ARCHITECTURE CASE STUDY IN TRANSFORMITY FACTORIZATION

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ABSTRACT

This paper studies the Giannantoni factorization of H.T. Odum's transformity into dissipative and generative components. A dissipative component of architecture was developed in the author's paper " 'Tropical' Emergy and (Dis-) Order" at the 4th Biennial Emergy Research Conference, and is related to the number of surfaces used up in architectural construction, for example making walls out of bricks. A generative component was developed in the author's paper "An Algorithm to Measure Symmetry and Positional Emergy of n Points," presented at the 2007 annual meeting of the American Mathematical Society, New Orleans, LA and included the the ISSS 2007 Bulletin; the generative component is related to the number of equal distances created between different parts of a structure. There is some evidence of ordinality; for example higher-dimensional structures can have orders of magnitude more symmetry. Emergy maximization is analyzed as a constrained calculus problem which for maximization requires middle values of both dissipation and generation. For example a placement of bricks around a yard in a highly symmetric fashion may have high symmetry but if they are not connected , will not lead to a desirable architectural structure. Similarly connectling the bricks into haphazard walls may have high dissipation but without some symmetry of construction into regular structures such as rooms, will be considered a waste of materials. Some other questions such as evolution of biological and animal structure are discussed.

INTRODUCTION

There is a certain paradox in the search for maximum empower, in that emergy is based on used-up energy, so that it seems a more wasteful production process (with more used up energy) would be favored. A way out of this paradox may be offered by Giannantoni's factorization of transformity into a dissipative part, which is based on used up energy, and a generative part, which is based on creative molding of energy into new types. In this way a process which merely uses up a large amount of energy without creating any new energy type would not necessarily be favored. Since Emergy = Transformity *Energy, taking the derivative with respect to time yields the equation: Empower = Transformity* Power, supposing Transformity is constant for a given process. Then a process has greater Empower if it has greater Transformity, for a given power use.

Architecture Case Study in Transformity Factorization

There are a couple relevant optimization problems, letting T = Td*Tg, where transformity T equals dissipative transformity Td multiplied by generative transformity Tg:

1) max (T) = max (Td*Tg), such that Td <= A, Tg <= B,

2) max (T) = max(Td*Tg) , such that Td+c*Tg = C. Here small c is a scale change between dissipative and generative transformity, and big C is a bound or limit.

3) max(T) = max(Td*Tg), such that Td and Tg are calculated dependent on specific placement of blocks.

1) The answer to the first problem is simply to take the largest possible value A of Td and the largest possible value B of Tg and multiply them, to get A*B.
2) By calculus, the answer to the second problem is Td = C/2 and Tg = C/(2c), so that the maximum product T comes out C^2/(4c).
3) The third problem remains challenging. In the case discussed below with ten 4x2 blocks, the maximization could be taken over the space (R_xU(1))_º, where R_ is three-dimensional Euclidean space and U(1) is the one-dimensional circle of orientations from 0 to 2π, with the constraint that two blocks cannot occupy the same space . Although this setup is the official way to state the problem, it seems intractable at present. However the first problem can provide a sound guide to solving the problem in the case of a local maximum.

The first problem is relevant if there is no "trade off" between Td and Tg, so that they can both be maximized at the same time.

The second problem is relevant if there is a "trade off" between Td and Tg, so that maximizing one of the factors decreases the ability to maximize the second factor.

In this paper the decision is made to measure dissipative transformity by the ratio of original surfaces of blocks divided by remaining block surfaces. If few surfaces are left, the denominator is low and the ratio (dissipative transformity) is high. Generative transformity is measured by the number of pairs of equal distances between blocks of the resulting structure.

This study is very limited in that it does not study the "Use Case," of architecture, or what the structure is designed for. These questions involve the placement of doors and windows and repeated pathways, which involve patterns, or cycles, in the time or fourth dimension. It is hoped later studies can extend the calculations to these essential questions. It would seem the most symmetry could be obtained in the 4-dimensional case by simply letting things stay the same from one moment to the next; however as H.T.Odum stressed and (Pico, 2002) points out, things are always decaying on their own, so that it takes feedback (change) to keep things to appear to stay the same, whereas they thus are not actually staying the same.

For the simple cases analyzed here, it seemed that problem 1) was sufficient to handle the architectural structures involved, i.e. that it was not necessary to worry about "trade offs," or, stated otherwise that it was possible, locally, to maximize both types of transformity Td and Tg at the same time.

MODEL CALCULATIONS

It was decided to limit the study to ten uniform 4x2 LEGO blocks. Each such block has an initial dissipative transformity, based on its being 8 cells (each cell with 6 sides) combined together, of 6x8=48 incoming sides dividied by 28 resulting sides (8 top, 8 bottom, 12 lateral), or Td = 48/28= 1.714.

The generative symmetry is based on putting one point at the center of each 2x2 block, or two points for each 4x2 block. The two points in each 4x2 block define an orientation. If the blocks are scattered randomly in space, the only equal distances will be the distance between the two points of each block.. (Here the definition of random is that there are no more pairs of equal distances. This situation is somewhat hard to obtain; for example if any two of the blocks are parallel, it will create at least another pair of equal distances.) The minimum number of pairs of equal distances will then be the combination of ten things taken 2 at a time , or C(10,2) = 10*9/2= 45, since any two blocks create a pair of equal distances, based on the common separation of their two internal points.

As a consequence, the product T = Td*Tg will always be at least 1.714*45 = 77.14.

Now what about maximizing T—various configurations create local maxima; it is claimed these are the structures that appear in architecture. Small changes in these structures decrease BOTH the dissipative and generative transformity. The following structures are considered:

1) straight line (1-dim)
2) square outline (3 blocks across each side, like foundation outline of a square room) (2-dim)
3) solid rectangle (4x5, like a roof or wall) (2-dim)
4) solid bench (5 adjacent blocks on bottom level and 5 adjacent blocks on top level) (3-dim)
5) pillar (5 levels of 2 adjacent blocks) (3 dim).

There is a complication with 3-dimensional structures since LEGO blocks are not cubical; the side length of a 2x2 block is 5/8 inches, but the height is only 3/8 inches. This difference causes 4) and 5) above (both in some sense 2x2x5) to come out with different values. The results of the transformity calculations are as follows:

Structure	Td	Tg	T = Product
1) Straight line	480/244=1.967	1140	2242.62
2) Square outline	480/240=2.000	1163	2326.00
3) Flat solid rectangle	480/196=2.448	1992	4878.36
4) Solid bench	480/136=3.529	1052	3712.94

5) Pillar	480/112=4.285	1595	6835.71

Interestingly, any slight change in the above structures typically decreases both the dissipative transformity and the generative transformity at the same time. The following results indicate the result of the given slight change in the above structure.

Altered Structure	Td	Tg	T= Product	% decrease
1) Break line in two	480/248=1.935	1050	2032.25	9.3
2) Move one side over one unit	480/252=1.904	851	1620.95	30.3
3) Move one 2x2 block out	480/204=2.352	1902	4475.29	8.2
4) Move one 2x2 block out	480/152=3.157	983	3104.21	16.3
5) Move one 2x2 block out	480/128=3.750	1446	5422.50	20.6

These results depend significantly on exactly how the pattern is broken, since the web of equal distances varies according to how exactly the block is moved; however the general idea will stay the same. In particular the case 2 in which two breaks were made in the square to move the side over has considerably more loss of transformity than the other cases with only one 2x2 block moved.

Remark 1: If cubical stacking were allowed (versus 3 to 5 ratio), the pillar case 5) would come out even more than the rectangle case.

Remark 2: The symmetry calculations Tg are based on one of the author's algorithms, for which a patent is applied for.

DISCUSSION

The results seem to follow the general outline of architecture, that certain structures--such as line, square, roof, pillar, and so on—representing local maxima of transformity, recur. Even slight deviations from these structures—a hole in the roof, a crack in the pillar—cause significant discomfort, i.e. decrease of transformity, mostly due to the generative (here symmetry) factor Tg.

There is also pause for thought in that the final transformities of the local maxima may not differ that much (4878 for roof versus 6835 for pillar), although any pathway from one to another (even straight line to square) may require an almost complete breakdown of transformity toward the minimum of 77.14 as structures are decomposed and re-assembled.

Thus the pulsing of one ecosystem or culture to another of nearly equal or greater transformity may go through the valley of chaos. This fact raises another question of how maximum empower might actually be achieved.

CONCLUSION

The simple results of this paper did not require the "trade off" theory of calculus; however more complicated cases would seem to require such trade offs. For example a house cannot be built only with a roof; it also requires pillars to hold up the roof. Thus the theory requires the further development of "Use Case" via time-varying or four-dimensional structures, to obtain practical results. It is believed, although results from one- to two-dimensional cases in this study only increased maximal transformity by a factor of about two, that higher-dimensional cases (such as four) may increase transformity by orders of magnitude. Only further study can determine if this possibility occurs. Also the question arises if symmetry per se can measure ordinal increases in transformity.

In terms of animals, the existing set of fauna seems to correspond to the local maxima of the architecture case study, as somehow giving at least local maxima of empower, in the sense that any small change in the structure of the animal is likely to cause problems for the animal.

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