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Generative methods and the design process: A design tool for conceptual settlement planning

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ABSTRACT

This paper implores the possible intervention of computers in the generative (concept) stage of settlement planning. The objective was to capture the complexity and character of naturally grown fishing settlements through simple rules and incorporate them in the process of design. A design tool was developed for this purpose. This design tool used a generative evolutionary design technique, which is based on multidisciplinary methods. Facets of designing addressed in this research are:

- allocation of each design element's space and geometry,
- defining the rules, constraints and relationships governing the elements of design,
- the purposeful search for better alternative solutions,
- quantitative evaluation of the solution based on spatial, comfort, complexity criterions to ensure the needed complexity, usability in the solutions.

Generative design methods such as geometric optimization, shape grammars and genetic algorithms have been combined for achieving the above purposes.

The allocation of space has been achieved by geometric optimization techniques, which allocate spaces by proliferation of a simple shape unit. This research conducts an analysis of various naturally grown fishing settlements and identifies the features that would be essential to recreate such an environment. Features such as the essential elements, their relationships, hierarchy, and order in the settlement pattern, which resulted due to the occupational and cultural demands of the fisher folk, are analysed. The random but ordered growth of the settlement is captured as rules and relations. These rules propel and guide the whole process of design generation.

These rules and certain constraints, restrictions control the random arrangement of the shape units. This research limits itself to conducting exhaustive search in the prescribed solution search space defined a priori by the rules and relationships. This search within a bounded space can be compared to the purposeful, constrained decision making process involved in designing.

The generated solutions use the evolutionary concept of genetic algorithms to deduce solutions within the predefined design solution search space. Simple evolutionary concepts such as reproduction, crossover and mutation aid this search process. These concepts transform by swapping/interchanging the genetic properties (the constituent data/material making up the solution) of two generated solutions to produce alternate solutions. Thus the genetic algorithm finds a series of new solutions. With such a tool in hand various possibilities of design solutions could be analysed and compared. A thorough search of possible solutions ensures a deeper probe essential for a good design.

The spatial quality, comfort quality of the solutions are compared and graded (fitness value) against the standard stipulations. These parameters look at the solution in the context of the whole and not as parts and most of these parameters could be improved only at the expense of another. The tool is able to produce multiple equally good solutions to the same problem, possibly with one candidate solution optimizing one parameter and another candidate optimizing a different one. The final choice of the suitable solution is made based on the user's preferences and objectives.

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The tool is tested for an existing fishing settlement. This was done to check for its credibility and to see if better alternatives evolved. The existing settlement is analysed based on the evaluation parameters used in the tool and compared with the generated solutions. The results of the tool has proved that simple rules when applied recursively within constraints would provide solutions that are unpredictable and also would resonate the qualities of the knowledge from which the rules were distilled from. The complex whole generated has often exhibited emergent properties and thus opens up new avenues of thinking.

1. Introduction

Design can be conceived of as a purposeful, constrained, decision making process, where decision-making implies a set of variables whose values have to be decided after a search process [1]. During this design process classified as routine design by Sargent [2], the designer operates within a defined schema and explores various possible solutions, which are predefined by the schema. Emergence being a property of creativity is an essential feature of the process of design. 'Emergence introduces ambiguity and history-dependence from successive transformations by creating new shapes (or old shapes in unexpected places) which are then available to be selected for further transformation [2].' But the emergence of new features is alone not enough – the emergent feature should evoke some new, useful meaning. Computation could enhance this multidimensional process and computational medium has the potential to address many such dimensions with greater accessibility. More than representing existing processes, computational medium could be used to rigorously explore the design solution space.

A settlement design involves multiple viewpoints, alternative solutions and complex associations within larger knowledge bases, which makes the problem of generating a design solution complex. Modelling complexity is a multidimensional problem and computational medium offers wide scope in handling such issues.

1.1. Modelling complexity – reductionist vs. generative approach

Real world problems are often multidimensional and complex. Researchers have been working for centuries to understand the complexity involved and to achieve a model representing the complex real. Some of the prime issues that any model has to address in order to be valid are the usefulness of the model, its comprehensiveness, its reusability and its simplicity. Initial attempts by the researchers deliberated complex systems by using a reductionist approach and more recently the synthetic or generative approach has been used. A reductionist approach is a kind of 'kit-of-parts' approach, which splits the complex whole into simpler parts and is undertaken mainly to develop the object manifestation or the end product [3]. On the other hand the generative does not pre-conceive the end product and could end up in different solutions for the same problem. It focuses on the relationships between elements and the dynamics involved.

Reductionist models reduce complex situations to simple ones, analyse the components and synthesize the original situation. In a reductionist view each element is individually designed to enhance its property and the aggregation of individual elements as a totality were supposed to be better solutions. Reductionist models uses parameters that could reproduce the present or past correctly and is expected to predict the future by fine tuning the relevant parameters.

The generative approach on the other hand can be used to model the complex changing world and its conflicting requirements by establishing relations between patterns, structures, processes, forms. It involves assumptions about the actions, behaviour and interaction of the individual agents which interact, dynamically, until macro-scale phenomena emerge – a piecing together rather than a dissection.

The explicitness of the assumptions is what that differentiates the traditional models from the generative models. All assumptions in the traditional models are testable and can be fine tuned by parameters but generative models have chains of relations that may be explicit and parameterized but some of them might not be parameterized and cannot be tested or validated in principle because data and observations are not available [4]. In the context of a post modern change in the focus of design perception to processuality (evolutionary change based on some value geared directive force) [5], generative models are still justified on the premise that the processes that underpin the model are too important to refrain from though it cannot be validated against data. For example a swarming behaviour of cells could never be tested with observable data.

A complex system generative model can never predict the present definitively and thus the focus changes on exploring a variety of presents – where the actual present and its variants are just different versions of some unknown future. The different outcomes of the model actually define a space of different model outcomes rather that depict different futures. This allows the model to be open and evolvable [6].

However, generative models are constructed in the full knowledge of these shortcomings. It is difficult to justify this view and its rationale usually depends on intuition and the intended use of the model [4]. Also, as of now most generative models are very context specific, and it is very unlikely for a tool developed for one context to be applied in another without modifications.

1.2. Generative evolutionary methodology

The process of design involves multiple viewpoints, alternative solutions and complex associations within larger knowledge bases, which makes the problem of generating a design solution more composite. A generative evolutionary methodology provides an answer to this problem [7]. It addresses the multi faceted design problem with tools that could specifically solve a particular facet of the problem such as handling data, analysing alternate solutions, involving multiple viewpoints, etc. By integrating multidisciplinary types of expertise (tools and theories) in an unconventional way, generative evolutionary methodology solves problems such as the process of design, which involves the complex interaction of multiple parameters simultaneously. It differs from other approaches in that the designer does not work directly with the materials and products but he/she works using a generative system. It uses few parameters to describe and represent the object and allows the computer to generate the object for the designer. The kind of processes that are achieved by the generative evolutionary methodology includes

- The process of producing output that hitherto was implicitly hidden in the input i.e., the user gets unanticipated results for the simple input that he/she had supplied.
- The process of using compact and small descriptions and rules to represent very complex structures.