DCC’08: workshop on Generative Urban Design

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Design support systems for sustainable development in the Thames Gateway area of London: “Smart Solutions for Spatial Planning “(SSSP)

SYNOPSIS

This presentation will describe the methods and approaches used to develop applications for Urban planners for use in masterplanning and scenario building. It was developed using a grant from the Higher Educational Council for England, and the Department for Trade and Industry as part of the “Building Sustainable Communities“ project.

BACKGROUND

After many years of inactivity, it seems the field of computational urban modeling has become live once more. The original explorations (Haggett & Chorley 1969, McLaughlin 1969) were left to develop into the more large scale area of GIS, and computational geography, and computational focus on the spatial morphology of settlements did not arise until Bill Hillier’s seminal paper (Hillier 1976); ‘Space syntax’ which in its first incarnation was a proposal for a set theoretic syntax for cellular agglomeration models. Batty’s work (Batty 1996) at the regional scale began to explore diffusion limited aggregation models of urban growth, and more recently work on cellular automata and self organizing feature mappings (DIappi 2004) has lead to developments in the emergent systems approach to urban decay and gentrification. Since then the recent work of Koenig (forthcoming) & Mueller(eg 2001) has shown the use of L-systems and other pattern-making systems, many of which are now in use in the games industry for generating ‘realistic looking’ urban space for scenarios.

In most computational work there has been, we suggest, a dichotomy between the study of people in cities and urban systems, and the study of spatial systems as geometrical entities. Hillier’s contribution was to link these two things together. Thus, the development of models of urban structure can be seen as both simple descriptions of the spatial consequences of aggregation in the plane, and also a way of describing social relations. Because the syntax is related by what Hillier calls an ‘inverse law’ (space constitutes society and society constitutes space) then it becomes a simple but powerful descriptor that welds together the over elaborate a-spatial models of society and non-social models of space and form.

We suggest that the actual practice of urban design has to some extent reverted from pattern making back to this original cybernetic approach to urban coding where relationships and systems are defined, and the urban morphology emerges from a synthesis of both the site structure and societal data. Our project, then, was to work closely with the regeneration units of Tower Hamlets and Newham (two inner London boroughs) and a team of Urban designers to understand their workflow and strategies so that we could build our simulation models to fit in with their way of working. To his end we built a set of urban design support methods – analytical and generative – that can iteratively be plugged into their workflow.

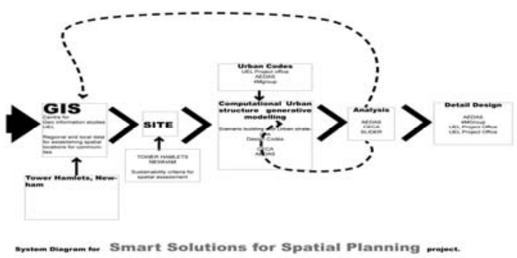

FIG 1 workflow diagram

SIMULATION STRUCTURE

The site for this knowledge transfer exercise, sits on the border between two London Boroughs – Tower Hamlet and Newham – within the Lea River valley. The site therefore is subject to two sets of policies Local Area Action Plans and is also topographically divided by the river itself. Those conditions let to the main issue on site, which is the lack of accessibility. Further, the London Borough of Hammersmith and Fulham have developed an accessibility mapping method, called PTAL – Public Transport Access Levels – which serves most urban planners as an initial briefing instrument for density levels, land-use distributions and transport strategies.

Hence, the present approach uses ***accessibility*** as a backbone, which underpins the overall strategy of building a digital chain from regional data sets, topographical data, social deprivation and access to services. The accessibility network feeds straight into the urban/ masterplan scale and the urban block scale.

Accessibility Levels

Using a derivative of Dijkstra's shortest path algorithm, all context paths, routes and access points are integrated to serve as a stimulus for generation of further axes and circulation paths.
Any newly generated network of paths and routes (see urban scale) recursively links into the existing graph and gives properties to the edges of the emergent urban blocks.

Urban Scale

While the urban block and its relation to public space is fairly well described and quantifiable, the urban scale structure lacks explicit design approaches. However, the most common heuristics of urban designers/ planners pointed towards differentiation of the urban structure by connectivity of 'activity' locations including linear spaces (knitted into external location points).
Therefore, a series of studies was undertaken to evaluate computational approaches for urban structure through connectivity (always embedded in the accessibility strategy), which were evaluated with our urban designer and council planner partners.

Initial studies used a Voronoi partitioning algorithm with the centers of the Voronoi cells self-regulating to achieve optimal block areas and block ratios. Further, we tried to implement a random orthogonal partitioning system responsive to the accessibility levels and activation points. Finally, the last of initial studies distorted an underlying grid towards the most integrated shortest path graph through a spring system based on Runge Kutta.

The most appropriate method however, proved to be a more literal transposition of urban design heuristics by implementing a K-minimum spanning tree (KCT) on a grid with a minimum average aspect ratio for urban blocks. The spanning tree calculates the sub-tree through an ant-colony optimization (ACO). The activation locations serve as the K input vertices and produce unpredictable yet rational urban blocks.

FIG 2 left: relaxation and deformation to shortest path network, right: K-minimum spanning tree

Block definition & Plot Uses

For the block definitions and land-use allocations, either hand-drawn outline urban blocks or the results from the KCT graph serve as input. Two methods in progress:

Aggregate Hill-Climber

According to context conditions, social data and local planning frameworks, a massing is generated dependent on the outline blocks (circulation graph). Single plot units 'hill-climb' within an unstructured grid and slowly aggregate towards the desired total area set in the masterplanning brief. The units hill-climb in order to reduce the errors in their adjacency preferences and distance requirement to functions and conditions. Each local change is benchmarked globally and continues until all criteria are satisfied. If the masterplanning brief is un-realistic according to density and accessibility (and other) planning criteria, the applications indicates alternative area schedules.

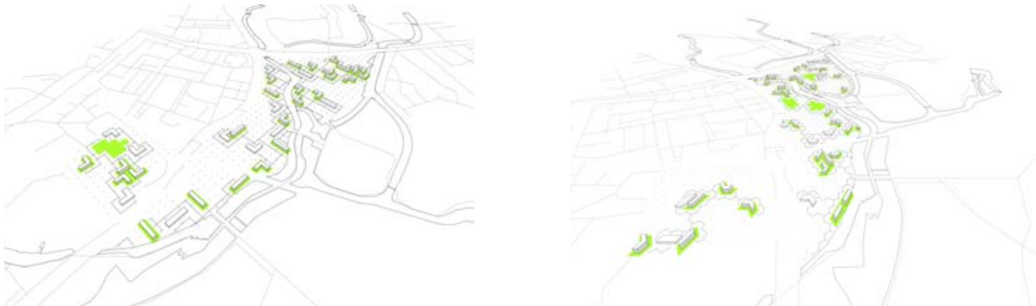

FIG 3 two land-use aggregation results with secondary path networks generated

Pareto Optimization

The multi-criteria Pareto optimization is developed to optimize the distribution of uses within a given urban block to achieve mix, density and environmental criteria. The target values are taken from policy documents used by the planners, which set out dwelling densities for a range of building typologies. In the example below of a test block the target density is of high density with elevated ratios of retail to residential. Using the Pareto Optimization allows balancing of non-commensurate criteria and targets including individual building typology and open space policies.

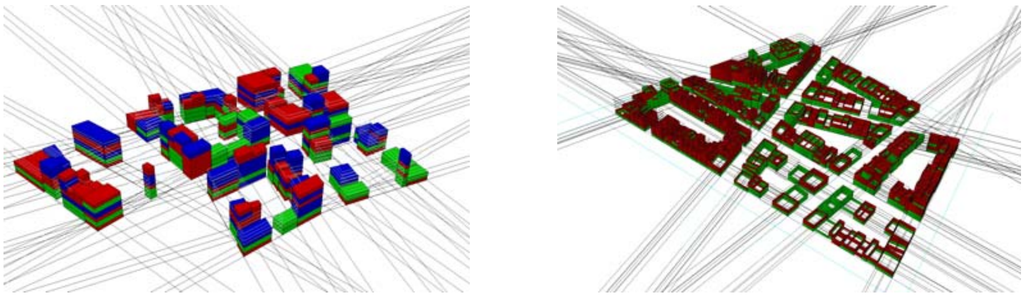

FIG 4 multi criteria optimization for urban blocks: residential target 425 Dwelling per Ha (from Urban Design Compendium), Retail 20% & maximize south facing elevations

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