Environmental Catalysts for a Computational Urbanism

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Abstract. It is perhaps no longer relevant to discuss digital tools purely as means in themselves; the growth of abstract systems or computational patterns for their own sake simply strain justification in light of real-world concerns such as climate change and economic crises. While growing concerns over climate change have necessitated an increased interest in sustainable urbanism and design, sustainability has done little to yet alter the morphological and typological consequences of architectural space (Hardy, 2008). In a series of overlapping research projects and design studio briefs, students, research assistants and we worked with the iterative and variable processes of Rhinoscript, McNeel’s Grasshopper and Bentley’s Generative Components to explore the possibilities of changing environmental extremes (specifically flooding) as catalysts for providing new urban morphologies and spatial organizations. Working between the master plan and the individual housing unit, we investigated arrays of terrace homes in the London Thames Valley flood zones while simultaneously exploring the potential for computational generation and parametric optimization.

Keywords. Computational urbanism; formative strategies; parametric design; adaptive vs. mitagative; environmental formations.

Introduction

According to the United Nations Population Division, over 60 percent of the world’s population is projected to live in urban areas by the year 2030. Many of these urban areas are located along coastal and estuaries regions and, like London, are set to lead the population growth with increases of almost 20 percent by 2029 (Frith, 2006). As London and other coastal and estuary cities continue to grow, partially hemmed by their natural border, land values increase and the pressures for development via means of coastal encroachments soar (Shih and Nicholls, 2007). Unfortunately coastal regions and their local ecosystems typically act as natural buffer zones; attempts to develop them have increased urban vulnerabilities and resulted in greater flood risks for both the newly developed and neighboring areas. These developments are typically approached through large infrastructural projects with defensive mitigation strategies like the Thames Barrier. While infrastructural mitigation remains a possible and
often necessary option for developments and the protection of historic fabrics, it carries the possible risk of future failure and eventual obsolescence due to rising seas levels brought about by changing environmental conditions.

The United Nations resolution A/RES/58/214 is an International Strategy of Disaster Reduction (ISDR) that sets out a framework for reducing vulnerability to natural disasters and their long-term negative social, economic and environmental consequences. While it is relatively easy to imagine the impacts of climate change as remote events of the distant future, recent news reports and current scientific data highlight the many urban areas already vulnerable to increased floods due to extreme weather and rising sea levels. From the global flood zones highlighted in 2007 (figure 1), it’s clear that the Southeast of England (compounded by its increasing population and development density) is currently facing and will continue to face increased challenges in the near future. While growing concerns over climate change have increased interests in sustainable design, the focus has primarily been on carbon mitigation (the reduction of carbon emissions) in order IPCC charges designers to seek adaptive strategies that cope with changing conditions rather than relying solely on designs which mitigate carbon use in attempts to abate climate change.

Adaptive design strategies can be classified into two basic types: defensive (mitigation) adaptations and offensive (projective) adaptations. Defensive adaptations include landfills, dams, and preventative infrastructural projects that, while temporarily effective, also erase possibilities for environmental impacts to affect the design morphology of the overall development and performance of the individual dwelling unit. Projective adaptations, on the other hand, produce fundamental morphological changes in the architectural design of the developments themselves. Examples of projective adaptations in flood-prone areas include hybrids of performance-oriented housing types like floating structures, plinth developments, or stilt-based dwellings. The simple act of raising the building from the ground, in contemporary England, suggests changes to the spatial and organizational morphology that adaptive mitigation strategies in the new development proposals plainly avoid.

Figure 1
Global flood zone map from Dartmouth Flood Observatory data. Graphic mapping by Marcos Zotes-López.

Computational Urbanism

In today’s computer savvy world it is perhaps no longer interesting to discuss digital tools purely as
means in themselves. The growth of abstract exponential systems or the generation of modulated patterns for their own sake simply strains justification in light of real-world concerns such as climate change and economic crises. Still, we pursue evolving digital technologies in hopes that they prompt innovative design strategies and creative organizational, spatial or formal results that align with the changing world and the evolving techno-cultures, which are so rapidly affecting modern life. Parametric tools permeate most contemporary design explorations but the generative techniques are no longer the topic of focus in themselves (Steele 2007), rather the tools serve as the means towards engaging a more projective architectural discourse. Explicit and symbolic logic modelers like Bentley’s Generative Components and McNeel’s Grasshopper plug-in for Rhino have had a substantial impact on design at the building scale (Leach, 2009). Over the last few years there has been an increasing effort, especially from schools of architecture, to explore the use of these tools at the scale of the city. Neil Leach presents a large body of this explorative work on the city in AD: Digital Cities and argues that digital technologies while being used to analyze and understand the operations of cities have also started to transform the city itself by creating overlaps and interfaces between the virtual and the real. However, the most transformative feature of digital technologies is perhaps also how they infiltrate the design process and affect design thinking and the fundamental design morphologies.

Urban form is simultaneously an action - engaged in both informative processes and formative strategies – as well as the formal and qualitative resultants. Informative processes serve as independent variables that help shape or inform the relationship within the design equation while formative strategies define the actual equations. The overall equations then affect the way that the independent variables are processed and produce a variety of results for the dependant variables and resulting forms. To deal with this type of complexity, we must go beyond modern approaches which rely on binary operations (like form and function) and recognize that we live within a complex, poly-variable world.

Parametric thinking is prevalent in the sense that we must learn (computationally or not) to work with the relationships between an increasingly complex array of variables. Design becomes the act of both balancing these relationships within a minimal means and striving towards elegant solutions.

As the world’s population continues to shift into and mandate the growth of our urban areas, there is an increased interest in balancing urbanism as an evolutive process while maintaining the ability to design and achieve coherent urban forms. In traditional practice, the continual flux of urban conditions brought on by growth and ongoing societal change, along with the polarization of architecture and planning, results in a lack of coherency (Jacoby, 2007). Traditional design methods which rely solely on an implicit logic simply lack the ability to
incorporate the diversity of requirements and large array of organizational variables needed to redefine city planning and refine urban form. The following design-research explorations and student samples have explored the possibilities of urban form/pattern generation and simulation through computational and parametric modeling. Rather than attempt to rework environmental parameters into existing design conditions and building/urban types, we are interested in the possibility of creating new urban forms necessitated by adaptive design strategies and explored through iterative processes, modulated massing, and computational optimization. Beyond flood-based performance criteria, the critical moments for designers and students to engage are the social and political affects created by simply raising the traditional dwelling from the ground, the morphological and organization implications to the dwelling itself, and the cyclical temporality of a sometimes flooded (but usable) dwelling within contemporary, affluent societies.

URBAN.NET // Instant (para)City
Urban network (URBAN.NET) strategies implement distributed rather than either centralized or decentralized organizational strategies. Partial limitations arise from the overuse of linguistic binaries such as ‘urban’ vs. ‘suburban’ rather than attempting to understand cities as distributed modulations of function, density, building type and organizational variation. Avoiding the pursuits of a singular urban core, URBAN.NET // Instant (para)City attempts to find potentials within current conditions and proposes distributed ‘urban’ patches to serve as nodes that infiltrate and connect otherwise disparate parts of the modern city. This patch approach both shuns the utopian tabula rasa and adopts the notion that the most sustainable approach towards a permacultural urbanism must contend with and work around the vast amounts of (pre-environmental) building and infrastructure that already exist.

URBAN.NET//Instant (para)City is a parametric-based set of explicit logic and scripted subroutines which allow the rapid iteration of urban landscape visualizations and simulations. By altering contextual sliders, large arrays of possible urban configurations are produced – from the slightly more typical to the more speculative. This application is currently being used by a new group of students for the investigation and generation of polycentric, urban/sub-urban remixes. Here it was used for the generation of terrace house patterns and aggregative-oriented apartments in development targeted, flood-prone areas in London.

Adaptive Environmental Strategies
In the wake of London’s housing shortage, the London Development Agency (LDA) together with the Greater London Authority (GLA) and the Mayor of London has pledged to promote the construction of over 30,000 new homes a year. Additionally, in December 2007 the LDA, the Homes and Communities Agency (HCA) and Communities and Local Government (CLG) jointly published the North London Development and Investment Framework Prospectus (NLDIF) alongside the Comprehensive Lea Valley Development Plan (LVDP). A large part of the strategy explores the increasing need for single family homes caused by the subdivision of homes into flats alongside the consequence of recent developmental focus on only one and two bed flats.

Coupled with the scarcity of land in London and the Mayor’s pledge to build homes, the LDA have highlighted tracks of developable land which are primarily located within known and problematic floodplains. However the UK, in particular the area along the Thames River, has been increasingly susceptible to more severe flooding. Developers of those projects are currently marketing a misaligned affect of the new homes - where development plans and marketing images promise iconic homes with smiling families - the reality facing those home owners is probably that of uninsurable, unsellable homes stricken by semi-annual floods. In the pursuit of marketing happiness for maximum profits,
developers refuse to readdress the performance and redesign of the typical house and instead, relying on infrastructural mitigation, choose to publish and promote iconic English houses that sit firmly on the floodplain.

**Twickenham Terrace Computations**

A large proportion of the London Borough of Richmond is situated in close proximity to the River Thames and its tributaries. The Environment Agency estimates that within Richmond, over 5,700 properties are at ‘significant’ risk of flooding. It is essential therefore that planning decisions are informed, and take due consideration of the risk posed to (and by) future development. Development and Flood Risk

 requires that the local planning authorities prepare a SFRA in consultation with the Environment Agency. The town is bordered on the south-eastern side by the River Thames and Eel Pie Island, the land adjacent to the river, from Strawberry Hill in the south to Marble Hill Park in the north, is occupied by a mixture of luxury dwellings, formal gardens, public housing, and a newly built park and leisure facility.

Working between the master plan and the individual housing unit, we investigated arrays of terrace homes while simultaneously exploring the potential for parametric optimization and modulation. Using Bentley’s Generative Componants and working with typological hybrids, we established a single terrace house as a component and began to explore the modulation of the terrace in terms of performance, site specificity and potential size customization. Our initial series, shown in figure 03, had a distinctly field-like cohesion, but with an amplified variability that historic terraces lack.

The urban array was established as a parametric system in order to test various relationships and configurational differences in response to both internal and external variables. The individual housing units were developed as relationship-based, parametric components, controlled via law curves; three of these curves were controlled the morphology of the street while other curves controlled the relationships between building masses and the front and back gardens. Some of the parameters were controlled through Law Curves or graph variables to explore a
variety of programmatic organizations and resulting spatial effects. As a result of this system, radically different types occurred at the end of a specific serial modulation where one type gradually morphed into another. The overall terrace strips became urban masses of fluid transition which followed the non-linear generation of the computational system.

With the explicit logic (parametric/computational) model established, we began to optimize a variety of simple parameters demonstrated in the top of figure 4: 1. roof pitches to maximize potential solar collection, 2. area calculations to determine layouts and room divisions, 3. street/terrace re-configurations, 4. drainage corridors, 5. views, 6. density, 7. ground topography, 8. building footprints and ground contact (or raised above ground). By exploring the iterations of these simple performance-oriented criteria we were able to generate subtle and familiar, yet radically different urban forms.

The simple parameter of changing the houses’ vertical positioning in relationship to the ground (bottom of figure 4) created a vast array of new morphological variations which challenged the traditional terrace house type. This change in typological form had a simple but profound impact on the houses’ potential performance in relation to future floods while producing organizational and typological configurations with profound social and spatial consequences. Outside the realm of pure computation, we were set to discuss the qualitative effects and sociological affects created by the result of the formative processes. These processes led to internal spatial differentiations within a housing row that basically evolved in response to both the global and local environmental conditions negotiated against functional tolerances and resulting volumetric quality. Figure 5 demonstrates one of the smaller sets of terraces, generated as a series of urban infill patches. Unlike its surrounding context, the proposed terraces are raised and cantilevered from earth mounds designed to lift house and its possessions above potential flood levels. Raising the house by approximately one-quarter to one-half of a level establishes a switchback stair which continues as the primary organizer of the design. The front and back of the house each raise in split-level increments as the house continues up. The cantilever was efficiently achieved via a triangulated truss along which triangulated panels with a variable porosity are placed. Great consideration was given to the consequential
affects of raising the house - both in terms of presence at street level and the location of the main entry. The new morphology opens up valuable land at the front of the house, raises the house from potential street-level crime, and creates a new quality of street interface for the otherwise bounding terrace house.

Cross River Park
The London Riverside is a new development area in East London and part of the larger Thames Gateway redevelopment zone. It is one of two zones whose responsibility for delivery is with London Thames Gateway Development Corporation; the other is the Lower Lea Valley redevelopment. The area of the London Riverside development stretches from Beckton in the London Borough of Newham in the west to Wennington in the London Borough of Havering in the east. The development spans the River Thames adjacent sections of these boroughs and the London Borough of Barking and Dagenham. Much of the development will re-use brownfield industrial land on the river. The area totals 35 km2. It is expected that by 2016 the London Riverside will provide 21,600 new homes and 25,000 jobs.

The Cross River Park area is in the high flood risk zone (figure 6, left) as much of it lies on the former Thames floodplain; however, 5,700 new homes have been planned by 2016. There are large industrial sites, including Beckton sewage works, the largest sewage works in Europe, a former gas works, retail parks, brown field land and housing are also there. Running alongside the Cross River area, the Roding has a rapid response to rainfall, which is typical of densely urbanized catchment overlying London clay. Flood events have been recorded in the Roding catchment since 1926, with the most recent event being in 2000 where over 200 properties were flooded. The majority of existing defenses are located in the...
heavily urbanized area of northeast London. Earth flood banks at Woodford, Roding Lane, Wanstead and Illford provide protection against floods of between a 5% and 1% probability of occurrence. However, there remain over 2000 properties at risk of flooding in a 1% annual probability flood event.

Whilst the Thames Tidal Defenses (TTD) reduce the risk of flooding considerably, they do not eliminate flood risk altogether. Risk is not finite and risk behind any defense must be considered no matter how remote. More extreme events or conditions may occur when those defenses are breached or overtopped. The term “Residual Risk’ is used for East London because a considerable proportion of the risk is be effectively managed by the TTD. Although the flight is at risk of flood the potential damage is considered as solely material. This is because in the event of a breach, flood depth and flow velocities would be comparatively low which would reduce the likelihood of the area being within the rapid inundation zone and water would only be “flowing through” this area at speeds that would not be life threatening. In light of this, development remains a possibility, if the potential of living within these more extreme environmental conditions engages a serious design exploration on how one can build quality environments that perform in both flooded conditions and dry conditions. Operating at the binary cusps of both extremes is as important as achieving proper performance within the flooded state. Achieving a dry performance in the potential of a flooded state while neglecting the social and political ramifications of a new ground engagement would render the project as much of a failure as if the project operated within social and organizational norms yet failed to protect against monetary and material loss due to flooding.

Computationally driven, the project sought an aggregative system of individual flats which were raised from the ground via small concrete plinths that, within the dry state, also serve as the main entry to each flat. Together the units create a roofscape (figure 7, top) that, in the event of a flood, operate as a new groundplane. This new groundplane allows residents to move across the matrix of terraces to the far west side where they would have access to dry ground. The raised undercroft (figure 7, bottom) is allowed to flood with no material or property damage occurring. In order to maintain access to individual green space and provide a quality park-like setting, the density and porosity of the flats were parametrically adjusted until adequate sunlight could properly light the undercroft and allow the soft landscaped areas to thrive.
Figure 7
Student project for Cross River Park development, flood plan for the Thames River and enlarged plan of Cross River Park area and River Roding Catchment, Marcos Zotes-López.

Figure 8
Student project for Cross River Park development, flood plan for the Thames River and enlarged plan of Cross River Park area and River Roding Catchment, Marcos Zotes-López.
Information-Based Design Scenarios

Within these design explorations the use of generative computation and parametric modeling, coupled with issues of climate and performance-oriented design, increasingly led to more situational considerations. Parametric definitions were used, not a means in themselves, but as a means towards an end. We were directed foremost by the discourse of architectural itself and secondly by the specific environmental performance, and the consequential social and political affects. It is only through these real-life informational inputs and the active consideration of resulting design qualities that computational process can offer absolute value and sustained value. Turning inward to computation alone offers repetitious explorations of spatial fields, variable modulations, and self-perpetuating complexities that have perhaps reached an endpoint of exploration. By merging the intrinsic logic of computational processes with the extrinsic parameters derived from real and dynamically changing events, we will continue to have a vast source of inspirational design generation which can meaningfully impact given situations and lived experiences.

References

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