A Center-Forming Calculus

Elementary Center-forming Processes.

Differentiation and Combination

What are the simplest forms, and how do they appear from nothing?

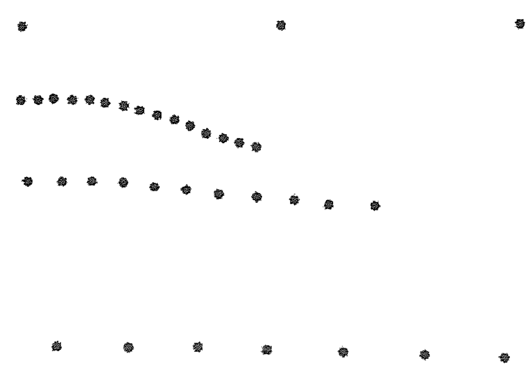
1. A point. A mark or dot, creates a singularity by differentiating that spot, from its surroundings. It may have a sharp boundary, or a gradient boundary – but the point is singled out and differentiated, creating its form.
   a. The point also generates rings around it at different distances
   b. It also generates radial lines going out from the point.

2. An edge. If there is a sharp edge, which differentiates an otherwise smooth gradient, that edge is read as a line.

3. Enclosure or partial enclosure of an area by a line or by an edge.

4. Juxtaposition. If two points are near each other, they 'generate' a line.

5. Repetition of dots, forms a line.
   a. If the spacing of the dots is irregular, the effect is weaker, and if the spacing is perfectly regular this has the strongest effect.
   b. If the dots are of different size, the effect is weaker.
   c. The strength of the line is also affected by the distance between dots, as a function of the dot diameter. Tight line is formed with spaces of 1 dot diameter; next line is formed with spaces about 2 dot diameters. Lowest line has about 5 dot diameters space. And the topmost line has about 17 dot diameters spacing. The first two are Ok, the other begin to fall apart.



6. It is significant that in the close spaced dots, the white space between dots has a defined shape, which is, in its own terms, good shape, so the composed line is in this case made of black shapes and white shapes – not true in the more open lines which fall apart.

7. We get a similar phenomenon when a line is induced between two dots. Once again, it is induced more easily if the white space that is the convex hull of the two dots alone, has a nice shape – i.e. a shape not much longer than 5 or ten diameters. So this niceness of the pseudo-rectangle formed between the dots, is what determines whether the induced line will be "seen."

8. Note: We see here, in paragraph 7, an indication which suggests the thick boundary rule – if the line of that boundary is well-shaped as a shape in itself, in relation to the dots at either end, it is more likely to be a strong boundary.

9. etc

Center-forming Process modified by Complexity of Context

10. The relative saliency of any one factor, will be modified by the larger context. For example, if the distance between dots is a little large, this might still make a line, if there are no other dots nearby. On the other hand, if other dos are nearby, and crowding the situation, so that the average distance between dots is low, then the induced line by dots far apart will fade, and may disappear altogether.

11. etc

A Center will become more strong if centers created between component centers are themselves as well shaped as the centers round about them.

Short List of Unsolved problems which must be solved.

- **Representation for "the" wholeness.**
    - There are a number of wholes that exist at a variety of different scales. They are discernible according to criteria for identifying centers.
    - Each whole also has a measure of coherence, calculated.
    - A whole does not necessarily have an exact boundary – so we need a way of marking its extent at least well enough to be able to perform the calculation.

- **Measure of relative wholeness or life in different things.**
    - This is a composite measure consisting of the number of centers that contribute to this center, weighted by their degree of life.
    - Another possible is Nikos's measure for temperature and life.
    - It is crucial that the comfortable fit between a given whole and the context in which it occurs is a criterion. This is vital to connect well with the theory of unfolding. And those things which have unfolded most smoothly should score highest on this measure.

- **Discover algorithm for finding latent centers.**
    - We wish to search a given configuration for centers which have some coherence, but not much, and which, if strengthened, will increase the coherence of the entire ensemble.
    - One approach, if we have a map of the configuration (a listing of the most salient centers), will be to consider the space between listed centers, or other combinations of arrangements of the existing centers.

- **Exact definition of a center.**
    - A center is a field-like centrality that occurs within a configuration or an ensemble of configurations.
    - Should it be measured (degree of centeredness) by counting the occurrence of fifteen properties?
    - Could one measure a center by the degree to which it corresponds to the archetypal unfolding process for a center?
    -

- **Exact definition of unfolding. Algorithm which can perform unfolding.**
    - One part of the algorithm is similar to L systems. It expands each geometric center to form other centers.
    - It has to be non-treelike. We need to find a protocol for that.

- **Recursive rule for building a new center out of other centers (up and down)**
    -

- **Ability to apply these definitions to a gradient field which has no sharp boundaries.**
    - How do we define the wholeness of that structure?
- **The basic rule of composition**

- Is the basic building block (1) a configuration, in which every configuration is a configuration of other configs? Or (2) a center, in which every center is a system of other centers? Or (3) something else.

A SYSTEMATIC SET OF GROWTH RULES, WHICH ARE THE FUNDAMENTAL PROCESSES FROM WHICH ALL MORPHOLOGY AND MORPHOGENESIS ARE BUILT.

I put forward a hypothesis of this kind: That there does exist such a set of growth rules, or algebra of rules, not too many, perhaps no more than twenty, and that these twenty form a "basis" for all possible morphogenesis.

1. Stretching.
2. Replacing
3. Gradient inducing
4. Making a local symmetry
5. Closing
6. Indenting
7. Bounding
8. Creating a level, upwards
9. Creating a level downwards
10. Growing along line
11. Growing outward from a center
12. Expanding until pressing against
13. Repeating
14. Creating the opposite
15. Adding or attaching to?
16. Placing inside of
17. Surrounding
18. Alternating with

QUESTION.
Are there any Cellular automata, in which the larger configurations that are created, are not only products of the cell-calculations, but themselves then influence the direction of the morphogenesis. At present all the CA that I know get their results, and sometimes beautiful patterns, by promoting interactions between cells and their neighborhoods, and only these. **Are there exceptions to this rule**?

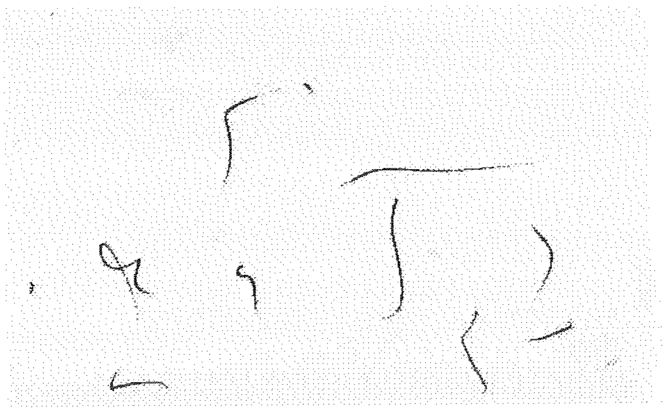
Basic elements of structure, primitives, etc

- Basic element is a center.
- A center has a value, weight or degree of liveness.

- A center is a field-like thing that appears in a set.
- It has a boundary.
- It has a feathering out to a distance.
- The liveness of a center is a function of the liveness of its component centers – these are any centers linked to the center in question, both those that are smaller, those that are same sized but adjacent, or those that are larger.
- Associated latent centers.

How are centers detected?

Consider this example:



Within the whole which is seen here, the imperfect vertical rectangle in the middle is perceived as a center. But this perceived fact comes from way the figure is seen as a whole. The larger whole, surrounding the rectangle, and forming a surrounding field which points inward towards it, gives the rectangle its force and its centrality.

Getting A First Approximation Of The Wholeness

Edge Detection

Software from Image Fusion Systems Research
(http://www.imgfsr.com/ifsr_nflsp.html)

- Edge $300
- Line $330

Edge Sharpening

Software from Image Fusion Systems Research

- Intensity Stretching $35
- Image sharpening $50

The Semi-lattice of Centers

Let us assume now that a map will be made, of all the strong centers in a given area of space. We may then have the following helpful possibilities:

- There will be many overlaps of centers, usually with the property that the common area of two strong centers will (usually, perhaps always?) itself be a strong center.
- Is it possible to recover the geometry in 2D, from this map of overlapping centers?
- In general, where there is an overlap, this will typically create a rigid relation in space, of the two larger centers that share this rigid "pivot". If this is always true, that is helpful, and makes it more likely that we may be able to recover the geometry from the semi-lattice.
- Can it be proved that this will always be possible?
- Or, if not, can one state conditions on the system of centers, that will guarantee that it can be done?

If this can be done it will be very exciting, since one then has the possibility of going back and forth between the configuration structure, and geometry of the plane configuration. A huge result, if this is so, or can be made so!

- A curve, whose curvature is varying, can be approached with a succession of overlapping circles, which get smaller as the radius of curvature gets smaller, and become larger as the radius of curvature increases.

- This series of circles of varying size -- and their areas -- may be a necessary part of the curve, and also helps to meet the rigidity requirement.

The Recovery Algorithm

What is the recovery algorithm? It is procedure which starts with the list of centers, their inclusion relations, and their overlap relations.
Can one obtain the geometry from this information alone?
Or, do we need detailed Cartesian coordinates for each center? If we do, then there is nothing to recover. We simply plot the position of each center, overlaid on a map, and fuse the layers to get the complete configuration in a single layer.

How much information do we need, to tie the centers together. Is the system of overlaps enough. Not, obviously, without size information about the centers. So how are they given their dimension – in what form. If they are to scale, it may then be that the rigidity of the system, caused by the overlap in centers of non-trivial area, will be enough to work out how they have to go together geometrically.

This needs to be tested, or proved.

What is the best way to display the wholeness?

- Is it a list?
- The list will have a semi-lattice structure.
- The larger must precede the smaller.
- Some dimension is associated with each center.
- The strength of "degree of life" is also shown for each center.

This is a very long list.

To be graspable the list must be shown in smaller groups. For Example:

It may be that the wholeness is only the topmost structure, visible at the scale of a given center. Thus the wholeness of a given center, is the system of major configurations which provide the essential configurational form of that center, only up to a certain level of approximation.

If we want more detail, we look down to one of the component centers.

How can we make this idea operational and practical?

A Proposal

Each center has, at its own scale, a system of smaller centers which provide its main configuration. Possibly it also needs to be stitched to the larger centers that hold it, once again only one order of magnitude larger.

Field effects

How is the field effect of morphogens in an embryo, or pheromones in a termite colony, actually represented in CA.

The Idea of A Center Making Calculus

We have a contemporary saying that we don't really understand the meaning of: the whole is more than the sum of the parts. The new calculus could show what that means, and possibly be taken up quickly as a result.

Children seem to know wholeness. Perhaps it gets taught out of them at an early age because the emphasis on arithmetic is so great. Indeed one can't get along in life without knowing arithmetic. Teaching of the new calculus needs to take its place next to arithmetic so that the two go hand in hand in early education.

The calculus would have to express how things are in relationship to one another. It would have to be flexible enough to encourage experimentation -- trying different relationships (moving parts or centers) to see which relationship works best.

Can the calculus be done on the map -- teach wholeness through the map. In many cases it is a rare opportunity for people to consider the wholeness of anything, if they have to keep coming back to the map to consider how the center they are preoccupied with fits in the whole.

The website can support people with what we have so far. Then we can use it to roll out the new calculus when it's ready.
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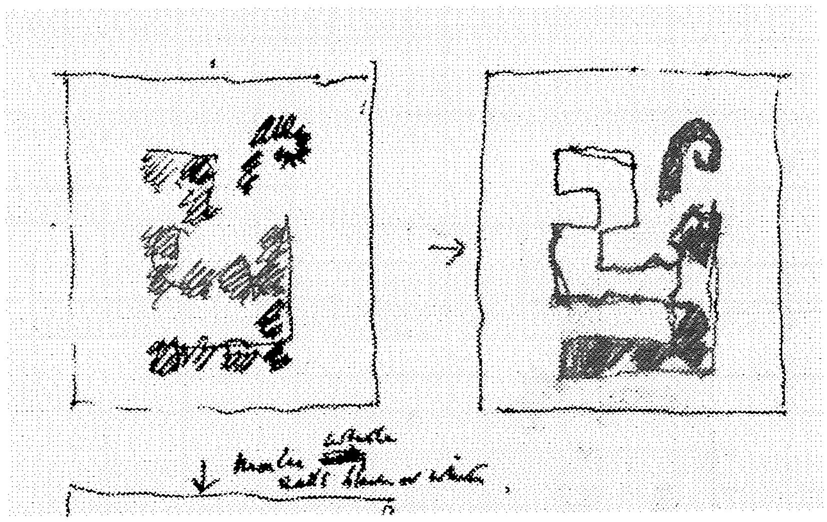
Definition of "a Configuration"



The left hand drawing was the starting point, drawn over a 1/8th inch grid. The right hand drawing was the beginning of an attempt to "regularize" it by sticking more closely to the grid. As you can see it already went badly off the mark, and I stopped drawing.

I originally started with the hope of finding something (by eye) in this drawing that I could call "the" wholeness. Even though I tried to capture the important contours, in the right hand drawing, it was still mindless copying. But the right-hand drawing completely fails to capture the actual wholeness of the left-hand original. You can see this, in particular, if you look at the white space in the left, and in the right. The right-hand one grossly simplifies these white spaces, and loses the form and character of the drawing.

In order to capture the configuration properly, I have concluded that the representation of the drawing must contain the following:

(a) The drawing itself
(b) A list of all the visible centers, in their detailed form, and with their significant sub-centers also included in the list.

(c) With the centers is shown the semi-lattice of inclusions, showing which centers are part of which others, and also showing overlapping centers, and their overlap (this comes automatically with the semi-lattice)
(d) Each center is given a measure showing its relative degree of life.

Max Wertheimer, Laws of Organisation in Perceptual Forms, 1923

Final paragraph:

“Epistemologically this distinction between "above" and "below" is of great importance. The mind and the psycho-physiological reception of stimuli do *not* respond after the manner of a mirror or photographic apparatus receiving individual 1. stimuli " *qua* individual units and working them up "from below" into the objects of experience. Instead response is made to articulation as a whole-and this after the manner suggested by the Factors of Sec. VII. It follows that the apparatus of reception cannot be described as a piecewise sort of mechanism. It must he of such a nature as to he able *to grasp the inner necessity* of articulated wholes. When we consider the problem in this light it becomes apparent that pieces are not even experienced as such but that apprehension itself is characteristically "from above".”

Similarity

Perception of form is perception of similarities and differences in the wholeness field. Edelman et al.

First Steps of an Algorithm

- **Step 1.** Consider the configuration as an array of pixels or raster. That means, it is simply an array of dots, with two or more colors. This array does not, as such, have any structure. So far, it is just an array of dots.
- **Step 2.** Identify the centers that exist (can be deciphered) in the array.
    - This is to be done by an amalgam of the principles identified by Wertheimer, Kohler, Koffka and others.
    - Sets will be selected to assign a measure on these principles, arithmetically weighted.
    - The structure of the sets picked out will be ordered as a semi lattice, by inclusion.
    - Each set has an associated degree of coherence, measured by a process to be defined.
    - Centers are associated with their geometrical position by superposition on the array.

- **Step 3.** This system of centers is defined as **the** wholeness of the array.
- **Step 4.** We notice that the wholeness is very vulnerable to small changes in the array. Even when a few small points are modified in the array, very large changes in the measures of the sets, and therefore in the overall configuration, can arise, so that an entirely different wholeness may come into existence, even though the actual geometric changes made in the array are very small. This is a vital feature of wholeness – somewhat similar to the butterfly effect in dynamic systems, but in this case purely spatial in its origin.
- **Step 5.** Note, in particular, that the wholeness, being principally dependent on the system of local symmetries generated within the array, internally, changes instantaneously, when small changes are made in the array – because, for instance, a long range local symmetry reaching across hundreds of pixels, can appear or disappear with only one or two pixels changing color – thus altering the balance and coherence of the centers entirely.
- **Step 6.** A further note. In most physical systems, interaction between distant loci is caused by a physical process which propagates, and therefore limits such a process to the speed of light. But in the changes of the wholeness, there is no speed of light limit on the propagation of the effect. The whole reacts, instantaneously, as the array changes, and any effect on the wholeness itself, propagates instantly.
- **Step 7.** Once we have the wholeness, we may then attempt to make changes in the array, which will be based on the fifteen properties. Using a random walk hill-climb, we may attempt to find better arrays, that have a higher scoring wholeness. The process of making this hill-climb economical has yet to be examined.
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More Detailed Steps of Step 2, the Perceiving Algorithm

- Let us now look, in more detail, at the way a perceiving algorithm can work, to pick out the coherent centers.
- Edge detectors.
- Locally symmetric sets
- Fitting a curve?
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- Proximity
- Closure
- Good continuations
- Simplicity
- Similarity
- Figure and Ground
- Common fate

Photoshop Algorithms

Here are some existing standard algorithms that could play a useful role in center detection.

- Contrast, increasing, decreasing, in combination with changes in brightness. This often brings out the wholeness effectively. What are the algorithms for these processes.
- Collapsing and enlarging a picture, by reducing or increasing number of pixels. What is the algorithm?. When we change scale, what is the algorithm, and does it preserve wholeness?
- Contours. Can we construct a series of isobars for an imaginary landscape, in the sense that if there is a smooth landscape, it may reveal the wholeness more clearly?
- Is there a leveling and sharpening algorithm, which smoothes out shape, or intensifies shape?
- Interpolation of grays on a different curve? Is there such a process?
- Invert black and white. This can be helpful in determining positive space. How does it work, or how might it work?
-