SYSTEMIC THINKING AND CIRCULAR FEEDBACK CHAINS IN A LIVE-ELETRONICS ALGORITHM FOR *GOSTO DE TERRA*

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RÉSUMÉ

La formalisation de certains présupposés de la pensée systémique dans un algorithme live-électronique à l'intérieur d'un patch de Max/MSP 6, fait partie de ma pièce *gosto de terra*, pour piano et live-électronique. Cela montre une possibilité de traiter des concepts comme *différence*, *information*, *numéro*, *quantité* et peut-être *pattern*, à la programmation dans un contexte musical qui intègre l'interprète, l'instrument, l'espace acoustique et l'algorithme dans sa conceptualisation. A partir des idées de Gregory Bateson sur ces concepts, le patch tente de recueillir des informations sur la performance, par des différences de second ordre, en comparant les différences entre les quantités dans le temps. Ceci est fait en comparant leur flux selon un seuil, qui établit un contrôle de "sensibilité". Le résultat de l'algorithme peut être utilisé pour déclencher d'autres algorithmes dans le patch, ce qui entraîne un fonctionnement du live-électronique suivant les caractéristiques prévues de la performance live.

ABSTRACT

The formalization of some presuppositions stemming from systemic thinking in a live-electronics algorithm within a Max/MSP 6 patch, is part of my piece *gosto de terra* for piano and live-electronics. It shows one possibility of dealing with concepts as *difference*, *information*, *number*, *quantity* and possibly *pattern* in programming within a musical context that integrates performer, instrument, acoustic space and the algorithm in its conceptualization. Following Gregory Bateson's ideas on these concepts, the patch tries to gather information about the performance, through second order differences, by comparing differences between quantities in time. This is done comparing their flow against a threshold, that sets a "sensibility" control. The result of the algorithm may be used to trigger other algorithms in the patch, resulting in a functioning of the live-electronics that follows the intended characteristics of the live performance.

1. INTRODUCTION

This text focuses on the formalization of some presuppositions in systemic thinking, in live-electronics algorithms within a Max/MSP 6 patch. They are part of my piece *gosto de terra*, for piano and live-electronics. The composition was finished in august 2013 and revised after the first performance, together with the pianist Adam Marks, to whom it was written for. It deals with different concepts included in the discussions presented in my doctoral dissertation.[1]

2. PRESUPPOSITIONS

The dissertation deals, among other discussions, with concepts stemming from Gregory Bateson's systemic thinking. In his book *Mind And Nature: a necessary unity* [1], he sets out to explain and exemplify a series of presuppositions that form the basis not only of further ideas developed in the text, but also of his whole systemic approach. The book was written by the end of his life, and according to his daughter Mary Catherine Bateson, co-author of some of his texts, it represents the real synthesis of his work and "the first of his books' composed to communicate with the nonspecialist reader" [3]. Ramage and Shipp summarize some of his main contributions as a systems thinker and note that the whole pattern of his work is still in the process of being understood and appreciated [8].

Bateson was concerned with *mental process* and how looking at it from a very different perspective could shed some light on different complex processes in nature. Apart from discussing his ideas in relation to musical composition with open forms, with it's consequences for the construction of graphical scores (those that use non-traditional musical notation) and the understanding of musical performance situations that imply improvisation by the performers, I have tried to implement them as the basis for interactive processes in live-electronics. This approach draws its perspective from *holism*, which in Bateson's definition is: "The tendency in nature to produce from the ordered grouping

[1] My doctoral research has been kindly supported by a scholarship from the German Academic Exchange Service (DAAD), that enabled an internship at the Universität der Künste (UdK-Berlin, under Prof. Dr. Dörte Schmidt). This has been a joint effort with the Brazilian Government, through my leave at Universidade Federal do Rio de Janeiro (UFRJ) and my doctorate at Universidade Federal do Estado do Rio de Janeiro (UNIRIO, under Prof. Dr. Carole Gubernikoff and Prof. Dr. Vania Dantas Leite).

of parts complex wholes with properties that are not present in or predictable from the separate parts" [3]. M. C. Bateson notes that Gregory frequently used the term and its adjective "holistic" to refer to modes of acting and observing that are attentive to holistic properties. These wholes have characteristics of self-organization, that are intimately linked to the presence of *circular feedback chains*, responsible for the dynamical self-regulation of the system. That is, different interacting components mutually affecting each other show emergent properties and characteristics that are sustained by their interaction [6]. The idea of *emergence*, in this sense, presupposes the understanding that that which emerges is: *irreversible*, can only be studied taking *time* into account and cannot be replicated; and *irreducible*, it resists a study through the reduction to its smaller parts. For Morin, "what is important in emergence is the fact that it is indeductible from the qualities of the parts, and thus irreducible; it appears only parting from the organization of the whole" [7]. Demo stresses that complex phenomena "produce modes of being that are always of becoming as well. They behave in a reconstructive way: they do not reproduce themselves linearly, they reconstruct themselves non-linearly" [5].[2]

For complexity studies, the whole is more than the sum of its parts, but it is, *at the same time*, less than the sum of its parts, whose qualities and properties can be inhibited by the organization of the whole. As Di Scipio puts it, "once the whole has emerged, it can reduce or inhibit the action of specific individual components. Take, for instance, a large-scale social organization: however complex, varied and efficient in its performance, the whole organization can never be as rich and complex as each single human being participating in it. It induces simplified, typified behaviors that are functional to the whole, but detrimental to the individual" [6].

Looking for complex behavior in the construction of the live-electronics algorithm in *gosto de terra*, I have focused in four of Bateson's presuppositions regarding different aspects of the functioning of circular feedback chains in mental process.

2.1. Difference and information

First, for Bateson "information consists of differences that make a difference" and difference "is a non-substantial phenomenon not located in space or time." He stresses that to produce news of difference, i.e., information, there must be a relationship between two different parts of a system, or the same part in two different moments, "such that the difference between them can be immanent in their mutual relationship" and the whole process be such that news of that difference can be represented inside an information-processing entity, such as a brain, an ecosystem or a computer [1]. To better clarify, it is important to understand that the difference that makes up information is a *class* of some sort of differences, immanent in the relationship of the involved parts. It is a second order difference, which can only make sense if regarded in its context. And that, for Bateson, "change" can be seen as a "difference which occurs across time" [2].

2.2. Number and quantity

Another presupposition that Bateson points out in *Mind and Nature* refers to the difference between number and quantity. What matters to him in this difference are not really their names, the way we describe these categories in words—number and quantity—, but the fact that the formal ideas behind them are immanent in the processes observed. For him, "number is of the world of pattern, gestalt, and digital computation; quantity is of the world of analogic and probabilistic computation" [1].

Drawing from examples coming from organic life to explain the concept, he refers to a flower that has five petals and many stamens. The number of petals will stay the same from one individual to another, but the number of stamens will vary enormously. Bateson tries to explain that it seems clear in biological terms that the pattern differences of smaller numbers, like three and five for example, are drastic and form even important taxonomic criteria. On the other hand, after a certain size of number, they become quantity, meaning that for the organism there is a different process going on for that part of its growing form: "numbers can conceivably be accurate because there is a discontinuity between each integer and the next. Between *two* and *three*, there is a jump. In the case of quantity, there is no such jump" [1]. He asserts that this difference is basic for theoretical thought in behavioral science, since it reveals two very different ways of conceiving the relation between parts of organism or between parts of processes in nature. For him, numbers are the product of counting and quantities of measurement, and therefore always approximate.

2.3. Digital and analogic

Extending that concept to the difference between digital and analogic systems, he writes: "digital systems more closely resemble systems containing number; whereas analogic systems seem to be dependent more on quantity" and goes on to clarify that in digital systems there is a discontinuity between "response" and "no response", yes and no, on and off [1], 1 and 0. Its parts function like a *switch*.

Looking at a switch from the point of view of the circuit, it does not exist when it is turned on, since in that case it is not different from the rest of the conducting wire. Similarly, when the switch is off, it also doesn't exist from the point of view of the circuit, since the conductors themselves only exist as conductors when the switch is on. "In other words, the switch is *not* except at the moments of its change of setting, and the concept 'switch' has thus a special relation to *time*. It is related to the notion 'change' rather than to the notion 'object'" [1].

[2] "(…) produzem modo de ser que são sempre também de vir a ser. Comportam-se de maneira reconstrutiva: não se reproduzem linearmente, reconstroem-se não linearmente."

2.4. Quantity and pattern

In trying to explain what he understood as pattern, Bateson points out the phenomenon of *moiré* among other examples, which can be explained by looking at Fig.1, where a third pattern *emerges* (to the right) from the superposition of the other two. Moiré phenomena are actually a classical example of emergence and to truly comprehend its implications, one has to try the superposition (e.g., with two sheets of transparent paper with the pattern to the center printed on them) and see how a slight change in the rotation angle can yield a drastic change in the resulting pattern.

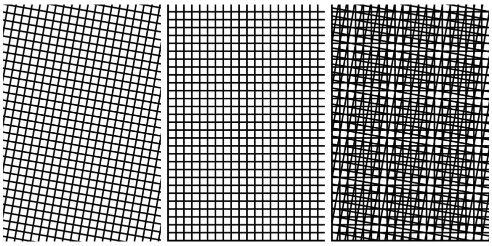

Figure 1. Moiré phenomenon: a third pattern emerges from the superposition of other two. (Source: Wikimedia Commons, Moiré_grid.svg, modified for the purposes of this text.)

For him: "First, any two patterns may, if appropriately combined, generate a third. Second, any two of these three patterns could serve as base for a description of the third. Third, the whole problem of defining what is meant by the word *pattern* can be approached through these phenomena." What triggered the solutions used in the constructed algorithm, was Bateson's observation that "*a ratio between two quantities* is already the beginning of pattern" [1]. So, if it would be possible to measure quantities in a digital system *and* gather information about differences in a given quantity in time, then quantities could be compared and a ratio between them may show an emergent pattern.

3. FORMALIZATION IN LIVE-ELECTRONICS

The patch[3] for *gosto de terra* tries to implement these ideas in a live-electronics setting, understanding it as part of a system.

3.1. The system, of parts and their interrelationships

Bateson clarifies that "the basic rule of systems theory is that, if you want to understand some phenomenon or appearance, you must consider that phenomenon within the context of all *completed* circuits which are relevant to it" and that a system "is any unit containing feedback structure and therefore competent to process information" [4]. Following the model drawn from systemic thinking, that a system is constituted by its parts *and* the interrelationships between them, the algorithm presupposes that this system is formed not only by the algorithm and its formalization in a Max/MSP patch, but also by the piano itself, with the sounding result of the interaction between the performer and the instrument, in a given acoustic space. The interactions between these four parts of the system (algorithm, performer, instrument and acoustic space), in turn, are dependent on the interface between: a given way of capturing digital data from the live performance and of returning the result of the algorithm to the acoustic space, i.e., to both the performer and the sound response of the instrument. In this case: a microphone is used to transduce typical aspects measured from sound (frequency and amplitude) and make them available as numbers to the digital system through FFT (Fast Fourier Transform); and loudspeakers that project sound back to the acoustic space, yielding possible sound responses of

Figure 2. User interface for the patch of *gosto de terra*.

[3] Fig.2 shows the user interface of the patch for *gosto de terra*, that can be obtained contacting the author. The score of the piece may also be obtained in the same way.

the instrument, by acoustically exciting vibration of the strings, but also responses of the performer that is encouraged to listen and respond musically to the sound result of all parts involved.

3.2. The "stable?" and "unstable?" algorithm: a jump between number and quantity

Typically, a digital system following the flow of data of a live performance in time returns a flow of numbers, but doesn't tell much about quantities in that flow. To bridge that gap, the algorithm compares the flow of numbers in *time*. Comparing a measurement of numbers in a given moment of the flow to the same measurement on a immediately subsequent moment, it returns equality (1) or inequality (0) of these measurements. This information is gathered for a relatively much longer time span and taken as a *set* of results. This set is then compared to a threshold, and the algorithm programmed to return the state of the set according to that threshold: if the quantity of equalities is above or below the threshold.

For example, analyzing the subpatch shown in Fig.3 from top to bottom, as this is the direction of the data flow in the patch, we have the following steps:

1) The flow of frequencies captured by the microphone, expressed as real numbers (floats), is analyzed and the result passed around every ten milliseconds (*speedlim* object). The *mean* value of about the last hundred values is rounded to a natural number.
2) Two subsequent results in time are fed through the *bucket* object to the "= =" (exactly equal to) object, which compares them and returns one (1) for an equality or zero (0) for an inequality. The second *zl stream* object gathers these results into a list.
3) The list of ones and zeros is shown in a *message box*, for a visualization of the set of results in time.
4) The quantity of ones in the set (*zl sum* object) is compared to the threshold through the ">" (greater than) object, which returns one (1) if it fulfills the condition or zero (0), if it doesn't.

In other words, the algorithm returns if frequencies are stable (not changing) in the performance, at any time. If instead of greater than (>) a smaller than (<) comparison to the threshold would be used, the same algorithm would return the information that the frequencies are unstable (changing in time). The result, one (1) or zero (0) according to the fulfillment or not of the given condition for the comparison to the threshold, is shown in a toggle object, that goes on and off (seen right below the first outlet of the patch, in Fig.3). This change of state triggers other algorithms in the live-electronics.

An information about the performance is gathered from a difference in quantity, according to a threshold. This difference is the result of a series of differences gathered from the flow of numbers in time, it is a second order difference, that tells something about the musical discourse, as it happens.

Since the accuracy of numbers does not matter much for the gathering of information about quantity, the flow goes through a series of approximations, so as to be useful for the comparison between numbers representing the flow of data in time. That is to say that the algorithm presupposes an amount of "coarseness" as necessary, or the jump to quantities wouldn't be possible from a flow of numbers. This, on the other hand, gives a certain "organic" characteristic to the result, that mirrors something like the "overall" characteristics of moments of the performance and not the accurate numeric details.

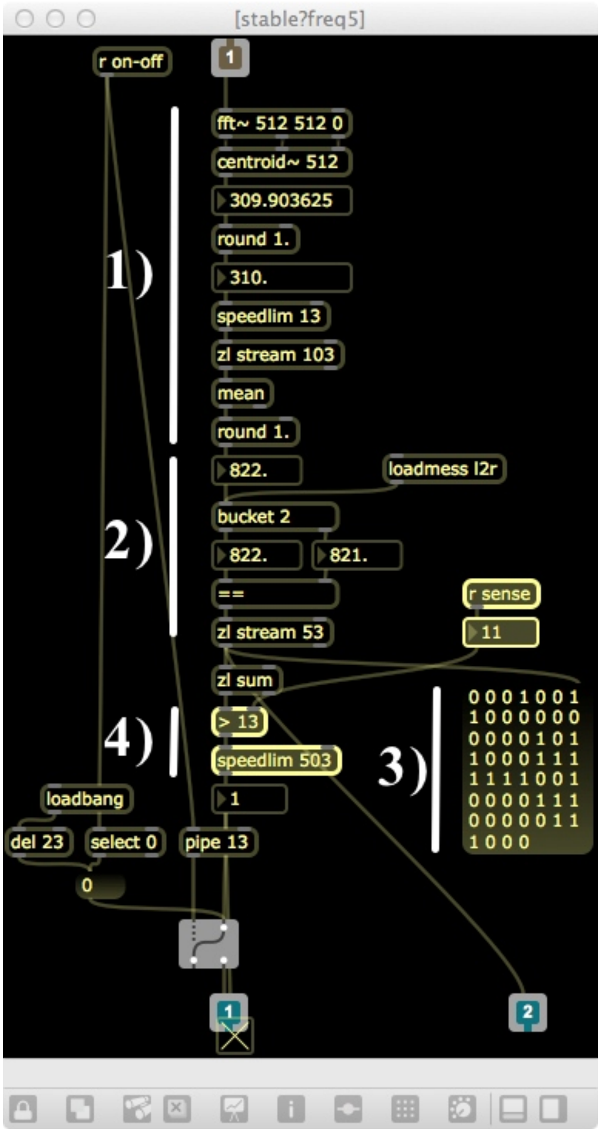

Figure 3. One instance of the subpatch "stable?" in the patch of *gosto de terra*: 1) data is treated; 2) compared in time; 3) visualized as a set of results; and 4) compared to a threshold.

A control of the number given as threshold can be seen as a control of the "sensibility" of the algorithm: a smaller number as threshold, makes the algorithm react to a lesser quantity of differences (more sensible), and a bigger, to a grater (less sensible). The value of the "sensibility" control, seen at the lefthand side of the user interface in Fig.2, is sent to the algorithm via the *receive* object named "r sense", highlighted in Fig.3.

3.3. Triggering other instances of the patch through the algorithm: the use of a third order difference

Following this, a second instance of the same algorithm is applied to the same flow of data in the patch (see Fig.2, “p stable?freq5” and “p stable?freq7”), but with a different time span. In Fig.3, the time span is given by the highlighted *speedlim* object with the argument 503 (five hundred and three), which means that the result of the comparison with the threshold, from the “>” (greater than) object, will pass only about every half a second (five hundred and three milliseconds). In the second instance mentioned here, this argument is set to 701 (seven hundred and one) milliseconds. The results of both instances are then coupled, and the big *toggle* object shown in Fig.2 —at the center of the patch, right above the window that shows a wave form, where a written information is given: “when stable: record”—, will only change its state if the value (1 or 0) of both instances coincide at any point in time. A third order difference is achieved through another comparison or ratio between quantities. The information about the stability or instability of frequencies in the performance is double-checked in different time spans. As indicated by the written information in the user interface, if both instances return an equal result, at any point in time, the recording is on, if unequal, the recording is off: the patch starts recording the performance when the algorithms detect any stable frequency that comes through the microphone for about half a second. The waveform of the recording is shown in the window below the toggle and, of course, changes during the performance.

The systematic use of prime numbers as time spans or number of elements in sets of numbers that refer to quantities, is a way of trying to avoid temporal constraints in the functioning of the algorithm (and, in fact, of the whole live-electronics system for *gosto de terra*) that would resemble an idea of time as isometric. The characteristic of prime numbers, i.e. their property of only being divided by themselves or one, increases the possibility that there will **not** be any co-incidence (literally understood) of events in time, reinforcing non-linearity —a characteristic also found in organic systems — and, in that way, the feeling of organicity implied above when referring to “coarseness”.

3.4. Circular feedback chains

It is interesting to note, that the microphone is used in the system not only to record sound from the live performance, but also as a kind of sensor. It is used for its capacity to sensor differences in time, transduce them and make them available to the algorithm described.

The recorded excerpts of the performance are used in a special convolution process with the sound result of the piano, i.e., of what is being played live by the performer. When the recording is triggered by the algorithm, it will obviously record anything that comes through the microphone, feeding the convolution with chunks of sound that have stable frequencies, but that also carry with them any musical content sounding at that moment, including sympathetic vibration of the strings, sounds in the piano body, anything played by the performer, acoustic responses of the performance space and so on.

Circular feedback chains are created, where the live-electronics influences itself, but is also influenced by the performer’s intentions, through listening and playing, responding to the whole sound space created. On the other hand, the performer has a certain control of the response of the algorithm through the performance itself. It feels possible to control the electronics by the very playing of the instrument. The patch helps the process, showing to the performer in written text, but also visually, what is happening in the algorithm.

In that way, one interesting result that may be the indication of the pattern that emerges from the compared differences in quantity, is the small window with vertical lines to the right side of the big *toggle* (Fig. 2). Every vertical line is the representation of a 1 (one) from the *set* of ones and zeros gathered by the algorithm in the *message box* linked to step 3) of the description of the algorithm in 3.2 and Fig.3. These lines move from right to left when the sound processing of the patch is on. When frequencies are stable, many “ones” are generated by the two instances of the algorithm, and more lines move in the small window, with more density in time, emulating a flux that gives a hint of when the recording will be triggered or not.

In the same way, the piano becomes active in the system when there are sympathetic vibrations of the strings, as does the acoustic space, resounding with its particular acoustic response what is fed to it by the performance. The piece adapts itself to all this factors without loosing a certain identity: there is a recognizable sound characteristic of the whole process, tied to what the score defines as the musical content to be sought, and dependent and independent, at the same time, of all parts of the system and their interrelationships.

4. CONCLUSIONS

The described algorithm is, of course, only one way of looking at the formalization of these presuppositions in systemic thinking. Dealing with concepts as difference, number and quantity in such a way, seems to point to the possibility of developing further formalizations that may be responsible for the emergence of complex patterns, specially if ratios between quantities could be formalized in such a way that they themselves yield second, third and maybe higher order information.

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