PROTO-DESIGN

ARCHITECTURE’S PRIMORDIAL SOUP AND THE QUEST FOR UNITS OF SYNTHETIC LIFE

Neri Oxman, Tropisms, Massachusetts Institute of Technology (MIT), 2006

Design for an inflatable furniture piece based on parallel rewriting logic. The underlying geometry and cell size and distribution are determined by an L-system and the anticipated load triggering inflation.
The local manipulations of each uniquely defined cell. Consistent tissue corresponding to local conditions through parts and wholes: an exploration into the relationship between cellular units and their assembly within a site.

An object-oriented finite element application is used to analyse and reconstructed into 3-D macro-scale prototypes by computing hypothetical physical responses. A pixel-based finite element application is used to determine material behaviour according to assigned properties and performance such as stress, strain, heat, flow, stored energy and deformation due to applied loads and temperature differences.

Questions regarding the units of digital design have been at the centre of the discipline since its inception. From masonry bricks to multi-dimensional voxels, architectural design is possessed with the search for synthesis. Motivated by new scientific discoveries, such enquiries are now advancing new ways of thinking and making architecture. Such is the case of protocells, hypothesised to have been pre-genomic blueprints for the units of life made of inanimate matter. Following the discovery of protocols, their contribution to spontaneous generation and to the emergence of life on earth, designers are now seeking the synthetic design counterpart to basic science.1 Pertaining to a gene’s-eye view of the built environment, wherein a material unit might incorporate data that is inclusive of its assembly, behaviour, decay and regeneration, what might the proto-brick of the future look like?

Parallel to, and inspired by the contemporary discourse in synthetic biology, a bottom-up approach to design is indeed one of the key characteristics of design inspired by performance. In this approach, a units-based strategy is commonly devised and encrypted in order to correlate between form’s material properties and its environmental milieu.

Material-Based Design Computation was developed at the Massachusetts Institute of Technology (MIT) as the theory and method by which to relate units of matter to units of performance in the generation of form. According to this approach, material properties are considered intermediary agents mediating environmental impetus with material response, such that inanimate matter might contain the information for its behaviour and evolution, not unlike protocols. This method assumes complete synergy between geometry, physical matter and energy.

Such synergy can only be achieved if and when the various processes of design will have been integrated to allow modelling, analysis and fabrication to occur simultaneously in parallel fashion not unlike the behaviour of living organisms. The systems assume that each and every cell comprising the whole is in constant flux as it remodels and evolves under environmental pressures: call it proto-design.

The explorations below, part of the Material-Based Design Computation project, illustrate three approaches for the definition of a proto-design unit from the modelling, analysis and fabrication perspectives respectively. However, it is only when these are combined into a single process that we may begin to speculate on the generation of a synthetic protocol.

Geometric Protocells: Tropisms

Devoid of sensor-actuator technologies, geometrically defined units comprise – within the scope of illustrated experiments – the simplest method for achieving bottom-up design. These units are parametrically defined as they contain curvature data, but do not typically designate and predict physical properties and material behaviour. In the case of Tropisms (MIT, 2006), a load-sensitive pneumatic furniture system, each geometrical component is designed to optimally inflate and deflate upon sitting and standing respectively.

The assembly logic of all cells determines the overall form its assembly would take as behaviour control and accommodation are geometrically defined and exercised.

Analysis Protocols: Fatemaps

Mesh discretisation processes allow the designer to subdivide a continuous mathematical domain into a set of discrete sub-domains referred to as elements and represented as singular geometrical entities. Lattices and triangulations are common rationalisation discretisation techniques, where the quadrant and triangulated elements may respectively wrap the surface area or volume of the object. These structural meshes are used by engineers to simulate structural loads, analyse their distribution and predict any potential displacements that may arise. More recently, engineers have been utilising mesh-free algorithms to rationalise 3-D form in the process of translating it from the digital domain to its material manifestation via appropriate fabrication routines. Such mesh-free methods eliminate some, or all of the traditional mesh-based view of the computational domain and rely on a particle view of a field problem.

When inverted, these analytical tools may be put into synthetic purposes of form generation. Mesh-free methods can then be viewed as continuous fields of particles that may potentially carry material data as they ‘grow’ a structure. This is the case with Fatemaps (Museum of Science, Boston, 2009, a study exploring natural tissue reconstruction using artificial materials). Perfect alignment between form and material behaviour may be considered by calibrating the size, shape and proximity of the element to the size and shape of the material unit from which the form is to be fabricated.
Imagine the case in which the size of a mesh-free particle, applied for the purpose of form generation informed by light performance, precisely matches the size of an imaginable powder molecule, or — more realistically speaking — a material aggregate providing for the substance of the 3-D printing process.