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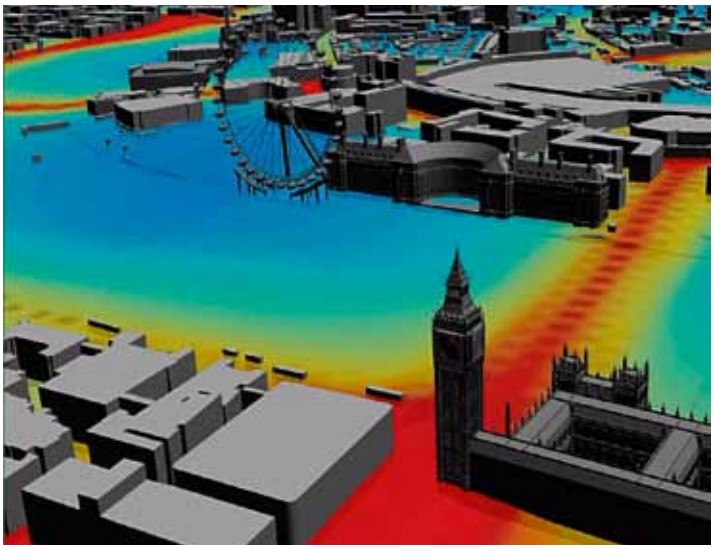
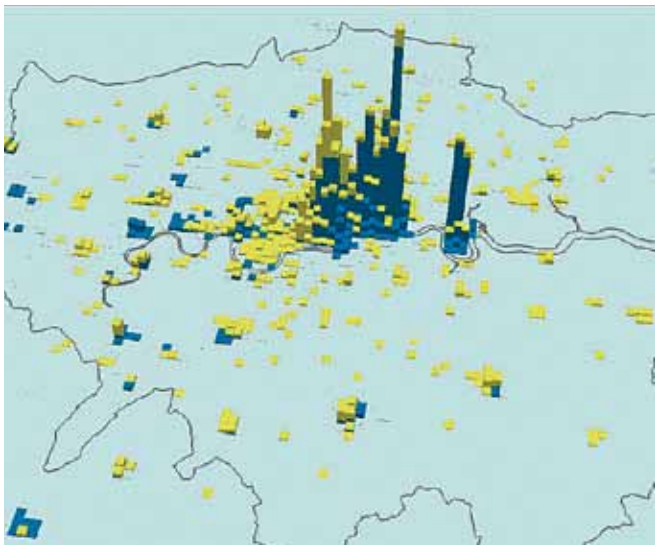
VISUAL ANALYTICS FOR URBAN DESIGN

Michael Batty and Andrew Hudson-Smith describe the wealth of tools available





↑ The Virtual London model built from vector land parcel, streetline and 3D LIDAR data and visualised in ArcGIS with a pollution layer in colour.
↗ London's office (blue) and retail (yellow) space as 3D histograms.

DEFINING VISUAL ANALYTICS

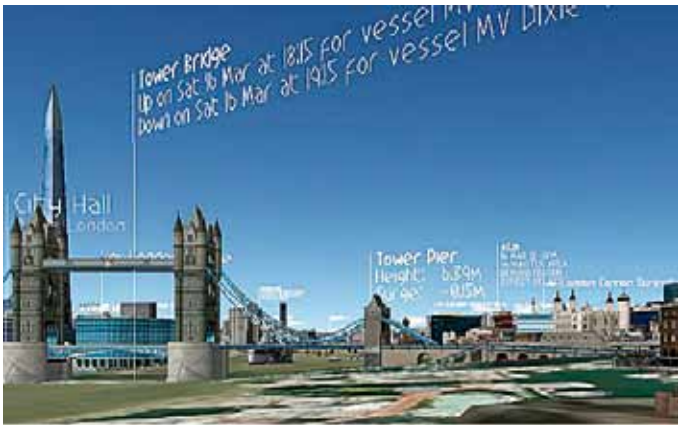
The dominant medium in urban design has and continues to be visual. Maps and physical models provide the lens through which design is developed and communicated, and pictures of the resultant designs, which largely focus on views of how buildings and people relate functionally and aesthetically to one another, are key to the definition of design. In a world that is now quickly moving to represent virtually every type of media from sound to sight, smell to hearing and touch in digital terms, the most obvious applications in urban design are based on digital representations of what traditionally was produced by hand: maps, layouts and perspectives. But the power of the digital world for urban design is much wider than mere pictorial visualisation, although this can be as effective if not more so than traditional media. Digital visualisation provides a powerful medium in which to abstract and analyse, and it is 'visual analytics' that is fast becoming the cutting edge of how urban design might be progressed.

Visual analytics goes beyond pictorial representations in that it associates the functions that define how for example, neighbourhoods work, with ways of making sense of them visually. It requires a model which we define as a set of abstractions embracing the functions that are central to design. The best way to describe this kind of analytics is to consider urban design to be composed of elements that vary over space and time, as well as over spatial scales, although here we will very much focus on localities or neighbourhoods. Such designs reflect a mix of goals relating to the aesthetic quality of design, reflecting the efficiencies with which people use the environment, as well as equitable principles that might be embodied and achieved by the design.

URBAN DESIGN FEATURES

Without going into theories about the neighbourhood, there are five core features of urban design around which we can illustrate visual analytics. First, there is the physical representation of the design as 2D maps and 3D visualisations of urban form that are captured and manipulated visually, and can be cast into various virtual environments to allow designers and users of the design to explore and experience the design in advance. In the last 20 years, the software to do this has evolved from geographic information systems (GIS for maps and some networks) to computer-aided design (CAD) software, and latterly to various kinds of immersive environments and animation. These kinds of systems are now scaling down to Building Information Systems (BIMs) that represent much the same idea but with a stronger emphasis on the function and materials of buildings.

The second feature involves networks. Clearly interaction and movement are key to urban design, and layouts of buildings are often complemented by these. There are many new ideas about networks, ranging from their morphology to their visualisation, that are being deployed to articulate designs. The third feature is new media. When most of us are connected to the internet using smart phones, then the kinds of interactions that can take place on virtual social networks are often reflected in quite complex ways in the physical environment; everything from Twitter feeds to email traffic serve to illustrate new ways in which social structures are intimately tied up with physical building structures. Our fourth feature involves new and more abstract methods of visualisation based on infographics. As we have implied, visual analytics is not simply about pictures of urban scenes or even about maps, but we can abstract aspects of a design problem and its potential solutions into forms that can be visualised



in powerful and effective new ways. The fifth feature is about the online world where much of our access to it is graphical and pictorial. Planning processes are now being dramatically restructured based on online information with new ways of generating participation, using stakeholders to generate data, and enabling much larger audiences to shape designs over the internet. All of this is critically dependent on visual analytics.

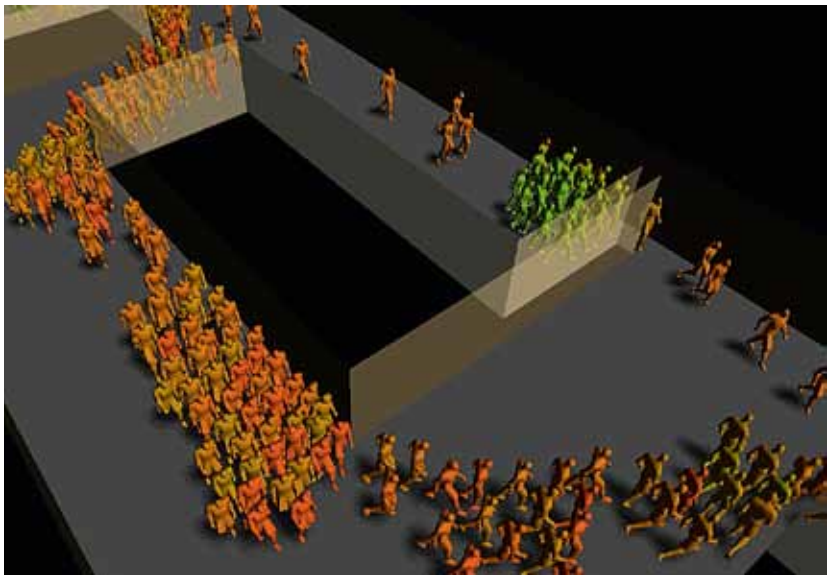
MOVING INTO 3D

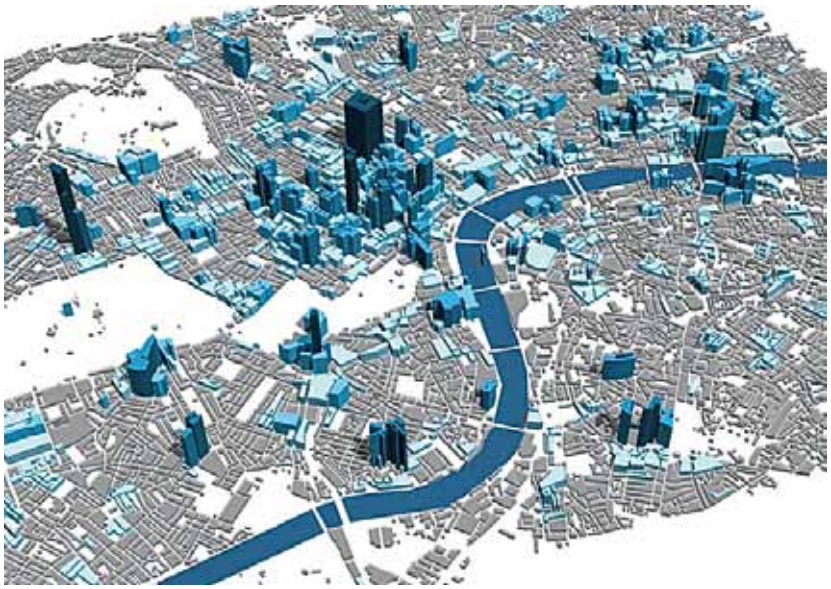
The core of digital visualisation in urban design resides in 2D and 3D representation, which was first illustrated for neighbourhoods and building complexes almost as soon as computers became graphical in the early 1980s. A whole panoply of GIS techniques in terms of treating the attributes of buildings as layers of data is now widely used. Taking this into the third dimension and tagging 3D representations to data layers enables new forms of analysis to be accomplished. We have a collage of 3D content from our Virtual London model, which enables users to tag these blocks with content and render them in much greater detail if required. Besides the usual fly-throughs that are possible and going down to street level, these 3D models can be associated with layers of pollution or water, which can be manipulated to simulate flooding, or any attributes that are relevant to good urban design. Once the content of the model has been built in digital form, the 3D analysis is straightforward. Importing a 3D scene into a virtual world that can be accessed online is now almost routine.

THE VIRTUAL AND THE REAL

We can also show how a portion of the Virtual London model can be entered into a virtual world with actors logging on from remote locations, appearing as avatars, and engaging in discussions on various aspects of the 3D scene to be manipulated (Batty and Hudson-Smith, 2005). In short, developments in 3D visualisation have spurred on the notion of the online studio; the idea that many people can work together on the same design at the same time, no matter how geographically remote they are, is the way of the future and that is beginning to be exploited in all kinds of collective work and design through structured crowdsourcing.

↑ The virtual and the real: creating a virtual exhibition space where users can interact, and with easier navigation using gaming media
↖↑ Flows in the city: public bikes in central London and key passenger flows on the underground





↑ and ↑↑ Modelling and visualising pedestrian movement in neighbourhoods and large buildings for congestion and speed of evacuation
↑↑↑ New media: the spatial distribution of 3500 tweets over 15 hours

There are many other ways of visualising buildings and neighbourhoods using augmented reality, in which digital content is central. We can still go back to reality by projecting digital analysis on conventional physical media – using a map like the London Data Table – and improve this by enabling users to interact with the design in holographic space or by flying through space.

LINES OF SIGHT

A key element in the design of any system is the way that the parts are assembled to produce the whole, and urban designers spend a great deal of time experimenting with fitting elements into restricted spaces to optimise human interactions and contacts. In the last decade, there has been a revolution in thinking about how to represent and manipulate networks, and many new visual tools are being developed to portray the strength of connections between buildings and areas within a design. Rudimentary network tools have been developed for examining lines of sight and view-sheds in urban design, and very early in this development the idea of calculating proximity based on the quality of how spaces connected to each other was developed as Space Syntax. There have been rapid developments recently in this area, and we can show the kinds of analytics about connectivity and accessibility by lines of sight and their intersections – the essence of space syntax – for the French village of Gassin, originally used by Hillier and Hanson (1984) and extended by Batty (2013).

> As the digital revolution has always suggested, what is possible today will become routine tomorrow

CITY FLOWS

Urban systems based solely on simple links between spaces and routes are simplistic as these links are always weighted by flows. Flows are significant because they illustrate how energy flows in an urban system: car traffic, people walking, goods moving, email, web use, high frequency trading and so on. The flow of public bikes on streets in central London and the dominant links associated with the tube system at key transport hubs are examples of this. There are many such visualisations and if they are animated, these illustrate how energy pulses through the fabric of the city in diurnal cycles, like peak hour concentrations. Flow systems tend to be more implicit at the urban design scale and only really come into their own when traffic flow patterns are identified which define the city at a more coarse grain.

PEDESTRIAN MOVEMENT

At finer scales, the focus is much more on how people walk and interact locally using slower modes of transport. Flow systems can be visualised at a very fine scale, simulating people moving in a building complex, how they crowd, flock, diffuse and cluster as they interact with others and with the buildings. We can also model evacuation from a large building complex using the Legion software (Zachariadis 2014). This begins to suggest that

some of our work in urban design relates to much shorter term issues about the smart city, where we are concerned with how design is affected by rapid movement, security and safety issues.

SPATIAL DISTRIBUTION

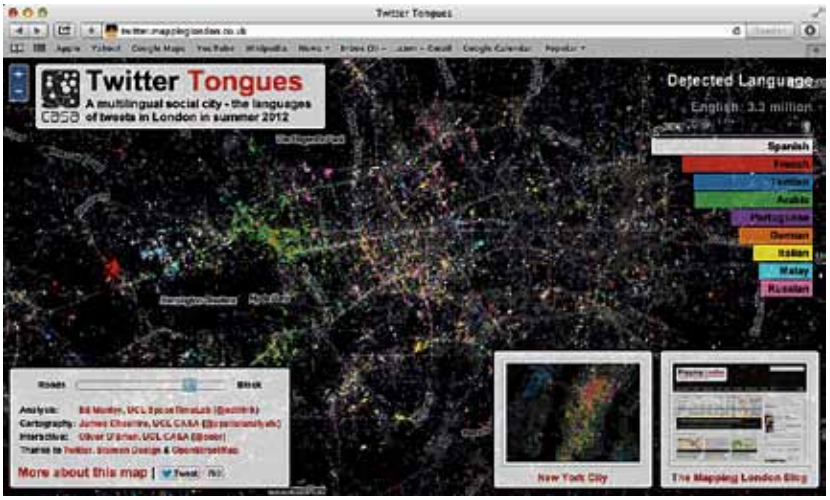
Data that streams in real time is now beginning to be captured and mapped at a very fine spatial scale. We have detailed transport flows second by second from smart payment cards as well as mobile devices used on social media. From this, we are able to explore the impact of social networks and interactions in small spaces and we can bring 2D maps and 3D visualisations together to locate and visualise social media, in this case Tweets, which illustrate how data can be associated with buildings and places. From this, social networks can be constructed which indicate how places are related to each another, complementing the other flow and network data that we have mapped and explored earlier.

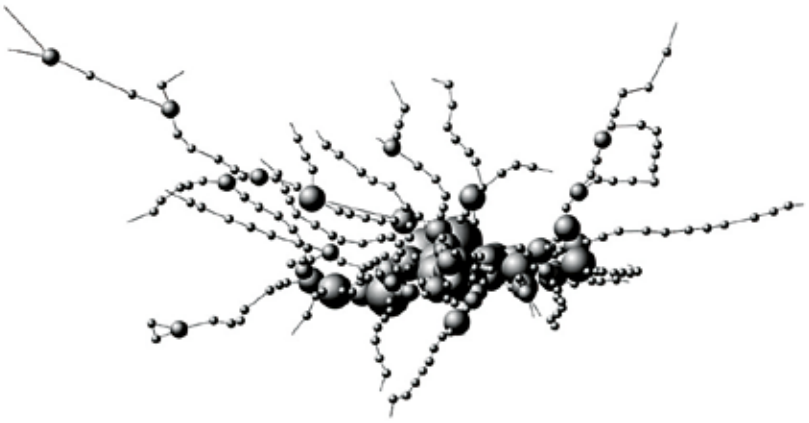
ABSTRACTING DESIGN PROBLEMS

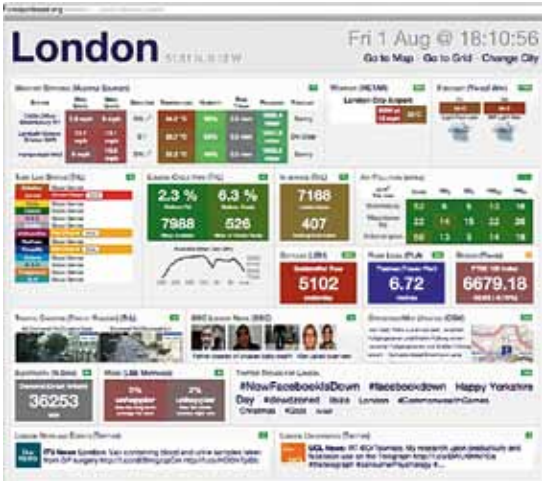
The beginnings of digital visualisation in the 1980s, which occurred on micro as well as supercomputers, were different to the examples illustrated here. Scientific visualisation essentially abstracts properties and visualises their structure using networks and statistical charts. There have been many advances, particularly involving networks and relationship diagrams. We can also show two very different examples: for flows based on the journey to work between places on the circular route network in London boroughs as a circular flow map, and for connectivity between subway stations in the London tube system. The real power of these visualisations is in abstracting the key points, so that in the circular flow map the dominant flows are within places, but the map also shows the key flows which represent major commuting into the centre of London. Visualising internal flows within places is very hard using conventional mapping in 2D. The connectivity of the tube stations enables the spheres to be positioned to make the graph intelligible while retaining its planar characteristics. Although we cannot show it here, the software makes it possible to animate and reposition the graphics showing its value in exploring urban design problems continuously.

This new world of visual analytics is exploding almost in front of our eyes because the internet enables all of us to become involved in these visualisations. In fact, data about urban problems is increasingly being delivered to our desktops and mobile devices through the web as shown in our Citydashboard, which collects data from live feeds and displays it in real time for particular places. We can scale this kind of visualisation to very local places, and improve them to be interactive so that designers and users can generate data using crowdsourcing. We can extend this to a variety of devices such as physical data tables and digital touch screens for extensive interaction by a range of stakeholders involved in the process of urban design.

In this paper, we have sketched out the possibilities that are currently being explored and as the digital revolution has always suggested, what is possible today will become routine tomorrow.







↑ The ethnic groups tweeting based on the languages used
↑↑ Infographics: abstracting spatial design problems to visualise the connectivity of tube stations
← Community design: disseminating real-time urban data using visual dashboards

Many of the new technologies described here reflect this and the time is ripe for a more considered exploration and integration of the array of visual technologies that are fast becoming central to urban design and planning. ●

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