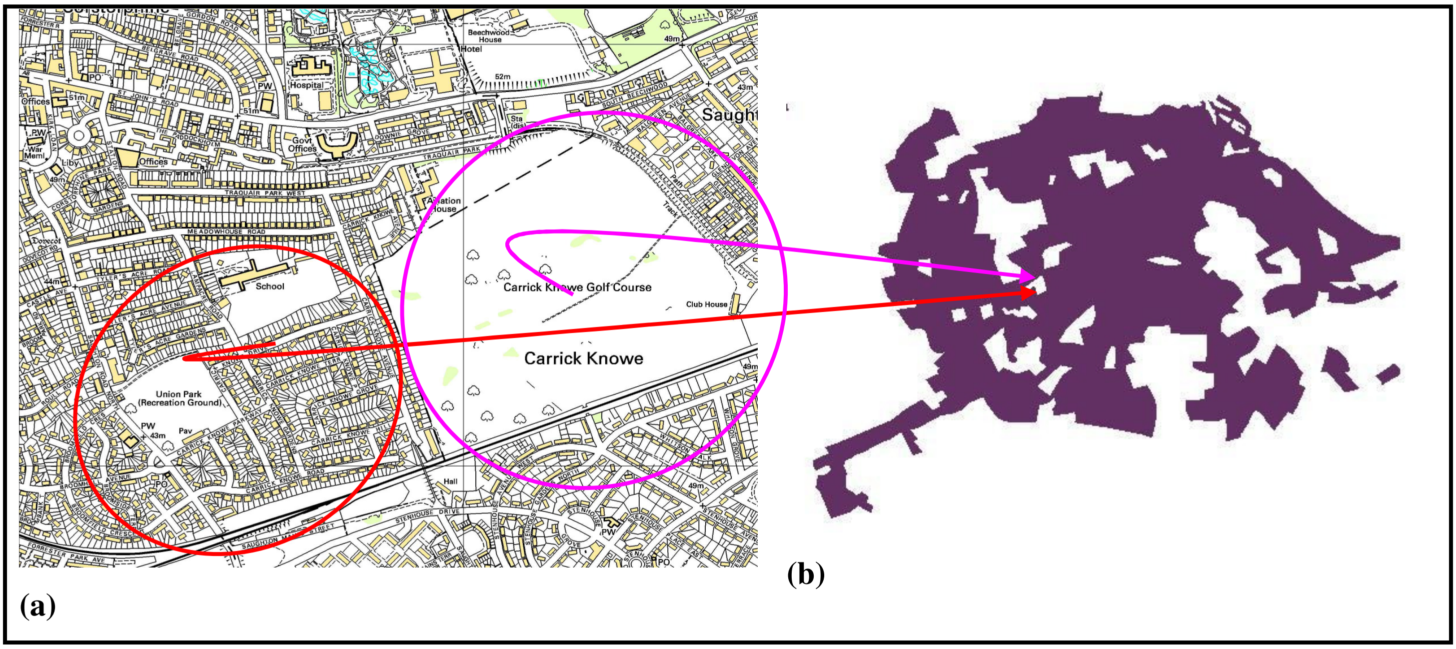

Figure 2. a). 1:10 000 scale map showing buildings and open spaces; b): how they are represented at 1:250 000 (OS Data sources).

Contrast this with the fine scale view (Figure 2a). Here the emphasis is on detail, precise delineation and location. We can undertake spatial analysis at a fine scale, between and 'within' different objects, and between classes of objects - both Euclidean and topological properties. The eye is able to group objects and infer activities and process. Comparing figure 2a with Figure 1 and 2b, we make the following observations:

- Patterns, shapes, interactions and extents are discernible and measurable in both maps.
- There is not 'less information' in the synoptic view, merely *different* information.
- Whilst many of the same cartographic principles apply to both, in the synoptic view, locational precision and completeness is sacrificed in the interests of higher levels of abstraction – which facilitates ease of interpretation.
- Maps at such different scales enable different forms of analysis between fundamentally different types of entities to be undertaken (the link between task and scale of observation).

2. Aim

This research is premised on the idea that theoretically it should be possible to automatically create such a synoptic view directly from the fine scale database – that the fine detailed features shown in Figure 2a can be agglomerated in a manner that enables us to create automatically the solution presented in Figure 2b. The challenge of spanning these scales links to Muller's idea of the existence of conceptual cusps – radical changes in the representational form of geographic phenomenon (Muller 1991). From a generalisation research perspective, this paper then, reports on research focused on the creation of small scale mapping (1:250K) directly from fine scale mapping (notionally 1:10K).

3. Methodology

A lot of Generalisation algorithms for urban buildings have been proposed but they seldom extend over large changes in scale. In this research, the methodology entails selecting all building features, and aggregating them in a way that reveals large areas continuously covered by dense housing. Small, sparsely covered regions internal to these large areas (such as parks) must be managed in a suitable manner. Part of the challenge in developing this methodology is working with poorly attributed features. The overall design of the proposed system is summarised in Figure 3.

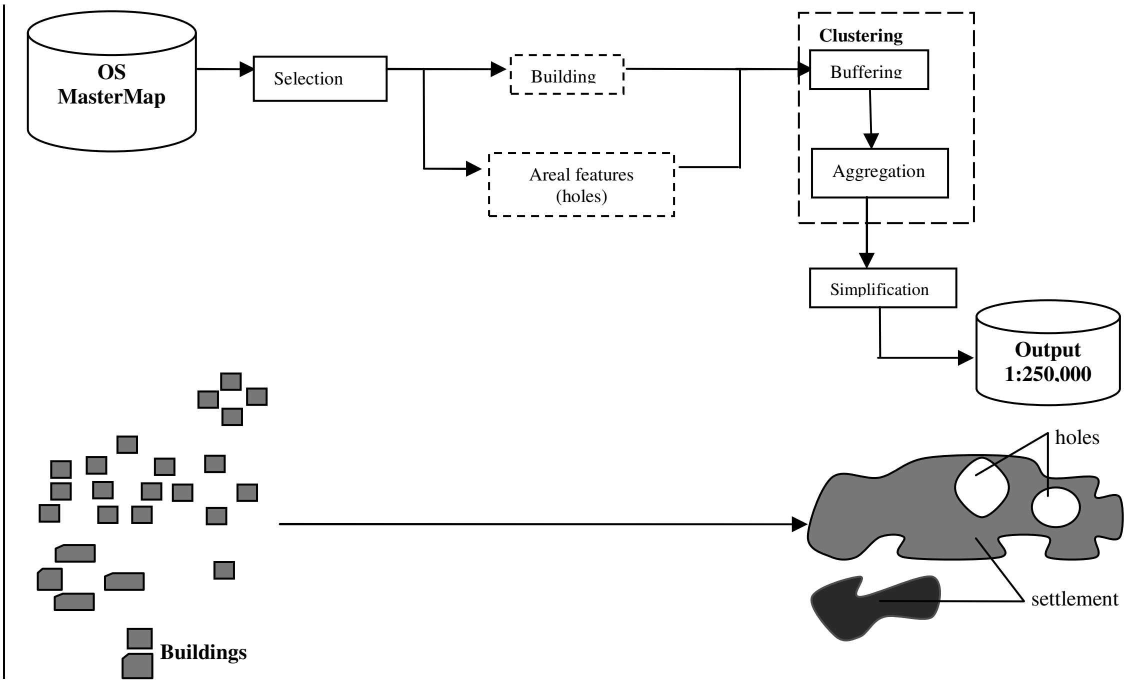

Figure 3: Overall Design

3.1 Clustering and Agregating

The first step is to extract all the buildings for the given area, and group them using a simple buffering technique. A range of buffer sizes from 50 – 150 m were tried and through empirically testing it was determined that for large urban areas and for a target output of 1:250 000, 100 meter buffer was most suitable. This simplistic approach was adopted since it was of prime importance that the algorithm should be capable of handling large datasets (fine detail over large regional extents). The next step was to aggregate the buffers (dissolving overlapping buffers) and thus generate the boundary of the urban area.

3.2 Simplification:

The next step is the classification, simplification or removal of 'small' polygons, for which we require a definition of what is large or small urban area. According to OS 1:250,000 map specification (Ordnance, 2005a): '*An urban area shown on the Small Scale Mapping Intelligence (SSMI) 1:250 000 metric plot that measures over 1 sq km is captured as an large urban area.'* And *'An urban area equal to or greater than 0.01 sq km and less than 1 sq km is captured as a small urban area'*. The area of each polygon was calculated and removed if found to be less than this threshold. 'Holes' remained within the urban region reflecting low densities of buildings in parks and open spaces. In some instances these might be removed, amalgamated, or retained. The boundary was then simplified using a simple filter and application of the Douglas- Peucker (DP) algorithm.

4. A Case Study:

We applied this methodology in the derivation of a synoptic view (1:250,000 map) directly from a fine scale database (OS MasterMap). It was implemented and the results were evaluated against OS Strategi data set (1:250,000). The platform selected for the implementation was Java, SQLJ and Oracle 10g. The new Java Geometry API offers a wide range of functions to manipulate spatial objects in Oracle. Oracle 10g supports all the geometrical and topological functions defined by OGC as reported in (Oosterom et al., 2002). The input file contained nearly 139K building polygons (Figure 4). Figure 5 shows the result of buffering and aggregating. Removal of small holes and small isolated regions resulted in Figure 6.

Figure 4:Buildings extracted from OS MasterMap of Edinburgh City

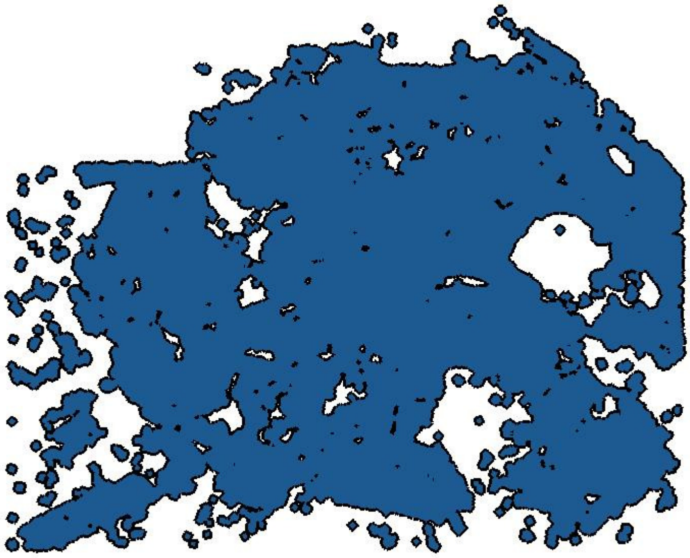

Figure 5: Initial output after aggregation and dissolving of buffers.

Figure 6:Output after being angluarized using a mixture of Douglas Peucker and Buffering

5. Evaluation:

Visual comparison was done between the output obtained (Figure 6) and OS Strategi settlement layer (Figure 7). Although subjective, it gives some indication of the success of the algorithm.

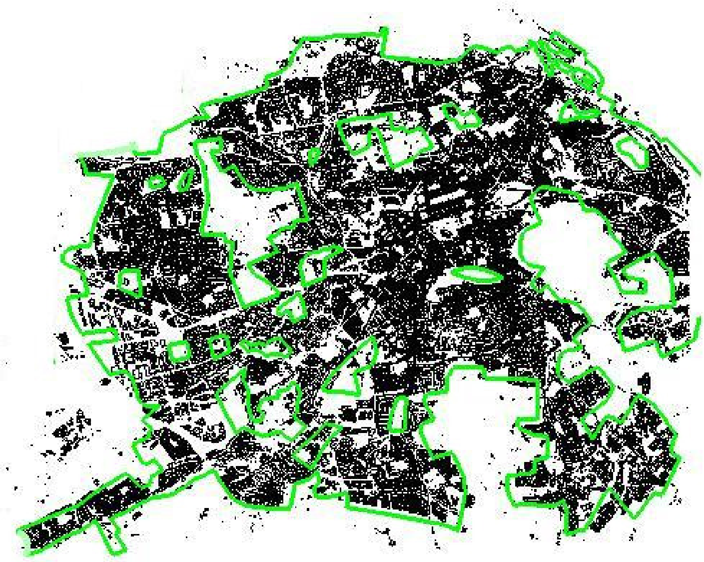

Figure 7:OS Strategi (1:250,000) settlement layer in grey.

7. Conclusion:

The challenge of deriving maps over large changes in scale is not new (Watson, 1970; Smaalen, 2003). But in this paper we argue that the creation of the synoptic view – the representation of concepts - requires a more focused development of model generalisation techniques and creation of relevant evaluation criteria. We argue that this work is relevant to spatial analysis and exploratory data analysis – that generalisation is fundamental to the revelation of different patterns and interdependencies between geographic phenomena. The paper proposed a methodology by which a synoptic view can be created. The paper also looked into the spatial functions provided by Oracle 10g and a case study was carried out to generalize the urban buildings and generate boundary of the urban settlement which compared quite favourably with the manually created urban settlement layer of 1:250,000 map. Further work will look at dealing with smaller settlements and mixtures of small and large settlements. Also it will look into density calculations of the buildings which appears to be an important precursor to clustering.

Acknowledgements:

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