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big - S M A L L : Design and production process for families of recursive structures.

Abstract:

Globalization has affected the perceptions of scale in intercontinental, regional and personal level. The condition of contemporary life of belonging to the globe while trying to establish a personal identity has been recently described in the texts of/for Koolhaas through the terms BIGNESS[1] , generic[2] , generic-specific[3] and in that of Polo through generic-specific[4]. However this concern is not [yet] so present in their architecture where in most cases is a unique signature building. I introduce the term *big - S M A L L*[5] to refer to the need for a type of architecture that can be flexible enough in order to respond to the global picture [*big*] as well as customize itself to the local or personal needs [*S M A L L*]. *big - S M A L L* is essentially a term to introduce a mass customized architecture for the production of a family of structures where all its members are unique but derive from the same genes.

This paper investigates the process of creation and production of the families of 2 structures that demonstrate the concept of *big - S M A L L* . First the *blanket*, a 3d modular surface which is an open air pavilion to be placed in different sites of the world and second *MCUS*, a 3d modular structure that consists off an artificial garden that 'erases' noise in the city. They are flexible mechanisms that fluctuate between the different scales *of big - S M A L L* . They both have been developed as parametric designs that depend on: facts, needs, and desires and they can be transformed into innumerable formations in space. Facts are the site conditions; needs are the programmatic requirements; desires are the preferences of the user. These 3 families of parameters have been analyzed computationally and empirically.

Blanket and *MCUS* investigate two different forms of customization: the *blanket* explores customization as parametric variations of a single topological structure and *MCUS* explores customization as infinite combinatorial variations of a family of predefined modules. While the actions of *S M A L L* influence the *big*, the fabrication of such structures is implemented with low cost and high customization.

Key words:

mass customization, part/whole relationship, parametric design, globalization, regional, personal, identity, recursive structures

I. INTRODUCTION: big-S M A L L

The origin for the use of the dyad concept comes from observations on contemporary life: Today architects [and students of architecture] form different parts of the world aim at a satisfactory solution for the globalized client [receiver]. Architects accept the *big* scale of the world by necessity, but they have to keep the *S M A L L* one. By using the *S M A L L* scale, one can hold or maintain the *specific characteristics*: the way light is trapped, the velocities developed in and out of the building, the openings, everything that one brings from the way she was brought up, from her background and so on. It allows the architect living in this Babylonian world to preserve the unit of her entity and existence as a creator and to put her stamp.

For these reasons the *big - S M A L L* and other related antitheses are defined as dualities where one of their opposites is inside the other. The members of the duality are not equal: They interchange positive or negative roles in the hierarchical dyad. Dualities interpreting *big - S M A L L* are: Generic – Specific, Macro – Micro, Differentiation – Repetition, Unique-Similar, Complexity – Simplicity, Global – Local, Global – Individual, Common – Particular etc.

big - S M A L L refers to the need for a type of architecture that can be flexible enough in order to respond to the global picture [*big*] as well as customize itself to the local or personal needs [*S M A L L*].

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[1] Koolhaas, R. *SMLXL*. New York: Monacelli Press, 1995.

[2] Gronlund, B. "Rem Koolhaas's Generic City", part of the research project *The Informational City and the Street as Urban Form*. Written 1997, revised 1999. Hjem.get2net.dk/gronlund/ Koolhaas. htlm

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[4] Zaera-Polo, A. and F. Moussavi. *Phylogenesis*: FOA's Ark: Barcelona: Actar, 2003.

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II. THE 2 FAMILIES

This paper investigates the process of creation and production of the families of 2 structures that demonstrate the concept of *big - S M A L L*. First the *blanket*, a 3d modular surface which is a open air pavilion to be placed in different sites of the world and second *MCUS*, a 3d modular structure that consists an artificial garden that 'erases' noise in the city. They are flexible mechanisms that fluctuate between the different scales *of big - S M A L L*. They both have been developed as parametric designs that depend on: facts, needs, and desires and they can be transformed to innumerable formations in space. Facts are the site conditions; needs are the programmatic requirements; desires are the preferences of the user. These 3 families of parameters have been analyzed computationally and empirically.

Blanket and *MCUS* investigate two different forms of customization: the *blanket* explores customization as parametric variations of a single topological structure and *MCUS* explores customization as infinite combinatorial variations of a family of predefined modules.

a. BLANKET

The *blanket* is a system of triangles connected to each other to create a flexible system that has infinite configurations in 3d dimensions. It can transform from a 2d into a 3d [horizontal or vertical] surface and finally to a spatial enclosure. This system is similar to the triangulation of surfaces appearing in 3d software programs where triangles are used to map a terrain or a curved object. [Fig01]

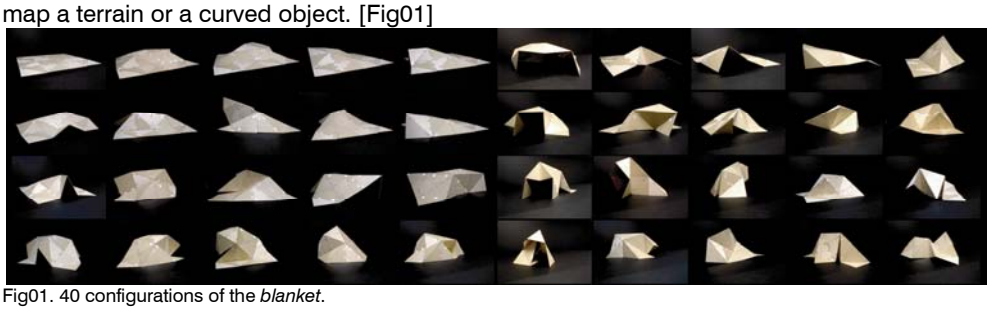

Fig01. 40 configurations of the *blanket*.

i. BLANKET: generic

Blanket relates to Paul Klee's sketches in his book *The thinking Eye*[6] through the duality of *dividual-individual* he introduces. As a surface consisted of simple triangles the *blanket* represents the *dividual*: It is only a structure. As it transforms to different formations it becomes the *individual*.
The *blanket* has potentiality to be used in architecture either as a 3d surface or as an envelope. This research is mainly using it as a mechanism to produce spatial configurations. As a mechanism the *blanket* is consisted by identical trigonal panels all connected to each other through hinges.
Blanket's hinges affect the formations according to their flexibility or friction. The initial idea of *blanket* includes hinges that have 360± rotation freedom to allow maximum possibilities of the envelope configurations. At least 20 physical models have been constructed to follow the *blanket*'s path from geometry to architecture. [fig02]

[6] Klee, P. The Thinking Eye, The Notebooks of Paul Klee. New York: G. Witten- born, 1961.

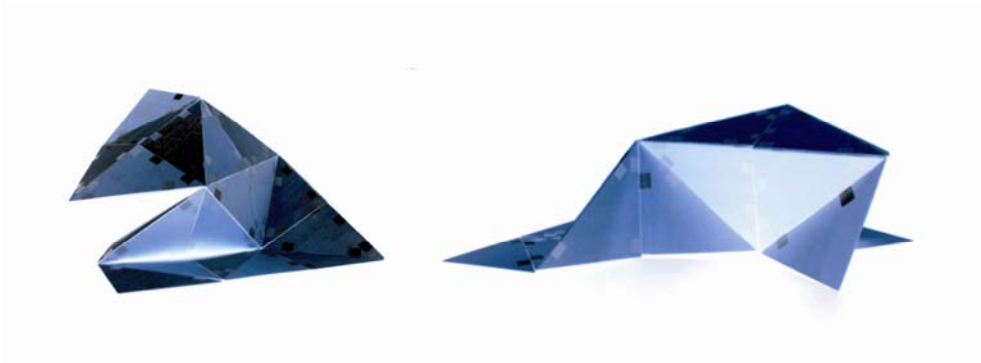

Fig02. The Plywood Model

ii. BLANKET: specific

The *blanket* is tested as a global pavilion that is sited in different locations of the world. The aim through this application was to see how the local facts, specific needs and desires would affect the formation and materiality of the *blanket* mechanism. The *blanket* acts as a parametric design approach where the system [*big*] is being transformed according to specific predefined parameters [includes climate, city/site, event, time, program, size/area and budget] that give various [S M A L L] results.

In an era of enormous efforts towards sustainability and ecological thinking, the most unappealable parameter to affect the design form is that of the climatic zone. For this reason the research focuses in 3 different climatic areas of average, extreme cold and extreme hot climates. The sites of London,UK, Barrow,Alaska and Tombouctou,Mali are chosen for their climatic representative character [Fig03]

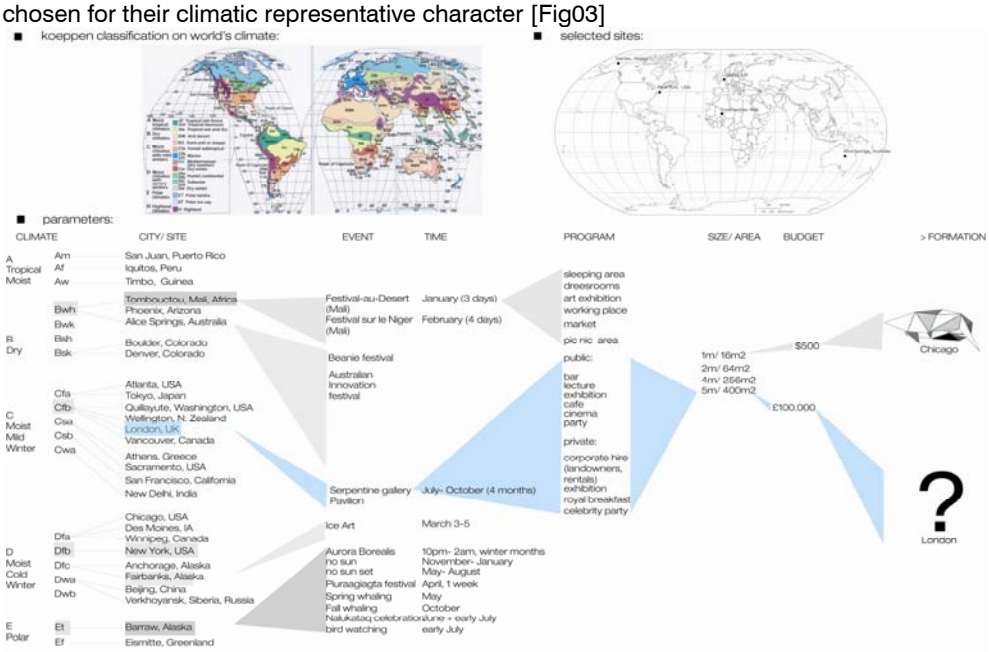

Fig03. Facts, needs and desires: The parameters that transform the *blanket*.

The first instance to be studied is placed in the London site. Every summer a temporary pavilion is constructed on the gardens of the Serpentine Gallery in Hyde Park in London by a famous architect. The brief is to create a cafe for the daytime and a place for parties at night. It is also desirable that the pavilion would be a demountable structure that can be relocated somewhere else.

The analysis focuses on gathering all the necessary information that will affect the final formation. Emphasis is given on the climatic and regional characteristics that could create

a more comfortable space to live on. The movements of the people together of the activities taking place every year are recorded and studied.

iii. BLANKET: mechanism

In order to avoid an intuitive and arbitrary selection of a possible formation, a methodology is created that documents a number of formations generated from one specific parameter each. The parameters studied explicitly are: movements of people, sun positions in different times per day in 4 different months, wind main directions and site attributes [unevenness and obstacles]. 43 different cases are studied: Some parameters cause resembling results. One result coming from one parameter has a level of complexity that can satisfy more than this one parameter. After the analysis of the results a final decision is taken that satisfies most of the preset parameters.[Fig04]

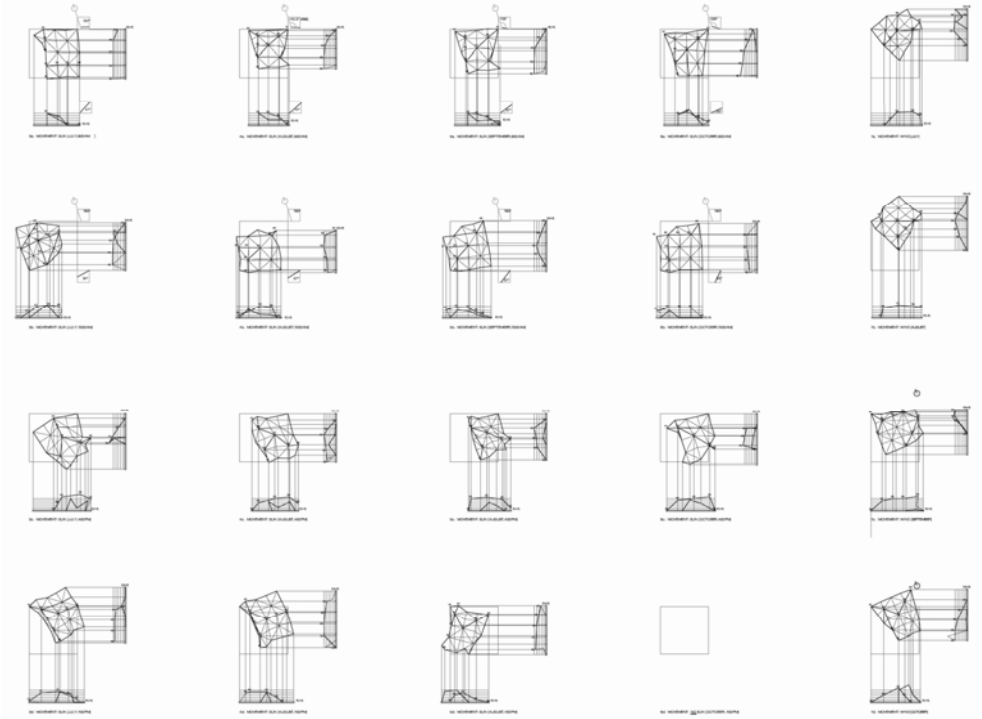

Fig04. *Blanket* formations generated from one specific parameter each. Examples of parameters are: movements of people, sun position, wind direction and site attributes.

The *blanket* mechanism is also an algorithm described as a matrix of points where each one has 3 coordinates [*x; y; z*] and other properties [color, height, 'personality', etc related to the list of parameters].The system is doing a form of artificial intelligence in terms of virtually exploring the physical abilities of the *blanket* mesh. A set of parameters is provided to the system in order to guide it towards specific needs and intentions. This method is similar to the empirical one but has more advantages due to the computer's ability for complicated calculations. [Fig05]

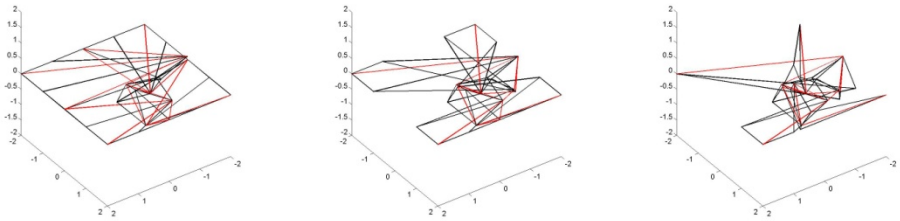

Fig05. *Blanket* algorithm development. Diagrams generated by Georgios Louizis.

The final formation of the pavilion instance came after the scrutiny on all the parameters: intuitively but mainly through the empirical and computational studies. The parameters that create similar formations were categorized. Few parameters that were creating conflicting formations were reconsidered and sometimes excluded. The final formation is the result of taking the [*big*] generic *blanket* mechanism and controlling it with the parameters that represent facts, needs and desires to a [*S M A L L*] unique pavilion for the Serpentine Gallery in London.[Fig06]

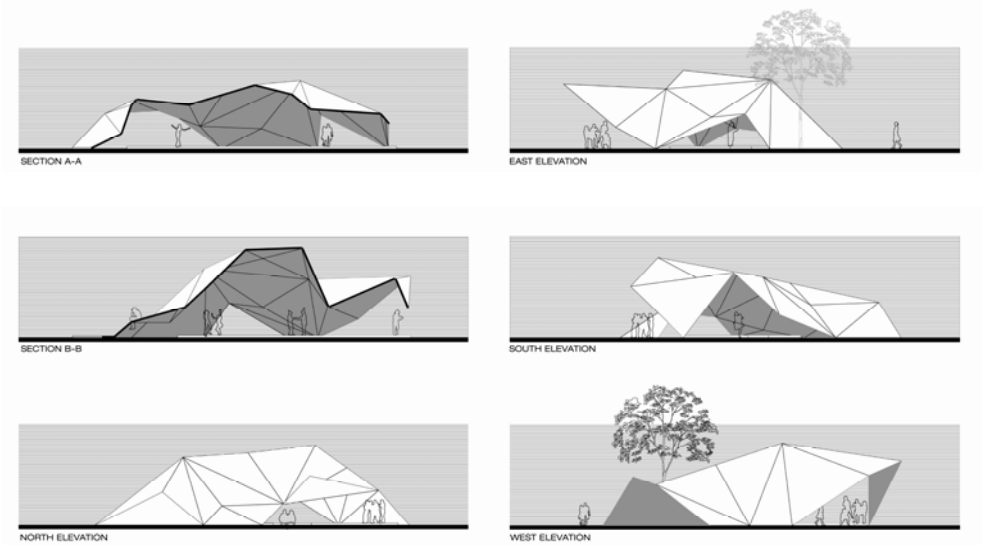

Fig06. *Blanket* final instance formation.

b. MCUS

Cities do have gardens, but they are sometimes remote. Based on this observation, there is a need for a different typology of a garden that would be more similar to that of a tree. This garden typology does not require a lot to grow; it can be spread in many spots in the city and is accessible to everyone.

i. MCUS: generic

The busy and noisy daily life in a metropolis calls for a spot, a heterotope where the tired worker of downtown or the man of the neighborhood can stop for a second, feel the city, the [everchanging] weather and take a break. Inspired by the carefree and scenic happy moment of a man enjoying life under a plane tree, the MICRO CEASEFIRE UNDER SHADOW [*MCUS*] is a *S M A L L* city garden growing next to the streets. The hybrid typology of *MCUS* is merging the quality of a rich plane-tree shadow by using artificial foliage that absorbs or reflects away the severe urban noise or even transforms it to a rustle or warble sound. *MCUS* is a *S M A L L* breath within the megalopolis where people can escape from the hostile urban environment to smoke a cigarette, eat a snack, chat, meet, talk on the phone, or simply loaf. Ideally many *MCUS* will cover the needs of passages for a pause by transforming the noise in the city to sounds of nature.

MCUS is conceived as a prototypical artificial micro-environment for the dense city with qualities of an urban tree. *MCUS* attributes are: 1. Leaf 2. Shadow 3. Enjoy 4. Anti-noise. [Fig07]. *MCUS* [artificial] foliage is made by one modular leaf that propagates itself in 3dspace in innumerable interlocking configurations. A number of models in were made to investigate the structure that would best qualify the 4 above mentioned criteria. Self-supporting structures and perforated ones that allow light to come through are preferred. A final structure was selected and tested in different scales. [Fig 08]

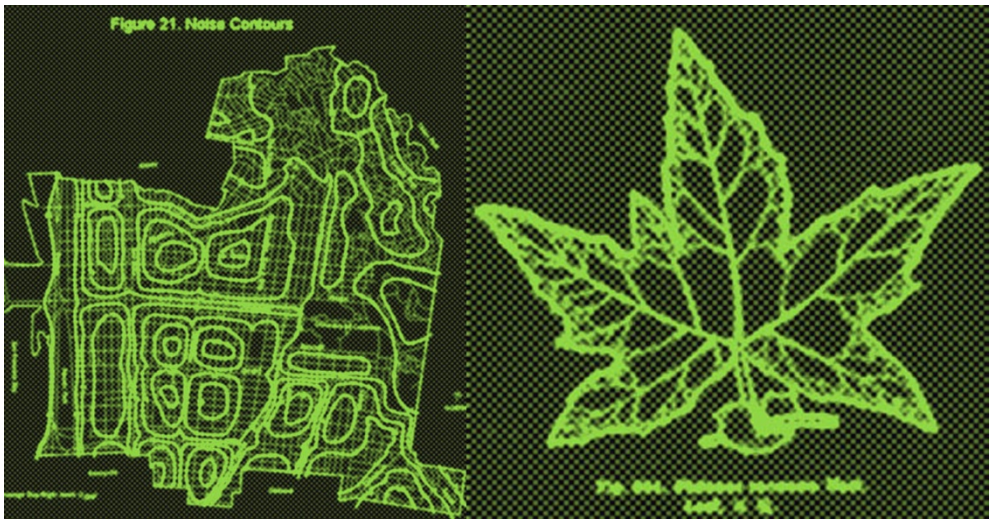

Fig07. *MCUS* attributes are 1. Leaf [right] 2. Shadow 3. Enjoy 4. Anti-noise [left].

Fig08. *MCUS* Shadow. Mock-up 1:1.

The interlocking leaf for *MCUS* is inspired by the platanus leaf. The platanus tree is associated with enjoyment, relaxation and community gathering. At the same time, platanus in its different species is planted in many cities worldwide due to its ability to absorb the city noise through the volume of its foliage. This noise absorption quality of platanus in the city is what this Micro-Ceasefire wants to be. The strategy to investigate the appropriate technology is twofold: One deals with the modular leaf materiality and the other related to noise-cancelling. The material candidates for *MCUS* leaf should qualify both sound and self supporting criteria. They range among: rigid materials, that have high self-supporting attributes but low noise absorption ability and flexible materials, like foamy materials that are incapable to support themselves but able to absorb noise. The best possible option is a composite honeycomb polymer material.

MCUS is an anti-noisy environment where [ideally] a sound wave reflects the noise of the city by making it zero locally, with the purpose to alter the noise contours of the city. This action is similar to the noise-cancelling technology used in earphones in airplanes, and other noisy environments. The single anti-sound wave creation for an outdoor structure, where multiple noise waves occur without meeting in a single spot [like in the case of noise cancelling technology where this spot is the ear hole] is an expensive research area that requires large simulation labs. Shopping malls are the first possible urban applications of this technology, but this research is still in early stage.
MCUS is accompanied by an active sound installation to simulate the anti-noise effect that the leaves would produce in real life. The bird and warble sounds act like a counterplot to attract the ear. The wired or wireless electrical sound system is embedded in the foliage and it is activated by the people's motion.

ii. MCUS: mechanism

MCUS is a *big - S M A L L* child like the *blanket*. It is conceived as a generic mechanism that forms itself by responding to specific facts, needs and desires. A mathematical expression was developed that responds to the following parameters:

a. Spatial form of foliage: This varies from strict geometrical ones to apparently anarchistic. Examples are: cubic, L-space, vertical or horizontal surface, tree like, and others depending on the area available in which *MCUS* will be placed.
b. Size of leaf and quantity of leaves: This range will define the density of *MCUS* shadow.
c. 3d representation of final format: This includes color variation, texture differentiation or material preference.
d. Software for automatic or interactive process: This aims in the creation of a friendly visual interface to allow the user to explore possibilities of formations. [Fig09]

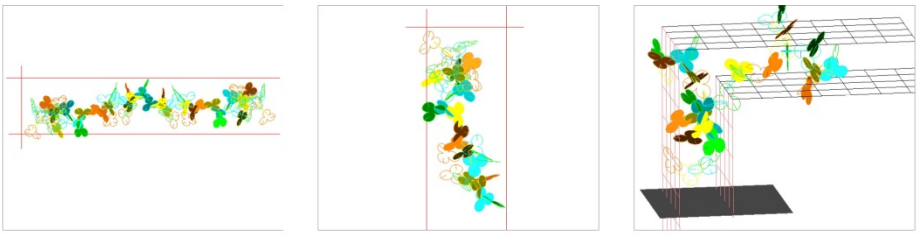

Fig09. *MCUS* intentional formations based on facts, needs and desires.

The programming deals with:

leaf shape selection
contour->geometrical description of outline [module]
limits ->description of desired space -> cube, sphere, some surface, etc
max_items->initial maximum number of leaves [arbitrary]
count_items->leaves counter initial 0

The algorithm includes the following steps [Fig10]:

/root -> first leaf as base ->insert 0,0,0
/new_leaf-> insert 0,0,0
/transofrmation >move x,y,z>rotate 3d -> new leaf in its position
/check_bbx -> check weather new leaf goes outside the bounding box

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If not incr 1 leaves counter
if count_items>=max_items stop exit
else repeat new_leaf
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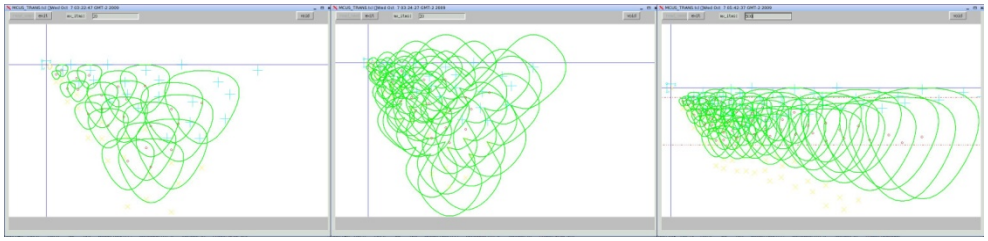

Fig10. *MCUS* algorithm development.

iii. MCUS: specific

MCUS was installed as one instance in Old Ice-Chambers of the Thessaloniki Harbor for the exhibition “Other Spaces” -Heterotopias: 1st Thessaloniki Biennale of Contemporary Art in September 2007[Fig 11] and as a second one in Athens Byzantine and Christian Museum as part of “Unbuilt” research events in September 2008. [Fig12].The two instances consist of the same leaves but each of the final formations is created based on the specific exhibition space to be installed. Ongoing research for the construction of a third instance deals with issues of materiality, self-support, sound absorption, density of shadow and the possibility to add another attribute to *MCUS*, this of solar energy harvest.

Fig11. *MCUS* first instance at Heterotopias: 1st Thessaloniki Biennale of Contemporary Art in September 2007.

Fig12. *MCUS* second instance at Athens Byzantine and Christian Museum as part of "Unbuilt" research events in September 2008.

III. DISCUSSION

This research is about the notion of *big - S M A L L*. The *big* and *S M A L L* are understood as a duality that its members are one inside the other. *big - S M A L L* describes the need for architecture to find systems or typologies that could respond to the global realm by allowing local, personal expressions through built work. While the actions of *S M A L L* influence the *big*, *blanket*, *MCUS* or other mechanisms of *big - S M A L L* can be implemented with low cost and high customization due to their characteristics, such as to be simultaneously: simple-complex structures, repetitive while having innumerable configurations, globally produced and locally sited, adaptive with a personal identity.

IV. ACKNOWLEDGMENTS

I would like to thank all the people involved in this work so far. *big - S M A L L* and *blanket* were formed during my Master thesis at IIT under the supervising of Ben Nicholson, Martin Felsen and Jonathan Miller. For the *blanket* hinge and *big - S M A L L* structural explorations I have been consulting the architect engineer George Toloudis. The *blanket* algorithm was developed together with the computer scientist Georgios Louizis. *MCUS* first instance was constructed with the help of the George Toloudis and Georgios Louizis. I wish also to thank Spiro Pollalis, Sanford Kwinter and Kostas Terzidis from Harvard GSD and William J. Mitchell from MIT who have been offering advice to my constant *big - S M A L L* speculations.