
MAKING A DIFFERENCE

Keywords: Design, Difference, Iterative, Time-based, Responsive

Abstract:
In direct contrast to the iconic 20th Century image of the mass-production facility locked into the making of the same, the implicit potential of the 21st Century CNC manufacturing environment is the making of difference.
With the route to manufacturing now directly within the grasp of the designer through the advent of computer-aided design and computer-aided manufacturing technologies (CAD/CAM) the opportunity exists to re-cast the design process in relation to the making of physical output and the potentials of infinite variety.
This paper will describe a methodology developed as part of an ongoing two year residency in which we explore how the digital loop might be closed, allowing a direct link from built artefacts back to the digital design model and permitting a continual iterative design cycle in an effort to become increasingly specific to local conditions – the design designing itself. This permits the possibility of responsive, time-based architectures that can exhibit difference in formal configuration and behaviour over time.

The Methodology.
An abstract generic model digitally encoding a collection of architectural attributes defines our 'genetic material' – an architectural 'seed'. This can be planted into a computer and replicated to provide a population of possible outcomes. Over time (measured in gigahertz and generations) individuals of that population are grown, driven by environmental data and their own imperative.
After a period of time suitable individuals are selected for synthesis. The means of synthesis is computer-numerically controlled (CNC) machinery. The designer need not interfere as the specific individuals have grown from the generic with all the necessary descriptions to be manufactured.
The constructs are then sited and sensors placed, the data from which provide a record of actual performance in relation to environmental conditions. This data set drives further generations in a process of reiteration.
Two parallel worlds are being described here. They are connected to each other to form a circular system with both positive and negative feedback loops. One connection acts as a data *input* 'bridge' from the world of the analogue and into the world of the digital, and the other connection acts as a data *output* 'bridge' direct to CNC facilities and back into the world of the analogue. This cycle need not be broken, resulting in an architecture that is in continual transformation –the design designing itself.
The use of computer-aided manufacturing is generally predicated upon the definition of a digital design model. In the majority of cases the digital representation is defined through the use of proprietary CAD packages that encode processes of geometry creation and geometry removal through the application of 'tools' by an 'operator' on the model to encode specific design intent.
The methodology outlined above offers an alternative approach to the generation and iteration of design model data. Explorations into this territory cross boundaries of design, computer science, mathematics, engineering, and belong to an emerging paradigm – computer-generated design (CGD).

The Site.
Moving though the Kielder landscape (Northumberland), histories of use, redundancy, re-use, appropriation and exploitation reveal themselves through marks and conditions to a backdrop of fairly typical temperate climatic conditions for the northern UK. The landscape possesses witnesses to most processes you can inflict upon a ground condition: turned, planted, eaten, harvested, parcelled, cut, excavated, relocated, detonated, burned, flooded, laid upon. Some conditions are layered in the severest of ways, the edges where they meet becoming thresholds between polarised conditions: dry/wet, hard/soft, enclosure/exposure, proximity/distance.
It is a working landscape operating to a strict temporal model – the 50 year cycle. This measure defines a period of growth, harvesting and preparation for re-growth for parcels of forest, the resource used to predominantly feed the construction industry. The transient nature of boundaries and conditions across so many different time-scales is one of the most compelling attributes of this territory.

Generating Difference.
We are interested in developing an architecture that can exhibit a sensitive dependence on the environment in which it is sited and the conditions it creates through its siting. It will be able to modulate its form directly to temperature fluctuations, and over longer periods to changing spatial conditions as reflected in thermal trends by the addition or removal of components.
A temperature driven passive actuator is being used to actuate a configuration of six aluminium 'leaves' hinged to form a closed chain (Sarrus Chain). The module is repeated and tessellated according to configuration rules that take into account local site conditions generating a variety of spatial qualities from the densely layered to tendril-like extensions.
Every module exhibits difference through outer leaf shape. Optimisation of the initially randomly determined leaf shapes will occur over time as performance data is percolated back into the digital model from the sited artefact.
An artefact with this degree of articulation requires surveying and re-surveying over time, measuring differences of articulation within the envelope of mechanical reachability against micro-climatic changes in temperature. Temperature will be logged using iButton 1-wire network thermocron devices with sufficient storage capacity to log a three month period with hourly readings. Actuated differences in configuration will be measured using photogrammetry techniques, where 3 dimensional data can be

extrapolated from a minimum 3 photographic images taken simultaneously from different vantage points. This optical method of generating positional data provides our bridge from the analogue to the digital, closing the loop.

Over time, trends will start to appear in the data set – diurnal and nocturnal fluctuations, seasonal variations and yearly rhythms. We also anticipate occasional sudden shifts in those trends. For example, a construct located on a south-facing incline under mature canopy is likely to be subject to very little solar gain during the day and exposure at night. Once harvested (a process that is guaranteed for almost all sites at some point in the 50 year cycle) this new condition of exposure will alter the thermal characteristics of the site and subsequently the passive behaviour of the current construct.
As new conditions begin to reveal themselves through changes in the trends of the data set, we anticipate adaptive responses from our models. With this iterative adaptive cycle implicitly retaining an embedded history and supporting progressive development, the adaptations will be directly related to the existing structure allowing the addition, replacement or removal of components thus altering its formal characteristics and behavioural potentials.
The initial construct will be going to site at the beginning of the summer (May/June 2005). The iterative cycle will then begin with differences being made and installed every 3 to 4 months.

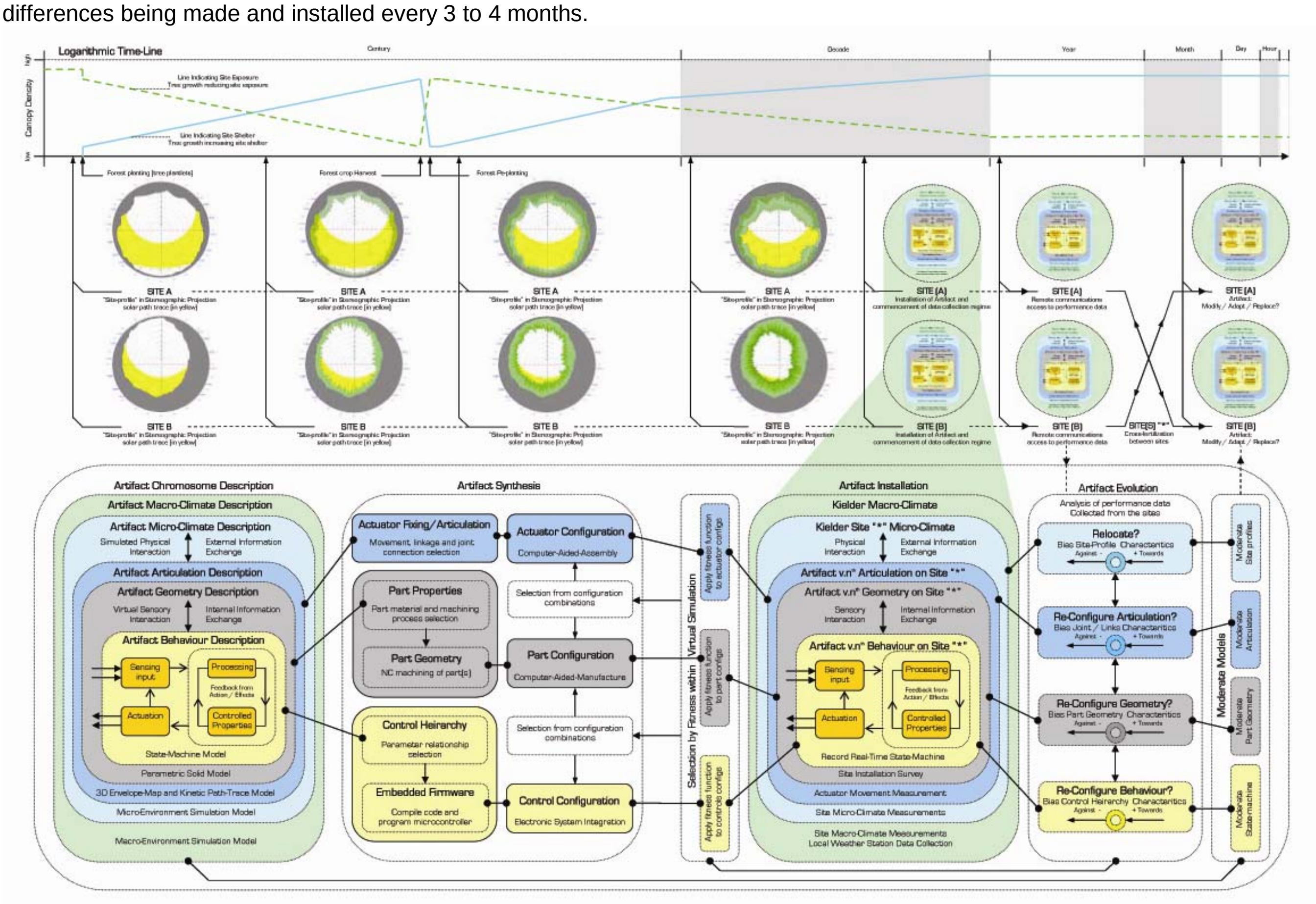

Figure 1. Kielder schematic relating logarithmic time-line to changing site conditions and iterative artefact cycle.
Diagram by Chris Leung, sixteen*(makers).

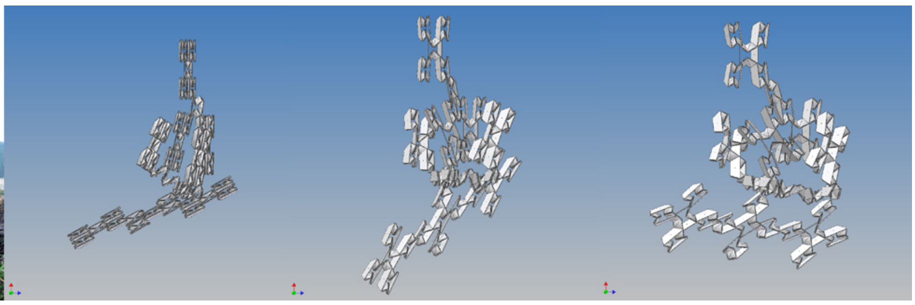

Figure 2. A plot being harvested generates and lays bare witnesses to various spatial and micro-climatic conditions: exposure, canopy, pockets.

Figures 3,4,5. Initial tessellation study exploring various connection possibilities of the base module to allow geometric transformation without interference. The first frame is the minima position with all actuators below 16 degrees Celsius. The subsequent two frames are indicative of a temperature increase by an increment of 3 degrees per frame.