ISBN: 978-972-9059-05-6

the origin/la source : http://www.afscet.asso.fr/resSystemica/Lisboa08/makarovitsch4.pdf
the title/le titre : TUBES II Novelty and complexity generation in a system with a simple root.
the author/l'auteur : MAKAROVITSCH Alexandre & Jean-Pierre FOLL
the pages/la pagination : 8 p.
the year/l'année : 2008
& the book/la publication: 7th Systems Science European Union Congress Proceedings, Lisboa, Portugal.

Systems Science European Union
Union Européenne de Systémique
UES
APOCOSIS

7th Congress of the UES
Systems Science European Union
Lisbon
Dec 17-19, 2008

TUBES II
Novelty and complexity generation in a system with a simple root.

Alexandre Makarovitsch Jean-Pierre Foll

Institut de Mathématiques Appliquées
Université Catholique de l'Ouest
44, rue Rabelais BP 10808
49008 Angers France
malex@club-internet.fr fojepi@gmail.com

Abstract

The Tube is a simple structure, which by application of certain operators could change and generate complex structures right from the first tenth of sequential applications. The operators used are "Cut" and "Paste".

Keywords : system, novelty, complexity, operators, hyperelast

Introduction

This is the follow-up of an ongoing research which has been first presented in 2005 at the ECCS.
The base, as described in detail in [1] is a tube built of a special material, actually a virtual material we call "hyperelast", being given its special properties. The material permanently shrinks to arrive at a minimal surface and edges, whatever operator is applied on the object built (or generated) out of this material.
The tube, a cylinder is a simple structure, which - by application of certain operators described later – could change and generate complex structures right from the first few sequential applications.
Actually, such an approach allows, as the research progresses, to relax some properties of the material to come closer to the reality by performing successive steps.
To move in time from one generation to another, a discrete time materialized by a clock tic synchronized with each operator application, will be used.

Summary of the initial experiments

The processing of a first case has allowed to learn more about the material and the operators.
The operators used are:

- **PASTE -** noted /**C**/ - by applying the operator once, it could stick together edges; any edge on itself or on another edge (eg: close one end of a tube, or paste the two ends of a tube together to form a torus). This operator can work when the object at hand has at least an edge (it doesn't work on a closed, edgeless object like a sphere or a torus).

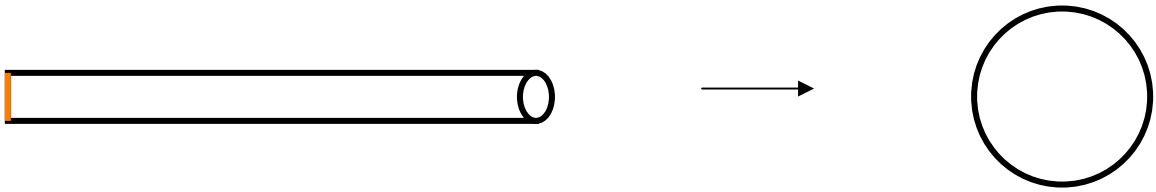
- **CUT** - noted /**K**/ - by applying the operator once, it performs a single cut on a single object, cut which either starts at one edge to join another, or starts at a point to join it again after having done a curve without crossing another edge (eg : transverse cut of a tube in two pieces ; longitudinal cut from one edge to the other to obtain a unique surface ; cut a hole in a tube).

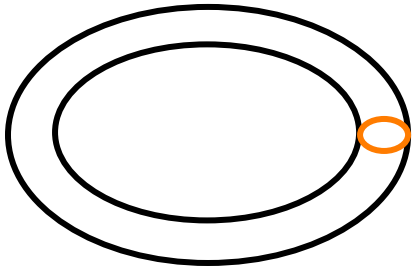
A few simple rules to perform the process:

- at each clock tic one single operator (/**C**/ or/**K**/) is applied only once,
- the operator is applied on a single object.

The root of the system is a tube noted « **I** ». It is an empty cylinder open at the two ends. By applying on **I**, at t=0, one of the two operators, the result at t=1 (generation **G1**) is:

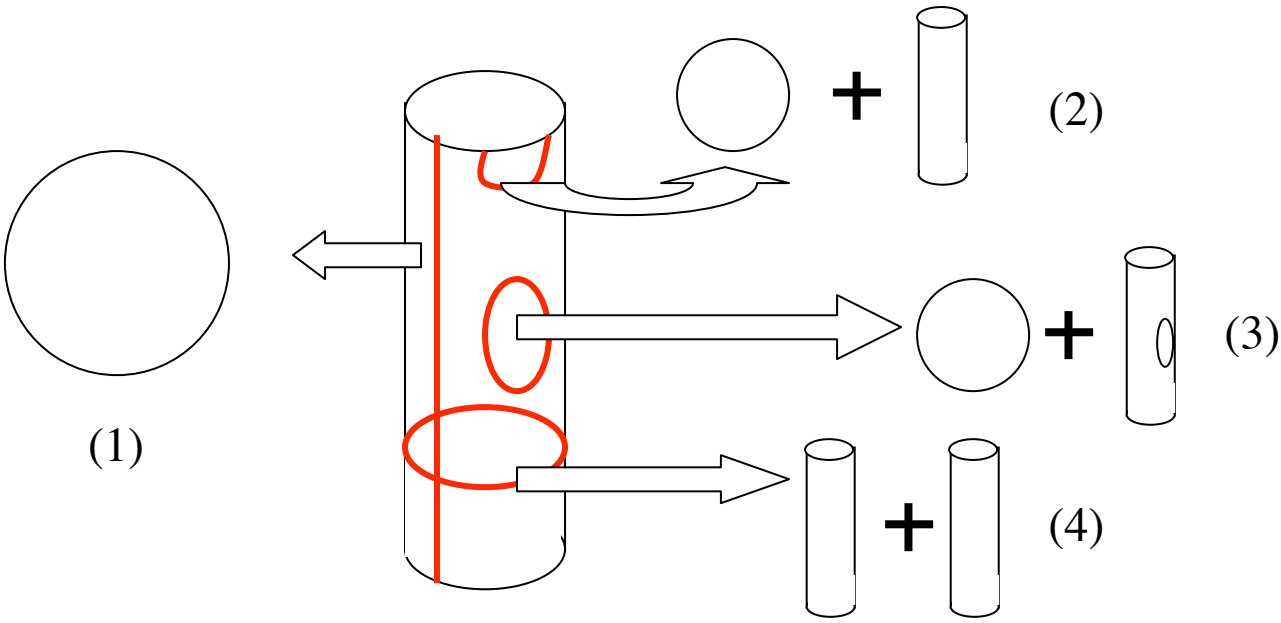
➢ **/C/I > D or T** (**D**=disk; **T**=Torus)





By application on the same root of the operator **/K/**:

/K/I > D or [D,I] or [D,I1] or [I,I]



The “or” in the cases described above is exclusive, in the sense that we can have at time « t » only one single result. This choice might be left at random or defined using specific rules.
Let us consider the root **I** at the generation **G0; D,T,[I,I],[D,I]** and **[I,I1]** are the potential elements of the first generation **G1** .
By applying **/C/** or **/K/** on the objects of generation **G1**, the generation **G2** may be obtained:

- **/C/D > [S]** (sphere)
- **/C/T > [T]** ("paste" on a torus is inoperant: it is edgeless)
- **/C/I > [D] or [T]**
- **/C/ [D,I] > [S,I] or [D,T] or [D,D] or [D]**
- **/C/ [D,I1] > [S,I1] or [D,T1]** (I1 – tube with a hole/ T1 – torus with a hole)

- **/K/D > [D,D] or [D,I]**
- **/K/T > [I] or [D, T1]**
- **/K/[I,I] > III or [D,I] or [D,I,I1]**
- **/K/ [D,I] > [D,D,I] or [D,I,I] or [D,D,I] or [D,I] or [D,D,I1] or [D,I,I] or [D,D]**
- **/K/ [D,I1] > [D,D,I1] or [D,D] or [D,I,I] or [D,I,I1] or [D,D,I2] or [D,D,I1] or [D,I]**

Let us also further simplify this example by ignoring all the multiple objects which do not contain novelty from one generation to the other and by keeping only the combinations which bring novelty :
G0 -> I
G1 -> D, T, [D,I1]
G2-> [S,I], [D,T1], [D,D,I2],
and extract from such selected groups only novelty:
G0 ->I
G1 -> D, T, I1
G2 -> S, T1, I2
In **G3,** by applying **/C/** on the novelties of **G2,** the novelty **T2 (** a torus with two holes**,** from **I2)** might be obtained, **/K/** on the same objects of **G2,** the novelty **I3** should be obtained**.**
G3 -> T2, I3
By performing the same operation on **G3,** one would obtain:
G4 -> L (L, a « pair of glases »(a torus with two empties) **–** by application of **/C/** on **T2), T3, I4**
G5 -> T4, I5, L1
G6 -> T5, I6, L2
G7 -> T6, I7, L3, 3L (3L, a torus with three empties**) –** by application of **/C/** on **2L2)**
…
Some interesting observations made looking at this this step:

- If **/K/** is applied on **D** or on **S** , **[D,D]** might be obtained**.** This means that **[D,D]** is the result either of **/K/->S** or of **/K/->D** .Therefore an indeterminacy is introduced in the possibility of knowledge of the past (if faced with **[D,D]** without more information).
- Applying **/C/** to completely closed structures is inoperant (spheres, tori , "glasses"...) ; by the contrary **/K/** might always be applied whatever the structure.
- The same structure might show up at different generations from different operators application sequences.

- 3D structures appear quite rapidly in the sequence (as soon as an operator /**C**/ is applied on a torus with 3 empties (**3L**) to paste together two holes on two non adjacent parts of the structure).

This leads us to the observation that a high level of complexity could be achieved with a couple of operators and a simple root. It is also possible to affirm that novelty is generated systematically, and that the root and the structures revealed at a point of the experiment are reproduced later. Once a novelty reveals, it will show up again later.

It is possible to imagine building a machine which would be capable of creating automatically new objects and present these graphically.
Other objects than « **I** » could be the root for the process.
Other couples of operators could also be envisaged: punch/patch or fold/unfold. To apply operators like fold/unfold brings in the necessity of relaxing some properties of the material and also requires the definition of rules regarding the folding angle. These go beyond the purpose of this paper.

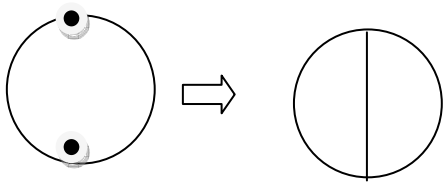
Going deeper in complexity
If considering closed forms with three "empties", with two holes placed in different regions of the object, regions which are not adjacent, to apply /**C**/ it is mandatory to pass over (under) the element which separates the holes.
A shape with four empties might have different structures and more possibilities to have holes separated by one or more neighbor elements. This leads to a development in real 3D, which wasn't the case for the generations at the beginning, where the 3rd dimension was not necessary to describe the object. There also is a combinatorial explosion of possibilities as generations progress. The objects which appear are close to knots and the complexity goes on limitless.
If creating an environment which is favorable to the manifestation of novelty, a sort of « soup » containing operators in which root elements are plunged, the new elements might appear faster and in larger numbers as well.

Further experiments
The sequence /K/ T > T1 ; /K/ T1 >T2 ; /C/ T2 > L is only one of a large set of possible sequences :
/K/ **T > T1,D** or **I** or **I**
The probability to get **T1** is 1/3
/K/ **T1,D** >**T2,D,D or T1,D,D or T1,I or I,D or I1,D**
The probability to get T2 is 1/5
and
/C/ **T** >**T**
/C/ **T1,D** > **T or T,D or T,S**
/C/ T2,D,D > **L,D,D** or **T1,D,D** or **T1,D,D** or **T1,D** or **T1,D** or **T1,D** or **T1,D** or **T2,S,D** or **T2,S,D** or **T2,S**

The probability of occurrence of **L is** therefore 1/3 x 1/5 x 1/10 and that of L11 or L12 is 1/300

Once we have discarded those shapes which are mandatorily "3D", the remaining three shapes evolution under operation with /C/ and /K/ will be analyzed in the following paragraphs

If on T2 we apply /C/ to paste the two holes together we obtain **L**:

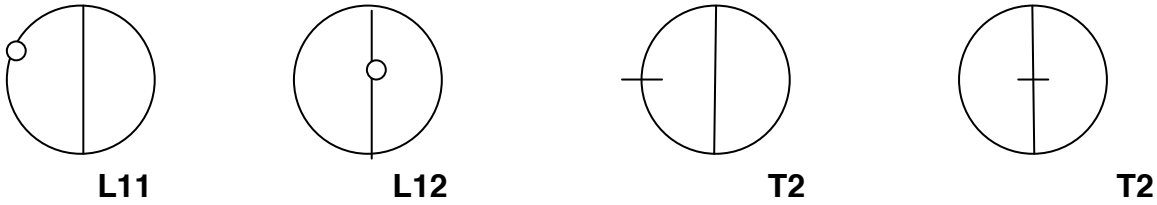


T2 L

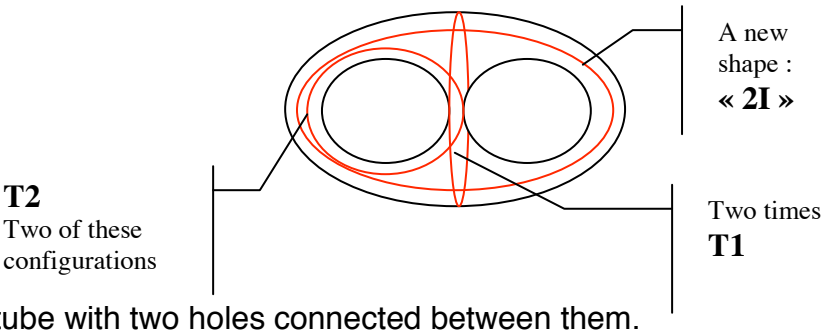
This new shape is somewhat rich, as far as novelty is concerned.

The Configuration **L** has the following possible outcomes if /K/ is applied (knowing that /C/ is not operable on this shape) :

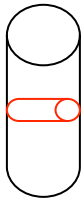
/K/ L > L11,D or **L11,D or L12,D or T2 or T2 or T1,T1 or T2 or T2 or 2I**



L11 **L12** **T2** **T2**



2I is a real novelty. A tube with two holes connected between them.



One step further :

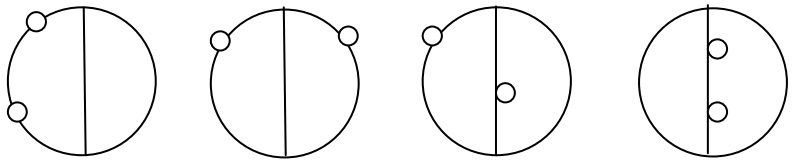
/K/ L11 > 2xL211,D or L221,D or 2xL212,D or 3xT3 or T2,T1 or 2I or 2I1

2I1 is a **2I** with a hole in the main tube.

/K/ L12 > 2xL212 or L222 or 2xT3 or 2xT2 or T1,T1 or T1,T2 or $2I^1$

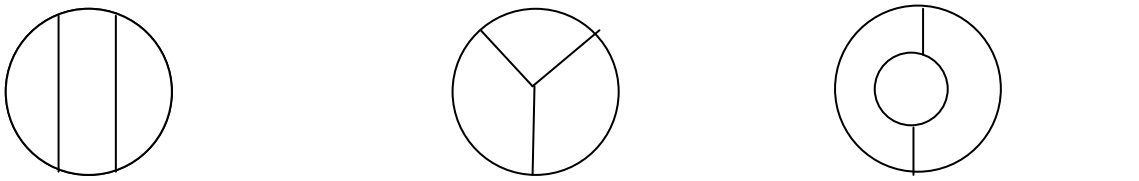
Another novelty is **$2I^1$,** a tube with two holes linked inside by a tube with a hole inside. This makes us assume that types of very complex nested structures could arise few generations later. The probability for such structures to show-up is nevertheless low, less than 1/10000.

The outcomes depend on the place where the holes are carved and the position of the /**K**/ operator
The possibilities for the holes are the following if /**K**/ operations are performed on the **L11** and L12 configurations:



L211 L221 L212 L222

In the following step, a /C/ operation is performed on each of the L211 to L222 configurations with a set of interesting potential results:

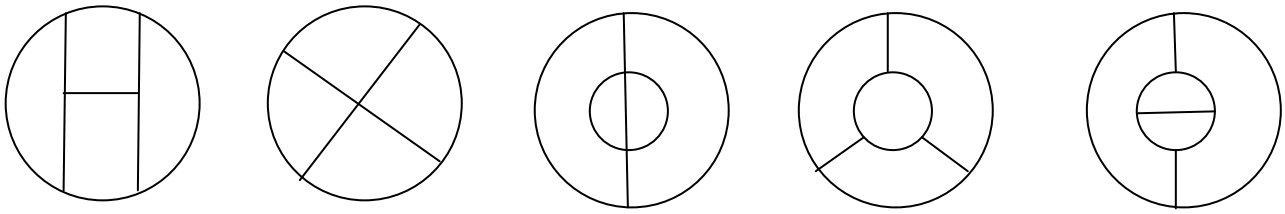


L2111 L2211 and L2121 L2221

If starting with the root, tube (**I**):
/K/ **I** > **D** or **I,I** or **I1,D** or **I,D**
I appears in two of the four possibilities (p=25% for each)
/C/**D** > **S**
/C/ **I,I** > **[D,I or T,I] or [D,I or T,I] or I**
/C/ **I1,D** > [**I, D** or **T1,D** or **I,D** or or **I,D**] or **I1,S** or [**I** or **I** or **I**]
/C/ **I,D** > [**D,D** or **D,D** or **T,D]** or **I,S** or **[D, or D]**
T1 appears just once after the /C/ operation which has 20 possible outcomes.
/K/ **T1, D** > [**T2,D** or **I1,D** or **I1D** or **I,D**]or [**T1,I** or **T1, D,D**]
T2 appears in one out of six outcomes.
To arrive at **T2** we have a probability of 1/256 which is quite low.
From **T2** to **L2111**
/C/ **T2,D** > [**L11,D or L12D or**] or **T2, S**
/K/ **L11,D** > [**L211,D** or **L221,D** or **L11, D,D** or **L11,I**] or …
The L2111 configuration has a probability to occur of 1/15360. This is very low.

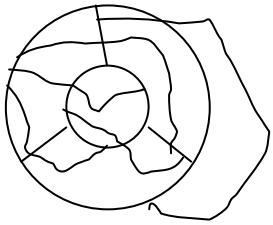
This confirms the complexification as well as the scarcity of novelty in the structures obtained with just two operators on the initial tube structure. It is important to underline again the scarcity in novelty occurrence, namely that novelty does only rarely occur.
The definition of novelty might be viewed as somewhat fuzzy. What we have retained for such definition is the fact that a new property emerges within the structure. For example, a torus is a new structure compared with a tube or a sphere. A sphere, as a torus has no borders, but the torus has a an empty as well; a torus with N empties is new compared with a torus with N-1 empties, etc. A tube has two borders, a disk has just one. New is also the emergence of tridimensionality (which, as said earlier, is beyond the scope of this paper, but definitely in our research program).

Some of the following generations structures might be:



This opens new paths for research, but the combinatorial explosion - even if there are only two operators which could be applied only in sequence – requires generous pruning of branches in the search space, which in turn might require new methods to efficiently perform such operation.
It is to be noted that the neighborhoods in the five shapes above (A,B,C,D,E) have not the same connectedness:
-the left and right regions of **A** have 2 neighbors and the two central regions have 3
-in **B** each region has only 2 neighbors
-in **C** each region has only 2 neighbors
-in **D** each region has 3 neighbors
-in **E** each region has 3 neighbors
This means that the frontiers between regions are not directly reachable for performing a /**C**/ operation unless going 3D (over a middle frontier)

.



The system might evolve to become a regular grid or a “n-slices pie” and many other shapes which remain unknown up to the moment these are actually developed.

It is sure that going 3D opens a much richer world which could be better explored with the appropriate computing resources. The main issues to be solved are:
-having a computer program generate the structures and present these graphically,
-having a computer program “understand” what novelty is, be able to name it and sort it from the already known structures,
-having the physics (properties) of the actual material well described.
Work is in progress these areas.

Conclusion
As a provisional conclusion, we might affirm that the model proposed in this paper is of interest in studying the way in which complexity appears in a structure submitted sequentially to two simple operators, “Paste” and “Cut”. It should be also true for other operators.
Complexity gets higher as generations proceed, and novelty appears.

Such model, on which a lot of work remains to be done to further refine it, should lead to a better understanding of structure per se. It also should bring us to a better understanding of the significance of operators as fold/unfold, so important in molecules and notably in proteins. It could maybe lead to a novelty producing machinery. The field is close to virgin and we have presented here only a very modest insight in this complexity world.

Bibliography:

A.Makarovitsch – TUBES Proceedings of ECCS, Paris 2005