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Research

Topology Catastrophe: Catastrophe Narrativization of Urban Morphologies

Abstract. This paper applies Rene Thom's catastrophe theory morphologies to the historical narrativization of urban environments. The confluence of narrative and topology could yield a qualitative yet stable spatial representation of the dynamic development of the human environment. Catastrophe Theory seeks such a qualitative and stable representation of discontinuous or chaotic behavior. Here the descriptions of catastrophe theory are applied to urban forms as a series of "narrative spatial operators" that affectively change the narrative space of urban histories or narratives of urban formation. Each operator is understood to be a combinatorial set of several of Rene Thom's elemental catastrophe morphologies, elemental relations found in communicative materials and used as building blocks of meaning. What is sought is the application of these elemental blocks to the city as an evolving environment. Such an application could possibly be developed into a method for explaining archetypal moments in the development of human settlements, an ontology and epistemology of development that is dynamic like the city itself, yet simple and easily accessed. This topological narrativization is briefly deployed to examine certain aspects in the development of the city of Chandigarh, India.

1 Introduction

At its simplest, catastrophe theory is used to model the behavioral potentials of systems with multiple variables within multidimensional spaces. This description casts a vast net over perceived or postulated systems; all that is needed to apply catastrophe theory to phenomena are the presence of multiple, interacting variables and the possibility of understanding their interactions as tending toward conditions of stasis. These postulated tendencies describe the existence of attractors within the systems analyzed. Following the mathematical shortcut created by Laplace in his early eighteenth-century study of celestial mechanics, if the forces at work upon an object within a system could be summed into a single quantity, the forces and object will tend to move toward a position where the summation of forces is minimized. This minimum position is known as the minimal potential. Because the object in the system exhibits a *tendency to move toward* this local minimum, it is said to be an *attractor*. Once within the domain or general area of the attractor, the behavior of the system will move toward a stable local point of minimal value [Woodcock and Davis 1978]. In addition to the local minima, the potential position of the attractor could also be a local maximum point within the system, but these positions tend to be rather infrequent and unstable.

Rene Thom (1923-2002), the creator of catastrophe theory, initially applied its systems to linguistics [Thom 1974]. Within the stable unfolding of catastrophe surfaces,

he found fixed analogs of language’s morphological structures. Morphemes and phonemes represent an analogical negotiation of space, forming a system of sound that indicates things out in the world, in physical space. The referential spatiality between the expressive material of language and the things it indicates becomes apparent when morphemes are built into expressions of the relationships between things in the world as simple verbs and conjugates. Catastrophe theory finds its efficacy in explaining complex phenomena with two and three dimensional space graphs. Thus, the relations between variables, the topologies of the systems and the catastrophes themselves can be graphically represented and understood visually, as lines and surfaces (fig. 1). With this graphic interface as his tool, Thom searched for stable occurrences in mathematical spaces that evoke the simple spatial relations so abundant in linguistic communication, relations that are at times quantitatively elusive. For workability, Thom limited the number of dimensions of the topological spaces utilized to five: adding dimensions beyond five would yield a plethora of stable catastrophes – far too many to be easily identified on sight, a condition necessary for usefulness. The original catastrophes are named to describe their figural, visual qualities: fold, cusp, swallowtail, butterfly, elliptic umbilic, hyperbolic umbilic, parabolic umbilic.

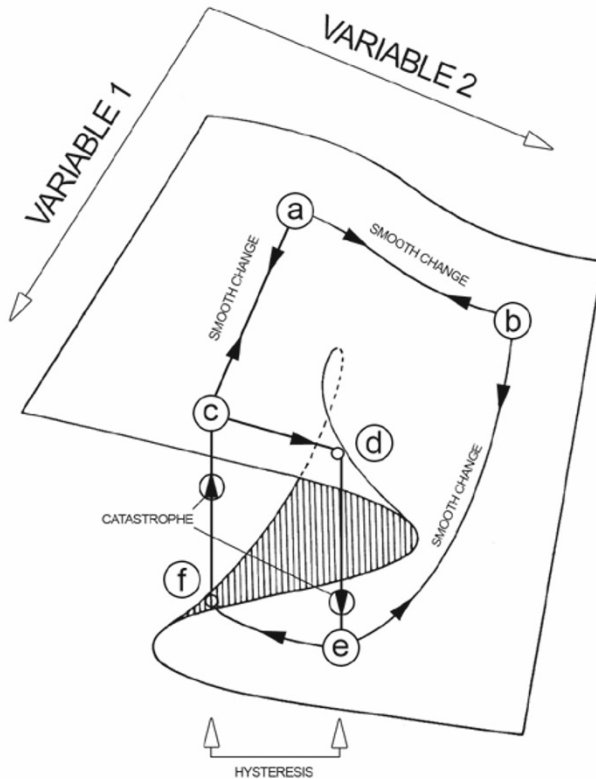


Fig. 1. Modeling continuous and discontinuous changes with a single, continuous “Cusp Catastrophe” surface. Drawing by Matt Demers

1.1 Morphologies and operators: language, narrative and space

While Thom sought to apply catastrophe theory to linguistics, the geneticist C. H. Waddington (1905–1975) became interested in using catastrophe topologies as a tool to understand *homeothesis* in biological processes, where stable canalized pathways of change resist disturbing influences in embryonic development (see [Woodcock and Davis 1978]). Waddington identified that initially homogenous clusters of embryonic cells differentiate, forming increasingly complex systems of limbs, nerves, and variously programmed tissues. This led to the belief in a qualitative and consistent way of tracking the flow of this developmental process. The sudden, discontinuous emergence of heterogeneity from homogenous sets of elements in time can be regressively linked to the consistencies perceived through time and across multiple examples of developmental processes – a continuous metastructure that references the possible emergence of the discontinuous phenomena.

Combining this initial ambition with Thom's linguistic application of catastrophe theory, we arrive at our current project – producing a stable, qualitative description of the language of evolution, or cast in another manner, the *narrativization of history*. The historical development of cities provides us with an application that is directly spatial – the evolution of the human built environment, how it is understood and communicated. We are seeking a language for the narrativization of urban development, which must contain a rigorous analog for spatial relations as well as a means for describing temporality.

1.2 Thom's sixteen elemental morphologies

Rene Thom identified sixteen stable morphologies derivable from the elementary catastrophe systems [Wildgen 1982; Thom 1975] (fig. 2). Their elementary designation is due to their limited quantity; defining the morphologies in a manner that limits their number to sixteen aids in making the forms qualitatively identifiable because they are being easily remembered. The catastrophes and morphologies referenced by Thom's two-dimensional diagrams are also easily distinguishable and unchanging without limiting their applications. Thus, the seven different catastrophes and their sixteen morphologies can be utilized to describe a seemingly infinite variety of conditions, making complex yet qualitatively similar phenomena in different fields of study graspable.

These two-dimensional morphology diagrams were produced for their didactic quality – their forms and titles are easily understood even if the implications and derivations of each form are beyond the grasp of the viewer/user. Complex topological unfoldings in spaces with up to five dimensions here become simple relational diagrams describing common spatial operations. The spatiality of Thom's French names is referenced by the new names given to the morphologies by Wolfgang Wildgen in his rigorous reworking of catastrophe theory's applications to linguistics, *Catastrophe Theoretic Semantics: An Elaboration and Application of Rene Thom's Theory* [1982]. In this reworking, the morphologies are refined and become known as archetypes, their corresponding names are: *The Archetype of* (1) Stable Existence; (2,3) Birth/Death; (5) Capture; (6) Emission; (7) The Archetype of Metastable Change; (12) Transfer. Wildgen also develops several of his own elemental archetypal morphologies which, while sometimes rather elaborate, highlight the profoundly spatial nature of Thom's original set: The Archetype of: Frontiers; Local Change; Change in Possession; Beating (heartbeat); Transient Existence; Gradual Birth/Death (capture); Passage; Polarization; Neutralization; Reduction of a Trimodal Field; Generating/Abolishing Transferred

Objects; Indirect/Instrumental Action; Object/Instrument Prominence; Compromise; and the Messenger [Wildgen 1982]. These morphologies index the profound link between language and space, allowing for dynamic relations to be maintained in the linguistic, descriptive process. Thom's morphologies offer a progression from continuous, uninterrupted existence (to be), to physical-spatial operations (to tie, to cut off) – a sense of this progression is recovered in Wildgen's archetypes. The progression from a simple ontological condition of existence to increasingly complex relationships between phenomena proceeds via folds in the behavior surfaces mapped in the catastrophe graphs. As spatial dimensions increase beyond three (up to seven dimensions in [Wildgen 1982]) we identify folds of folds as well as folding surfaces contained within folded spaces, etc.

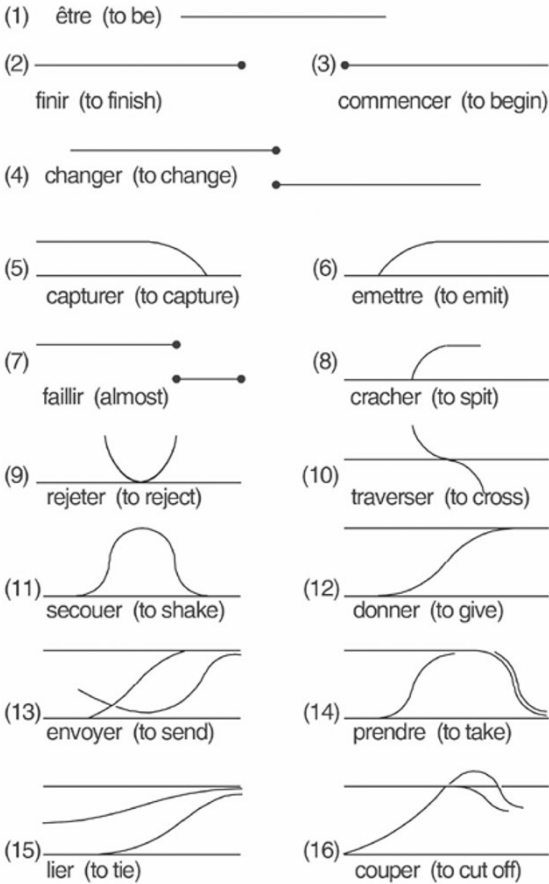


Fig. 2. Table of archetypal morphologies

The richness found in the catastrophe systems allows for analogy with the multifarious conditions of linguistic forms. A specification should be observed to maintain the utility of this analogy: spoken language, while being a sensory analog of spatial relations (the expression of spatial relations in the medium of sound), is itself an extremely dynamic system. Definitions, accents, habits and lexicons are only consistent in their flux, exhibiting conditions of change played out maximally in oral communication. Thom's catastrophe morphologies provide a ground within or against which the flux of

language occurs. Certain relationships of elements – to one another, to space and to time – can be combined and recombined to create any spatio-temporal situation described by language.

One way to understand the manner in which the morphologies work is through “scene-and-frames” semantics, where events in their prototypical shape are composed as diagrammatic analogical “scenes,” as in the presentation forms of theater or film [Wildgen 1982]. Using a semantics of scenes and frames to describe a commercial event, the scene is seen to have a set of prototypical characters: buyer, seller, objects exchanged, money, etc. To communicate information about this event, we select parts of a scene to first construct minimal sentences by placing the characters and other scenic elements in simple relationships. Wildgen chose to utilize scenes-and-frames semantics for his application of catastrophe theory, to provide within this specific linguistic paradigm a classificatory schema of the typical spatial and temporal relationships among characters in the scenes [Wildgen 1982: 22-23].

The analysis of language is more easily conducted upon its written forms, which provide an index of oral communication found in a slightly more stable, fixed mode of expression (see [Havelock 1986]). If working with texts instead of oral communication, we need to specify the application of catastrophe morphologies to literate communication; this leaves implications for further study of orality (to be explored elsewhere). Our text will be the historical narrative of city formation and development.

For this analysis we will include at least one more text. The philosopher Michel Serres applied Thom’s catastrophe morphologies to narrative processes in his text “Language and Space: From Oedipus to Zola” [Serres 1992]. In his text Serres identified a “set of operators” at work in every narrative:

The Bridge: a path that connects two banks, making a discontinuity continuous.

The Well: a hole in space, which can disconnect a trajectory that passes through and simultaneously connects piled spatial varieties and produces a new trajectory – the fall.

The Hotel: organizes spatial extension into local domains of minimal differentiation.

The Labyrinth: organizes global space into complex and intertwining relations.

The Prison: defines a finite space within a global condition.

Death: the cessation of existence.

Serres describes the operators as perfectly recognizable reproductions of constellated relations commonly found in myths, relations that comprise the series of important events described in the mythic narrative. These operators perform their work specifically on the spaces described in narratives, and one could make the case that the operations implied by each operator form an inclusive subset of modes of relation between Thom’s more simple elementary morphologies. For example, the Well Operator could be seen as a bundling of archetypes 4 (*changer*), 10 (*traverser*), 15 (*lier*) and 16 (*couper*). The beginning and ending of the catastrophic event also adds to the archetypal set of each operator: 2 (*finir*), 3 (*commencer*), etc.

Much of Serres’s insights in communications theory and narrativization depend on moving beyond the binary logic of membership in classical set theory, where an element

either belongs to a set or does not [Zadeh 1993]; Serres's analyses frequently include fuzzy sets and sack logic. In his influential exploration of communications theory, *The Parasite* [2007], the logic of fuzzy sets is utilized to describe a full spectrum of infinite values and conditions between exclusion and inclusion, thesis and antithesis, etc. In this way, a milieu is constructed out of what was previously a simple selection, a field of equally possible relations among elements, finite groupings formed along with the maintenance of infinite possibilities. Similarly, sack logic is presented as an alternative to what Serres describes as "case logic", a logic of rigid boxes that describe spaces of definite and unchanging size/volume. In case logic, a box or case that holds a large volume can fit a smaller case inside it, but the possibility of including the larger case within the smaller is impossible; if the cases are rigid, the larger will not fit within the smaller. However, utilizing sack logic, the volumes that can be contained by sacks are finite and as clearly describable as the volumes of the rigid cases, yet there is a greater range of inclusive possibilities and relationships between the spaces that can be held. A large sack may well contain a greater volume of material than a small sack, yet under certain conditions, the sacks being empty or nearly so, the largest of sacks could be tightly crumpled and fit within a sack that describes a much smaller volume of space. Both systems of logic, cases and sacks, are perfectly logical and consistent, yet the range of possible conditions and relations they describe are drastically different. The milieu of the fuzzy set and the scalar manipulations of sack-spaces are both useful for describing the spatial logic of language and narrative; a large variety of spatial conditions and phenomena can be described while maintaining the logical consistency of the system employed.

The logic employed by the set-structure of the operators includes the gradual assessment of element membership, exhibited by fuzzy sets and the inclusive scalar flexibilities of sack logic; the binary yes/no condition of classical sets is expanded to provide a multitude of possibilities for member relations. It is important to realize here that we are dealing with a set of operators that describe ways of working (on) spaces. The changes induced are not necessarily transformations, not merely the changing of conditions from *a* to *b*, but are more frequently temporary alterations of a milieu, representing the dynamic component of dynamic systems. This will become clearer when the operators are deployed to describe dynamic narrative spaces.

2 Deployment

2.1 Chandigarh, narrative scales and "sack-logic"

For this investigation, Chandigarh, India, offers an appropriate setting to deploy the catastrophe operators and explore how a city's historical narratives influence features of the physical environment, and how relationships formed by individual citizens and planners evolve over time with that environment as objects of knowledge. Several layers of historical narrativization are at work in the formation of Chandigarh as an object of knowledge in writing. Based on an iconic design by the European modernist master, Le Corbusier, Chandigarh was planned as the modern capital city of the State of Punjab following the Partition of India in 1947, when British India split into the separate nations of India and Pakistan. At the most general, then, Chandigarh represented a modern capital planned as a single, massive project and indicative of the new directions of a sovereign Indian nation. On another level, Chandigarh was planned after the Partition had caused Punjab's loss of its traditional cultural center, Lahore. Thus the newly invented urban fabric was imbued with the tenor of loss and displacement. Finer-

grained details – including administrative, design and construction documents – reveal deeper complexities that appear to subvert the more general narratives (see [Kalia 1987]).

Chandigarh is a poignant example because of the stature still granted to the *Edict of Chandigarh*, an iconic planning document from the city's inception that specified the urban environment in considerable detail. Commemorated by its inscription in a plaque, the Edict is an abbreviated version of the Establishment Statute of the Land of 1959, and today presents the defining spatial features of the city to the world on the official municipal website, http://chandigarh.nic.in/knowchd_edict.htm. But the narrative of development indicated by the static presence of the *Edict* as a development guide for the city's form is of course far too simple to capture the evolution of an entire urban environment over the past fifty years: there is a profusion of discrepancies between the planning document *as written* and the dynamic urban environment to which it gave rise. These deviations should not necessarily be cast in a negative light, however. In fact, they are telling characteristics of the spatial image-metaphors chosen to model the urban environment as an object of knowledge.

A topological analysis of Chandigarh's historical narratives offers a spatial structure for sifting rhetorical details about the design and formation of the city. If we apply sack logic to the narratives, complexities at the documented but quotidian scale of daily interactions – among individual members of the governmental or administrative bodies, alongside the multiplicity of designers engaged in any city-scale project – are not considered contradictory or be found to invalidate logically members of a more general set of elements. As a narrativization structure that encompasses local narrative details within increasingly larger and more general “meta” narratives, the design and development of Chandigarh becomes, at the global-historical level, an instance of propagation of the “International Style” of the Modern Movement, performed to a large extent by the agency granted to Le Corbusier, his ego and his talents. If the metaphorical space of the narrative is perceived as a rigid system of containers (using case logic), generalizations effected in the construction of increasingly larger scales to contain local details seem to negate the value or applicability of many local elements. The observation of element profusion at multiple scales contradicts the containment effected by generalization unless each scale and the *topos* it describes can be seen to be flexible, bendable and collapsible.

Imagine that the complexities of quotidian elements (such as the large cast of designers at work in the project of designing Chandigarh and the individual agency each would command) and the separate variables they may beg for in system-state representation become dimensions that can easily be collapsed, folded and thus contained within a deceptively simple (and seemingly larger) sack system. Initially, this image of a crumpled ball of forgotten and problematic material hidden within an all-but-empty and apparently clear/clean container might seem akin to the metaphorical image of the Grand Narratives of Modernism as a monolithic solid, pocked by tiny fissures and cracks that ultimately undermine its logic. Yet while the sack image allows for the co-existence of multiple scales and disparate and/or contradictory details, there is an important qualitative difference: metaphorically, the sack image eliminates the mental picture of smaller “fissures” undermining a larger narrative. The largest sack, the Grand Narrative of the Whole City, nurtured by an umbilical connection to a singular City Plan and the genealogical material of the founding father, is not altered in any radical or structural manner by the presence of a possibly infinite series of crumpled sacks contained within. The Grand Narrative becomes a *topos* that will hold a variety of contents. Utilizing a

spatial metaphor of sack logic thus modifies the understanding of relevance and value of the narrative materials represented in the rhetoric of history.

2.2 The *Edict* and the *Well*: deployment of “narrative operators”

The *Edict of Chandigarh* discursively represents the inauguration of an urban environment, and in the vocabulary of spatial operators enumerated above it has a dual spatial function in the topology of the city’s narrative. To “inaugurate” is “to take the auguries” or omens of a place or event, to presage its dynamic development. Topologically, the *Well* works as a hole in space, cutting trajectories that cross it and simultaneously connecting diverse layers of space by forming new trajectories made locally possible by the working of the hole. Like the *Edict of Chandigarh*, any planning document that offers a general guide for the possible forms of the urban environment can be seen to operate on a discursive topology by forming a *Well*, augmenting existing local trajectories of development and supporting new trajectories through a process of gathering and funneling into determined local conditions.

The richness of relations possible with the vocabulary of spatial operators allows us to see that a local operation that affects the space of the urban system in representation forms a *new space* or *topos*. The workings of the *Well* Operator can be seen to form a *Bridge*, connecting separate domains by a continuous path that was not previously possible. The operators, like the layers of narrative representation in the previous section, can be usefully envisioned utilizing sack logic. Such discursive modeling augments our conception of the dynamic and often unpredictable relations between the seminal vision for a city, and the everyday details of the complex urban environment it precipitates. Perhaps it is obvious that the *Edict of Chandigarh* promoted certain directions for the city’s development while precluding others. However, by means of a topological metaphor like sack logic, these generative parameters may be appreciated in a more nuanced light, stimulating rather than prohibiting a profusion of *new* idiosyncrasies and an infinite conception of scales within the confines of the domain of operation. In short, such operations stimulate the perpetual variegation of a city and its narrative. In turn, each spatial operator contains multiple archetypal morphologies which, when postulated and examined individually, add a finer grain of specificity and rigor to the topological representations. Recalling the “bundling of archetypes” mentioned previously, the *Well* formed by the *Edict* can be seen to combine 4 (*changer*), 10 (*traverser*), 15 (*lier*) and 16 (*couper*) and perhaps 5 (*capturer*), and each of these morphologies can be tied to specific aspects of the administrative object being examined.

Conclusion

The logic of founding events allows for a seemingly infinite variety of spaces of relation to emerge, a variety that does not undermine the descriptive power of the means of expression or its logical consistency. From a single narration of place can emerge a rigorous language of space that can then be used as a template for reading and understanding other places. If this language proves useful in describing spatial relations of seemingly disparate conditions (for example, comparing Chandigarh with New York City, the archaeological site of Teotihuacan in Mexico and fictional utopias like Samuel Butler’s *Erewhon*), then it might reveal imminent similarities between urban objects, indicating qualifications of urbanity. It is in this flash of recognition, the emergent event so effectively spatialized by catastrophe theory’s topologies, that we might find the morphology of the city.

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About the author

Matt Demers is a Ph.D. candidate in architecture at the University of Florida. His research addresses the literary and physical legacies of the Modern Movements in architecture and urbanism, and aims to establish a more constructive relationship with our immediate intellectual past, as well as the present and difficult forms of our cities. He believes that re-establishing a connection with Le Corbusier's modern urbanisms in an affective manner has become a task to resuscitate human agency in the urban environment. He has worked on large-scale development projects in the U.S. and India. While working on a small project in Chandigarh, he became fascinated with the city's development alongside its critical and historical literatures. He has also engaged actor-network theory, catastrophe theory and heuristics as lines of research that can guide a creative epistemology of urbanity.