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EX SILICO

AD VIVO

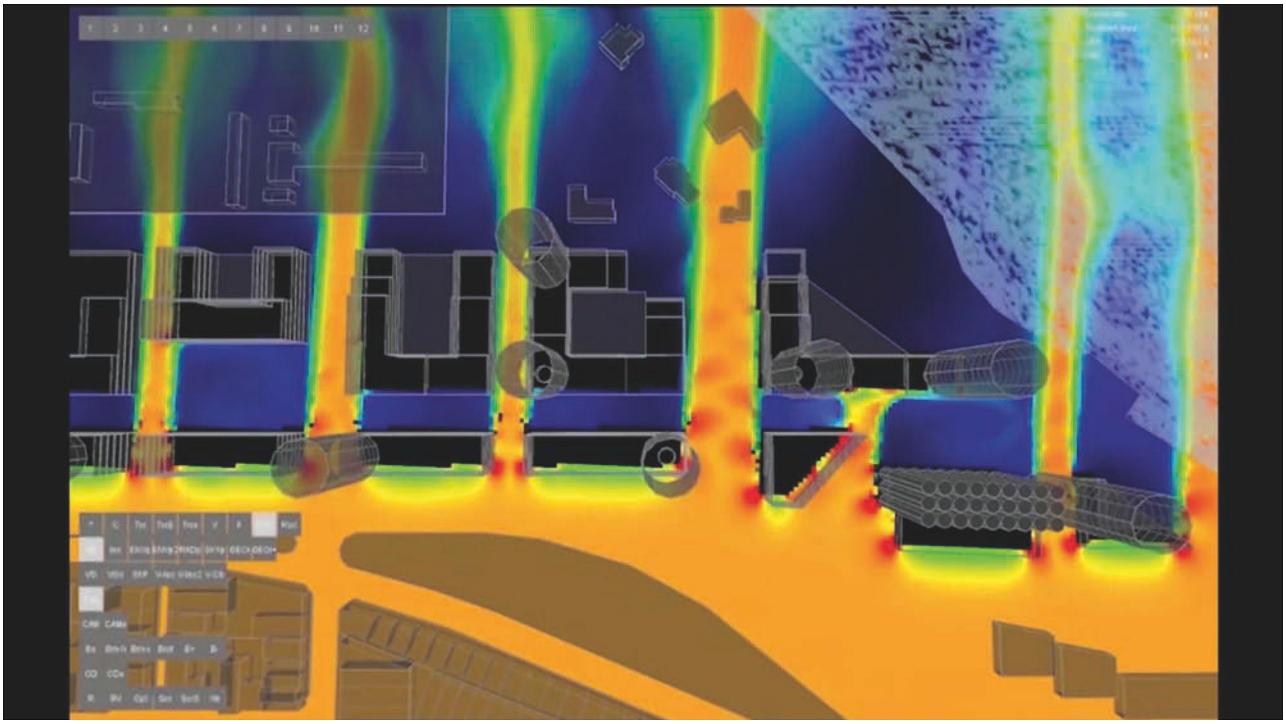
What makes a successful city? Can this be replicated simply by following tried-and-tested urban typologies? **Francis Aish, Adam Davis and Martha Tsigkari** of Foster + Partners' Applied Research + Development (ARD) group argue that technology allows other approaches to urban design. They explain that computational simulation is increasingly valuable in predicting how the dynamic and complex systems of a city might play out in an urban context, forging an exciting new alliance between computation and intuition.

Just as cities are alive, so are the design processes that create them. Urban design is a dynamic and complex activity that harnesses the expertise of a range of disciplines. Foster + Partners' approach is based on research and analysis, underpinned by a philosophy that responds to the needs and aspirations of people.

Within the practice, a dedicated team of urban designers works with the design groups, supported by the practice's extensive research capabilities. This article focuses on the role of the Applied Research + Development (ARD) team, in particular the tools it has developed to allow designers to introduce accessible, real-time analysis to this constantly evolving process.

Many early approaches to urban design were predicated on the idea that imitating a successful space in an existing city would end up making a good place in a new one.[1] However, every place is unique and demands a special response. While we might try to replicate the vibrancy and spontaneity of an established neighbourhood, this must develop within the context of modern construction, finance and planning. This leads design teams to experiment with competing configurations, in a systematic analysis of different options that can be by turns exhilarating and exhausting. The ARD team has explored the potential for innovation in this process, through the application of computational simulation to visualise how scenarios will play out in the urban realm.

Foster + Partners, Masdar City, Abu Dhabi, 2007–
The masterplan for Masdar City explores sustainable technologies and the planning principles of traditional Arab settlements to create a desert community that aims to be carbon neutral and zero waste. The 640-hectare (1,581-acre) project is a key component of the Masdar Initiative established by the government of Abu Dhabi to advance the development and commercialisation of renewable energy and clean-technology solutions.



The computer will not replace human experience of the idiosyncrasies that make urban living inspiring. But computational design does provide us with an increasingly sophisticated foil for testing ever-more elaborate hypotheses about what makes cities work.

Foster + Partners, Real-time CFD simulation, 2010–
top: Real-time computational fluid dynamics (CFD) simulation of the prevailing wind behaviour on an urban site. This real-time feedback enables designers to interactively optimise building configuration, to enhance natural ventilation and increase pedestrian comfort.

Foster + Partners, Real-time pedestrian simulation, 2011–
bottom: Real-time pedestrian simulation using an agent approach. Software agents emulate the movement of people on site in terms of wayfinding, and respond in real time to changes in site configuration.

In this way, the energy of the design process can be carried into the real city. Physical considerations, such as daylight, wind and insolation, can be studied at multiple scales and can take into account the complex interactions of existing conditions, as well as changes within a design proposal. New ways of reflecting the experience of a place are also emerging: we are at the beginning of an era in which we can train our design and analysis tools to recognise the most comfortable spots in a neighbourhood, where the combination of shade, sunlight and breeze are just right. We can teach our computers how to recognise an attractive view, or to predict which route pedestrians will prefer as they travel between destinations.

Experience is still the best guide for creating successful cities, especially the understanding gained through the design of previous masterplans such as Masdar City. The computer will not replace human experience of the idiosyncrasies that make urban living inspiring. But computational design does provide us with an increasingly sophisticated foil for testing ever-more elaborate hypotheses about what makes cities work.

Evolution in Silico

Many complex systems demonstrate a paradox where intricate behaviour arises from a set of seemingly simple parts and rules. Every urban environment is composed of a set of interrelated parts, many of which may be uncomplicated when dealt with in isolation, but whose interaction exhibits an array of interesting and emergent trends. Disorganised or organised complexity is prompted by the relationships between these parts, which lay a foundation of multilayered – and often unpredictable – behaviour.

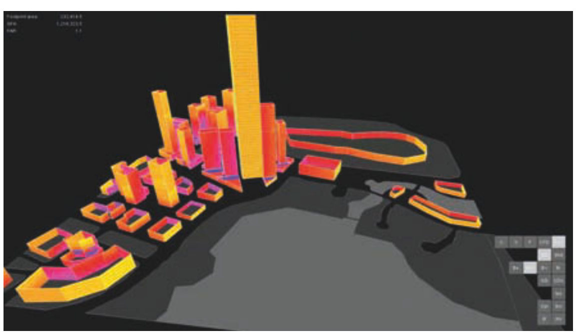
In such complex systems, minimal changes in inputs can have a disproportionate impact on their potential development. In urban environments, the development of a place is impacted by numerous factors whose patterns of interaction are hard to predict, making the potential outcome uncertain at best. The key challenge for designers is to determine how simple changes of the key aspects will propagate throughout the system, and the final effect these changes may have.

These challenges can be addressed by computational platforms that allow for the evolution of systems via simulation processes. Through this *evolution in silico* one can observe the effects that certain changes of initial variables may have, how these propagate through the system, and what the potential responses may be.

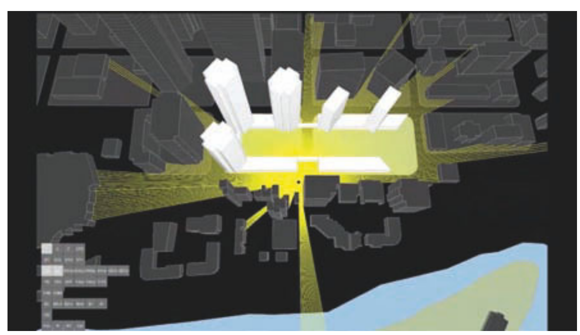
Population Thinking

Manuel DeLanda champions the notion of 'population thinking', considering design options as a family, sharing genes of expressed parameterised variation.[2] Those designs which will fare best are more likely to survive an evolutionary design process, and those which do not excel are likely to recede in their influence. Foster + Partners considers population not just in terms of designed populations (buildings, open space designs, regional connections), but also in regard to the numerous inhabitants who will test a design. In this context, the fitness of a design is not at all a simple (linear) function, but instead is a response to a complex, agent-based notion of urban inhabitance.[3]

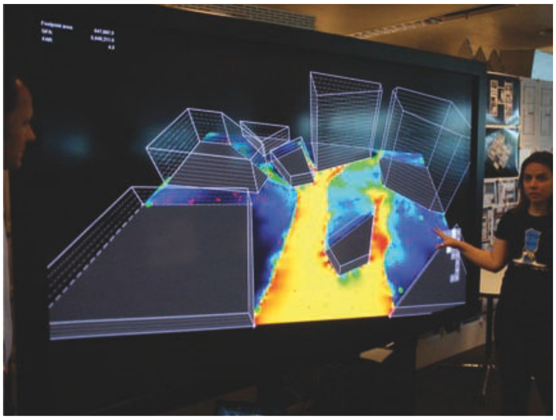
Agent-based simulation of pedestrian or crowd movement is one such application of this approach. Here, the aggregate behaviours of populations of individuals can be studied following simple rules. Effectively, at every step in a grid of urban open space, an individual moves in the direction that affords them the broadest uninterrupted field of view. Combining this with simple avoidance rules, an evaluation of urban occupation can be obtained which, while crude, still mirrors accepted measures of spatial connectivity. This analysis is sufficiently computationally streamlined that these populations can adapt to design changes – for instance, the change in a building outline – in real time. This allows for the possibility of deploying these agent populations in a genetic simulation of building design ('co-evolution') or of allowing the designer to engage with analysis in an intuitive fashion ('user-defined fitness').

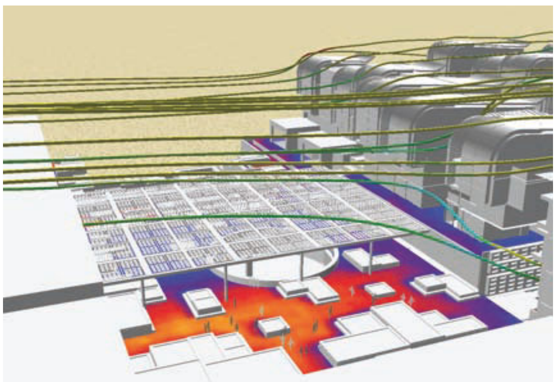


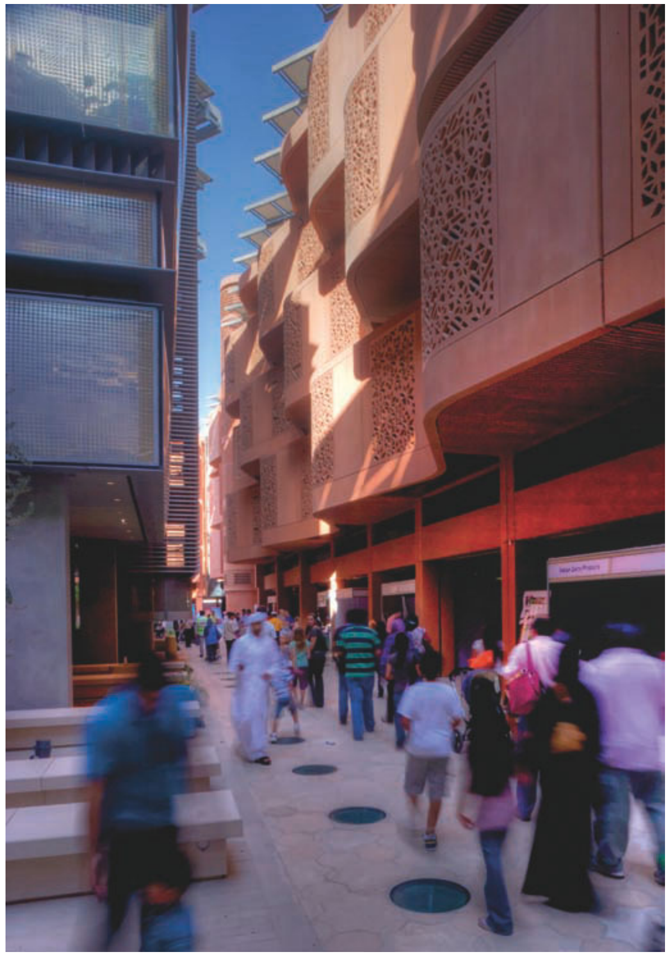
Foster + Partners, Solar simulation, 2010–
Solar analysis tools provide fast feedback on overshadowing, solar gain and daylight.



Foster + Partners, Real-time isovist simulation, 2011–
Isovists represent the visible boundary for a pedestrian walking through an urban environment. They provide a feel for the perceived field and depth of view, which can shape the experience of a space and wayfinding within it.







Solely technical approaches to urban design risk delivering sterile urban spaces, in the same way that solely intuitive approaches risk delivering impractical ones.

Foster + Partners, Masdar Institute, Abu Dhabi, 2007–
right: The Masdar Institute is the first phase of Masdar City to be completed, and is a research-driven university with a focus on advanced energy and sustainable technologies.

above bottom: Early real-time immersive walkthrough of the Masdar City project. The additional visualisation of airflow and solar gain allowed designers to better understand the interaction between spatial experience and environmental performance.

Foster + Partners, Interactive masterplanning system, 2010–
top: Interactive masterplanning system. This touch-enabled real-time modelling and simulation system enables architects, urban designers and engineers to engage in a collaborative integrated design process.

Quality Over Quantity

By allowing designers to actively and intuitively engage with analysis, this approach has the potential to bring about a change in the way that analysis data is understood and applied within the design process. Like its counterpart in structural engineering, environmental design and engineering often relies on rules of thumb in the early stages of design. This is rightfully so, as designers with a sensitivity for comfortable, enjoyable places can often anticipate the feeling of a prospective design. It is possible, however, to engage our computational tools to identify some of the same patterns that seasoned designers would recognise, and to do so at a microclimatic scale that would be tedious and exhausting for a designer to do thoroughly.

Continuing the example above, we began to ask how agents might occupy space in a more complex context, taking into account environmental comfort in addition to the intervisibility measures mentioned previously. As a custom-built, bespoke platform is being used for modelling and analysis, it was straightforward to incorporate modules that we had already written to determine sunlight hours, insolation and wind speed at the street level. This brings yet another level of immediacy to the evaluation of designs such that we can begin to assess how people would move – and where they might congregate – based on the complex patterns of others moving around them, as well as the qualities of light, heat and breeze in their environment.

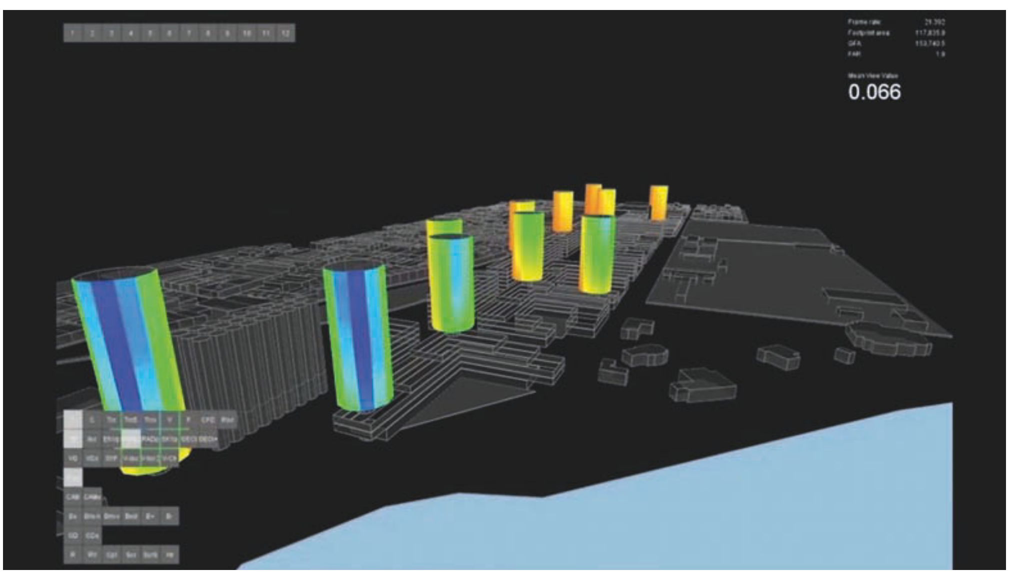
The analyses discussed thus far attempt to apply quantitative thresholds to notions of how people will behave in the aggregate. For instance, most people in selecting a rest spot while walking across town will avoid overcrowded spaces, and will try to find an optimal microclimate using cues of shadow, awareness of breeze, and other related factors. Such common behaviour can, to an extent, be understood as qualitative, and we are therefore also conducting research into simulations of the urban environment that might be considered more qualitative than quantitative; for example, engaging with the issue of 'quality of view' as an attempt to understand some of the factors in how people conceptualise the aesthetic and informational qualities of urban environments. Using the tools of artificial intelligence, we can intuit how designers or developers might appreciate views – of a prominent landmark, for instance – and then apply this understanding on a scale that would be daunting to undertake without computer automation.

The Creation of Places

Solely technical approaches to urban design risk delivering sterile urban spaces, in the same way that solely intuitive approaches risk delivering impractical ones. Innovative tools and interfaces allow a systematic approach to the place design problem, by incorporating both computation and intuition. Custom applications with radically diminished running times allow designers to investigate a plethora of competing options, and judge – in real time – how these configurations are performing relative to environmental, socioeconomical and aesthetic criteria. Furthermore, the qualitative nature of the outputs enhances the way designers perceive 'cause and effect' in alterations of building topology and morphology, as the impact of each change is directly visible. These tools and processes allow us to take a holistic, integrated approach, where architects, urban designers and engineers can combine the best of human intuition and cultural experience with computational rigour to create true places rather than just spaces. AD

Notes

1. See Peter Katz, Vincent Joseph Scully and Todd W Bressi, *The New Urbanism: Toward an Architecture of Community*, McGraw-Hill (New York), 1994, and Christopher Alexander, *A Pattern Language: Towns, Buildings, Construction*, Oxford University Press (New York), 1977.
2. Manuel DeLanda, 'DeLeuze and the Use of the Genetic Algorithm in Architecture', in Neil Leach (ed), *Designing for a Digital World*, John Wiley & Sons (Chichester), 2002.
3. Neil Leach, 'The Limits of Urban Simulation: An Interview with Manuel DeLanda', AD *Digital Cities*, July/August (no 4), 2009, pp 50–5.



Foster + Partners, View Analysis, 2005–
View analysis, providing quantitative and qualitative measures of views from the building facades.