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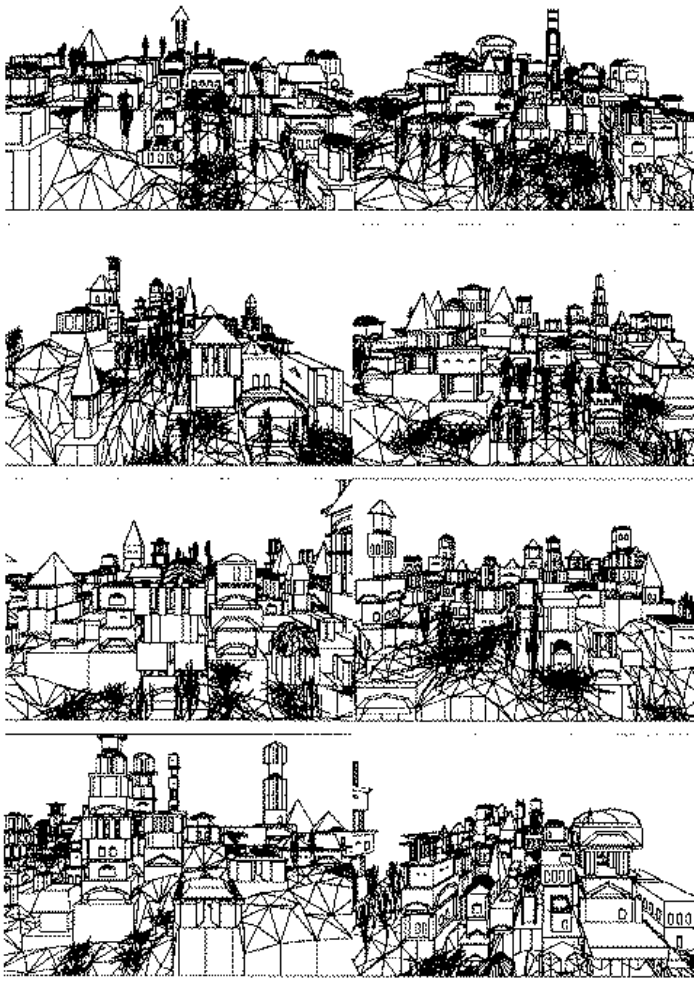
SIMULATION TOOLS FOR THE DYNAMIC EVOLUTION OF TOWN SHAPE PLANNING

(The Simulation of Dynamic Urban Development with Research Software That Generates 3d Town Models which are Always Different But Always Identifiable as The Same Environmental Town Shape)

OXFORD Polytechnic, 1991



1988. Sequences of ever different 3D models generated by the project of morphogenesis"BORGO" realised as an original software by the Autor.

ABSTRACT

The experimental research I have recently been doing springs from a question. It is possible, with custom designed software, to simulate the dynamic morphological variation of the urban image? And to simulate the development through time of formal town evolution, time that is taken by irreversible architectural events and that renders the urban landscape increasingly complex?

Yes, if we try to work directly with the instability of dynamic town systems, and decline to base our analysis on the equilibrated moments that represent only (when they occur) an accidental configuration in town time development.

This is a morphological approach that identifies the "modus operandi" of formal transformations during the time, and using algorithms, writes the rules of the dynamic and chaotic system that draws the town image development.

This scenario of possible town development is made up of an infinite number of unexpected and dissimilar images.

Each image springs from an iterative process of formalisation which, ad each stage, increases the complexity and randomness of the result.

The paper I propose, accompanied by images of scenarios of possible town environments generated by my software (examples include medieval, technological and contemporary metropolitan environments), explains and demonstrate this research and its possible application in urban planning.

I have published this research in my book:

Celestino Soddu, "Citta' Aleatorie", Masson Editor, Milano 1989.

INTRODUCTION

The possibility of computer simulation of the dynamics of system evolution achieved recently in many scientific fields has given a new stimulus to research. Computer simulation applied to town planning modifies the traditional approach to this discipline: experience and causal explanation. The problem of interchangeability of reality with a formalised system, of passage from determinism to formal logic is still open.

This paper is on the experimental utilisation of formal logic for the simulation of urban shape development.

The software I present was developed, starting with the disequilibrium state of the system (the presence of different architectural forms together with different stages of urban growth, often contradictory), to simulate time and produce a series of computerised three-dimensional models of urban shapes, identifiable as a whole as "species" and differentiated as "individuals". These models represent the multiplicity of possible scenarios of a town after a simulated evolution.

THE SIMULATION OF A TOWN SYSTEM

The development of adequate control and representation tools is necessary for a systematic approach to the contemporary ever changing urban shape in order to evaluate the morphogenetic dynamics, the structure of the history of towns, that is stressed by the architectural events, that are not reversible and modifies the development of urban growth.

The displays currently used have an incontestable limit that is the difficulty of examining one of the most important aspects of urban shape: time. A display that is approximate with respect to time dynamism, that is limited in tracing and controlling urban shape referring only to the stationary moment of hypothetical equilibrium, denies the essence of the town. It is an abstraction where urban-time is absent, frozen into a reductive representation of successive moments of equilibrium.

Towns are, in fact, accumulations of events with different and often contradictory objectives; their structures are unstable, their evolution unpredictable.

Instruments, capable of examining and testing the dynamics of transformation render possible a positive approach towards the comprehension of urban structures. the target is to operate into the morphogenetic dynamics and not only into the occasional modifications. If the purpose of graphic representation is to investigate urban patterns and their progressive disintegration and/or requalification, the instrument used should trace back and analyse the formation process of urban shape through simulation of the entire cycle.

Every architectural event does, in fact, modify urban shape as every urban shape modifies successive architectural events.

If we try to investigate on the cycle architecture/town evaluating the causes and events that have determined every formal order, we will be in the impossibility to continue our work. Every formal architectural detail is the product of a variety of causes belonging to different spheres: cultural, technological, economical and functional including subjective and casual aspects. Even if we leave out the casualness of some choices, we will not be able to attain, with sufficient approximation, a scenario susceptible of verification. This is due to the fact, that, to arrive at a cause and effect relationship, it is necessary to analyse every cause. It means, for a town system in its formal evolution, to analyse and evaluate every event, from urban and economical choices to an unknown master builder who, centuries ago, changed the original project, from political choices to carelessness that has caused the collapse of a building.

The awareness of the impossibility of evaluating all the causes that brought about the actual urban shape should bring us to operate within a specific field based on form and its transformation in order to obtain more exact and pertinent results. This implies the capacity of identifying a logical process to explain how and not why a form is evolving, how and not why an aggregation of forms gives a recognisable urban shape.

The results did within a specific field, using a multidisciplinary approach transferred in the same formal logic, are more pertinent, verifiable and available for utilisation in real situations. It is possible to have a direct approach to a town formal dynamism and to follow its transformation using adequate algorithms. It is not useful, for example, to analyse systematically all the causes that brought about a town expansion in order to give a model. It is less dispersing and reductive to define the transformations that have taken place using an algorithm. This algorithm will produce, on request, the successive contour lines of the town expansion based on preexisting formal elements like traffic arteries, soil morphology, relations with nearby towns and villages...etc.

This algorithm will be unveiled and identified inside the dynamics of successive transformations without considering external causes and will always produce different urban contour lines. Its correspondence to reality will be calibrated by means of subsequent verifications done on a sufficiently large number of results. The algorithm should be adopted only when all simulated transformations, in their evolution are congruent with a specific "species" of urban configuration. Every configuration, although produced randomly and unpredictably, should be identifiable as part of an entity that can be found in reality.

The same approach is used for the transformation of a square. An algorithm, capable of representing possible transformations between buildings and open space can be traced in order to generate different architectural solutions having the same size and form requisites and respecting the characteristics of the square.

This approach, which is exclusively morphological, allows reproducing the complexity of urban shape in its morphogenetic dynamism. However, can this be used in reality?

Can it become an operative tool for the control of growth and evolution of the cities we live in?

Like all mathematical and formal models, those that represent the logic of urban evolution are an effective tool to simulate interactions. Any variations in the model generate transformations that can be analysed and evaluated in relation to time.

Each result is identifiable and characteristic and always reflects the identity of a single town. Each result is like an "individual" and each series of results like a "species".

To represent the "species", instead of the "individual", offers many advantages. First of all, it allows us to evaluate to what degree a few and limited changes can interfere, after a simulated time, in urban shape through the infinite series of transformations produced. It can also help us to identify the phase in which our model produces transformations such as to bring about the loss of a town identity.

What are the characteristics of a formal transformation of a town system and how can it be represented and simulated?

RANDOMNESS AND EVOLUTION, INSTABILITY AND TIME

As clouds, towns evolve with time, expanding, contracting, transforming themselves, their image, their characteristics under economical, cultural, political and technological impulses. It is easy to predict, in short terms, the development of towns, as for any natural system. Everything happens according to precise rules deriving from urban planning, current technology, economic and social influences.

However, previsions are almost impossible in long terms since towns are inhabited by man and that each choice, each successive step brings about margins of subjectivity and unpredictability. This subjectivity produces one of the most important characteristics of urban shape: formal diversity of solutions responding to the same necessity.

It must be remembered that most subjective and casual aspects of decision making have little influence and will disappear in the subsequent transformations of a town.

However, some events or marginal aspects will persist and, because of concomitant casual circumstances, they will assume more and more a capacity of influencing the course of future development. This influence, once it has been consolidated becomes irreversible and can outgrow the importance of the event that caused it.

Some architectural forms, originating from the contingent, casual or subjective choices very often loose their raison d'etre and become pure formalisation of relations between following events; they often disappear surviving only as a trace, as a testimony of the passage of time leaving a strong characterisation of urban shape.

Piazza Navona, in Rome, is a good example of this continuity. The form, the dimension, the sequence of the various architectural structures of Piazza Navona have been determined by a building no longer existing and little is known about its past function. This building has had an irreversible influence since its form has conditioned the surrounding architecture and has contributed to the formation of one of the fascinating places of Rome.

Other Roman buildings, from the same period, conceived then to have a greater influence on urban development, as for example Trajan Forum, did not have the same fortune.

Of many fragments breaking off from a glacier, only a few, at random, become an avalanche and only a few avalanches can modify the environment and only a few forms in the environment have the capacity of fascination due to the casual contribution of rivers, winds, vegetation and why not architecture.

All this is not predictable since the succession of ever growing changeable events cannot be predicted and above all because the casual, subjective event that may become incisive on the whole system cannot be imagined and be clearly defined in advance.

The system is not predictable, however, it can be represented through numerous simulations done in order to produce a large variety of possible results.

My research introduces a mechanism/software for the simulation of time in a system-town whose instability is due to the complexity of objectives often contradictory. This mechanism should produce an endless series of urban events temporarily parallel and recognisable as different "individuals" from the same "species".

This implies, as it happens in current scientific research, to abandon the idea of the possibility of identifying and defining an order capable of assuring, with time, an urban characteristic, if this order takes form from a static evaluation, from the analysis of one moment of equilibrium leaving out the dynamics of the time. The evolution, and also the time, starts from the system unstableness.

Urban growth can, therefore, be more appropriately analysed if it is represented not as a temporal stratification of successive equilibria but as an unstable system that proceeds through irreversible changes even if it keeps a modus operandi that can be individualised and characterised. This instability, once it has been represented mathematically, is the characteristic of an unpredictable dynamic system.

Towns, in other words, can be considered as complex entities that can be individualised in their uniqueness and above all, as entities in evolution capable of modifying their form in an unpredictable way.

Evolution, the passage through irreversible events and morphogenesis are characteristic of urban form but also of living beings. Towns are not, in fact, notwithstanding their artificiality, very different, from that point of view, from nature and, according to the trend of current scientific debates, can be considered living entities. The scientific debate on what has to be considered a living entity is still open.

Every single cell of the human body can be considered a living entity, following its independence and evolution capacity but the entire earth can also be considered a living entity. Towns, in this sense, are also capable of self-regulation and evolution but also of controlling modifications and variations of a growth model maintaining their identity through history, and must be considered living entities that can be represented and analysed as such.

The dissipation process of evolving entities like towns (and like the universe, the earth, animal and vegetable species...etc) does not, however, produce disorder (the necessity to have entropy and disorder coincide no more prevails, see Ilya Prigogine in "The Birth of Time") but irreversible transformations that testifying the passage of time, produce new forms bringing about evolution.

A particular disequilibrium state is characterised by the presence of irreversible events and can also be analysed and represented only by a dynamic simulation of the system and of time generating modalities. Casual and contingent aspects will afterwards give the identity of each single town.

Some considerations on the manner of dealing morphologically with the transformations of the contemporary metropolitan image can be made.

One of the aspects that, today, is considered negative in urban development is the progressive loss of the image of formal characterisation. This aspect is surely linked to the increasing complexity that each city must face in order to respond to the contemporary challenge.

We must, first of all, choose to operate inside the individual sphere (each single town in its uniqueness) or inside a "species". It is obvious that some aspects of the deterioration of urban image are contingent and are due to the peculiarities of a local situation; however, these aspects are secondary with respect to the deterioration of urban image affecting indiscriminately towns with extremely different structures and traditions.

One can, therefore, ask if and how every town system, in its evolving structure, already include inside its formal logic the possibility of losing or acquiring an image, if a loss of image has to be considered reversible or not and if it is possible to control the parameters of this transformation.

REPRESENTATION OF URBAN DYNAMICS. VIRTUAL UNPREDICTABLE TOWNS.

I have developed an experimental tool which offers the possibility of computer simulation of the formal dynamics of town system identifying its particularities starting from the instability of the system and simulating the transformations of urban shape through time.

I have designed an original software to produce computerised three-dimensional models of possible urban patterns. These models, although they are produced with the same series of algorithms, are always different and unpredictable.

The models can be visualised using different techniques (perspective, curve perspective, total cylindrical perspective, axonometry,...etc). They give an unequivocal view of possible utilisation of unpredictable growth patterns.

The capacity for irreversible events to modify the structure of urban growth system is represented by the plurality of formal potentials, of scenarios that the system can produce.

The experimental software developed is, therefore, an instrument capable of generating dynamic sequences of urban shapes through time. It offers an almost infinite variety of possible shapes, thus realising a pertinent representation. The objective is, in fact, to illustrate the dynamics of development of urban shapes, not to concentrate on one single ephemeral moment of equilibrium.

Urban scenarios B1, B2 and Bn at a time T+t are obtained from scenario A at a time T through simulation. let us analyse this process first, in its entire structure and then, step by step.

Scenarios A and B do not represent moments of equilibrium of the system but moments of disequilibrium as they include the presupposed conditions of dynamic evolution.

Time, in fact, (Prigogine op.cit.) can originate only in a dynamic system in a disequilibrium state.

What does this assumption mean for the urban system we want to represent? The algorithms I have used for the initial urban scenario are not only different and autonomous but can also be contradictory. And not only each single algorithm but also the series of algorithms, that are not reciprocally integrable. For example, the series representing the logic of urban growth can be contradictory with the series for architectural formalisation.

The simultaneous or cyclical utilisation of these series (whose simultaneity goes towards disequilibrium) gives rise to the virtual beginning of time.

Each new architectural form modifies the urban shape, each new urban development influences the style to come, contributing irreversibly to a town history.

Although the process occurs within the same logic, each simulation starting from scenario A produces different scenarios B. The fact that each scenario B derives from A renders all scenarios B recognisable as "species" and the urban image produced is always recognisable as belonging to a particular town.

Let's see, in more details, how morphogenic simulation is carried on with the passage of time in the history of a town. To simulate the passage of time, it is necessary to define an initial situation of disequilibrium to begin a series of transformations. The initial situation of disequilibrium is determined through a series of disconnected algorithms representing different development sequences, often contradictory but that must operate simultaneously. The increasing complexity in the tracing of urban shape simulates the series of irreversible events in the history of a town.

Let's follow this cycle starting from any point, for example, a new architectural form:

1. The urban context generated until this moment, A, is confronted with a series of algorithms in progress (SCENARIOS/n) operating to represent the possible/desiderated delineation of an every new urban shape.(the evaluation of quality in made the difference between actual context and desiderated context, that is ever in progress: SCENARIOS/1, 2, 3, 4, n).

2. The result is a series of growth requests corresponding to the expectations of SCENARIOS/n with respect to A.

3. These growth requests are directed to a series of algorithms representing one of the logical pathways adopted for the formalisation of the architectural object (SAn). SAn makes an evaluation of functional interstices and margins of feasibility inside the framework. These margins are defined as design opportunities to increase shape complexity that goes beyond the programme requests.

The formalisation is made by the software not using a database of elements because this kind of answers are predictable and so, not suitable for a dynamic process.

The process occurs activating simultaneously many different devices (formal, geometrical, dimensional, integrators of complexity, etc.) that are autonomous, not necessarily congruent between themselves.

4. The result of this operation is an architectural event more o=/9 or less exceptional depending on the randomness of the generating instruments. This event is then confronted with SCENARIOS/n that evaluates its acceptability. If the event is normal, it is accepted and if it is exceptional it can be accepted or not according to the availability registered in SCENARIOS/n. If it is not accepted, we go back to point 3.

5. The event is inserted in the context. A becomes A+1. The event becomes irreversible. In fact, even if it is eliminated afterwards, it has existed and has conditioned the urban shape evolution.

6. SCENARIOS/n must be adjusted after this irreversible modification. SCENARIOS/n becomes SCENARIOS/n+1. It can be a matter of simple adjustment if the architectural event is to be considered normal, however, in the case of an exceptional event it can be necessary to modify substantially some proposals of SCENARIOS/n: This requires the passage from a form to another one and can be represented using the theory of catastrophes (Rene' Thom) related to discontinuous changing processes. This variation can be described as the passage from an attractor to another one recognising the attractor as a model capable of representing the formal characteristics of an event in a dynamic sequence.

7. The context A+1 is then used starting again from point 1 and continuing until the time (t) has been entirely simulated and the initial shape transformed into A+1.

I used this approach to simulate the urban development of some towns, identifying and reconstructing the elements of disequilibrium in their evolution.

The aim of my research was not the reconstruction of an unstable dynamic system to simulate the evolution of an existing town, although this is of its possible utilisation, but the individualisation of the structures of a town transformation and representation of the characteristics of dynamic transformation of urban events through a simulated time that initiates with the simultaneous presence of various development pathways. The disequilibrium found in the initial phase is due to the simultaneous presence of different and very often contradictory dynamic particularities. The logic of urban growth, of composition and control of exceptions pertinent to the dynamics to simulate, is set in motion. The following representations are, after the first moment of hypothetical sequences, absolutely unpredictable.

The dynamics of development of a system in disequilibrium goes through a series of events capable of increasing the margins of randomness present in a choice and often of modifying the characteristics of the system. The system proceeds through successive bifurcations and its potentiality (due to different alternatives) goes beyond the reasons that have determined the choice. Once the choice is made, the series of events becomes irreversible and can even condition and modify the entire system.

The programme output is a series, almost infinite, of urban shapes that refers to the image of a town after a certain period of time. Each shape shows a possibility of urban development. The operative utilisation of this software originates from a kind of approach not reductive to the complexity of a town system. The software can be used directly in town planning especially to control the quality of the environment.

You can download, for free, the original book in Italian at http://www.artscience-ebookshop.com

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