From the Model to its algorithmic application

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1. INTRODUCTION

To begin with, I should like to cite the influence, both direct and indirect, of the following disciplines on my personal research: philosophical reflection, linguistics and physics. I will do this by briefly sketching the fusion of these disciplines, not strictly with my music itself, but with my manner of conceiving music and the role it plays as the foundation of a personal aesthetic.

A philosophical system is a work complete in itself; this spirit of system can no doubt be supported within the framework of a musical composition. In philosophical research there is a sort of obsession with the idea of pushing ever further the limits of an investigation of thought, thus giving justice to the system by bringing it to the virtually unsurpassable limits in the midst of which can be found the freedom to totally rethink a given problem. These situations near the limits give rise to the possibility of formulating the limits of intelligibility. This research is the search for truth, a truth which can guarantee a framework of ideas. Linguistics, and more precisely semantics, allow one to evaluate the structure of meaning by studying the processes of intelligibility inherent to language. Physics, for its part, allows one to evaluate experimentally, scientifically, based on the knowledge that we have about the complex processes which generate our natural environment.

Music, in a certain manner, evokes a capacity for concentration that is practically abstract in nature. It achieves this by placing categories into action; in other words, objects[1] of diverse qualities are submitted to various fluctuations, dynamic and temporal. These fluctuations could, for example, capture the listener's attention, then shake his perception, thus finally eliciting emotion. A certain musical category is fairly compatible with the idea of concept in language. Its function is, likewise, to evoke an image, a moment infused with sense; the specific meaning is of little importance, because the overriding importance is in the trajectories within space–time that these changing significations trace. Sounds are remembered much more clearly when they are presented within a frame of reference which gives points of comparison for the listener. Musical intelligibility is found in this precise level of perception: the dynamic recognition of instants, their identification and their sequence. The quality of an object is therefore external to its contents, it rests in the object's internal dynamic; in other words, in all the characteristics that design its relation within a given space–time (its direction, volume, resistance, etc. . . .).

Once the composer has created a model, or borrowed a nonmusical paradigm, to begin the actual composition he must perform a transformation such that the internal dynamics of the model can be applied to music. This means translating the internal organisations into musical potentials. This provokes the question of why should one make use of models which lack a direct perceptual connection to music. All abstraction, whether scientific or conceptual, is only legitimate for music when the dynamic properties of the object are considered. These dynamic properties are directly related to musical emotion, which represents the terrain of musical sentiments. There is, therefore, a constant struggle in the construction of such an object, since all systems not based on acoustic realities will naturally resist their musical coding. It is thus legitimate to aim not simply for an objective reality, as does Xenakis who creates a mathematical world of calculations whose results offer a sonic representation of the equations that were used, but to take inspiration and seek integration, holding in view musical mechanisms while using the model. Thus, one can hope to achieve effects on the level of emotion from the workings particular to the world of sounds.

Composers who explain their works by using images borrowed from painting, literature, other arts or science do not present a very convincing basis if they underestimate the direct relationship between musical technique and the representation of the model that they have selected. This is no longer a true

[1] The musical objects referred to here are not meant in the normal sense – thus to clarify how the term is used I will define what is meant by this use of the term. A musical object might, sometimes, refer to a musical characteristic, such as the repetition of a trill, a glissando, or the same note, while at other times it represents, at a larger perspective, the process of an entire mass hypothetically locked in obedience to that process, which finds its identity in the actions of the process.

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case of models, but of evocative references that inspire a composition. Therefore, the transition from metaphor to composition is always forced to remain evocative in nature.[2] To be more convincing, the model must be used in the strict sense; thus, conforming to a strict musical coding. This is necessary because the use of a model does not, in truth, concern the model itself but rather what the model expresses musically; its external structure.[3]

When I began thinking about *Network*, I was confronted by many questions. The first concerned the idea that I wished to express (What do I want to say?). This question poses two distinct problems; firstly, the plausibility of what I wish to express in musical terms and secondly, the musical processes which contain the possibility of turning those ideas into a sonic form. At the same time, I was looking for a radical means of controlling all the parameters involved in writing for the orchestra. Although all composition poses this same type of problem, idea and realisation, the conjectures behind *Network* were centred on the idea of resolving this problem through a specific systematisation (in this case a basic algorithm) to treat globally all the parameters to translate an idea into a form executable by an orchestra. My central preoccupation in *Network* concerned the function of memory and its role in the creation of new musical structures. It is from this preoccupation that I derive what I call 'the aesthetic of disappearance', which I will deal with in more detail in another section and which forms, in a certain manner, a musical paradigm.

2. MEMORY AND REPETITION

I consider there being two distinct types of memory: a memory that extends throughout time without a specific limitation to a given psychological duration – I qualify this as nontemporal memory – and an active memory that exists as instants that may be longer or shorter, but are limited to perceptible durations. In music, these two types of memory are in opposition. The virtual limits of nontemporal memory dissimulate behind the significative limits of active memory and, through saturation, active memory fades back behind the nontemporal memory creating a dielectical game of durations. Taking into account the inherent fragility of musical time, composition returns to sometimes increasing and sometimes decreasing the instances of one or another of these memories.

Musical time passes through a perspective made of volumes and durations that are continually changing against the background of an immemorial and intemporal pulsation. Nontemporal memory interrogates passive listening in the sense that it forces us to rely on a temporal absolute, what Xenakis calls the 'out-of-time'.[4] Active memory, however, interrogates active listening. This deals with music's immediate capacity to elicit variations on the levels of attention in a listener, through the construction of mnemonic structures which constantly effect the perception of these variations.

The principle of a mnemonic model in music is based on repetition: repetition of a cycle, repetition of a model, or repetition of durations. Memory is essentially based on repetition, psychological repetition of nontemporal memory and cyclical repetition of temporal memory.[5] In essence, repetition assures both identity and variation. The basic identity is the model, variation is the repetition of the model transformed; together they form the difference as described by Gilles Deleuze.[6] On the formal level, as much as in the specific parameters, repetition is the essential principle behind musical organisation; it assures both the power and the coherence of a musical discourse. Together as an entity, identity/variation constitutes the dialectic equilibrium fundamental to musical time. Different musical systems have attempted other means of resolving this equilibrium, to the point of forbidding repetition (at least thematic repetition); this repetition was replaced by the repetition of the series, thus weakening tonal logic and eliminating initial function. Serialism, by declaring repetition forbidden, has relegated musical identity to a new role, that of assuring the structural coherence of parameters and form. As a reaction in the face of that heritage, memory finds itself shaken and a re-evaluation of the function of identity in memory is forced.

One must stimulate the role of active memory in musical technique. Even though this memory cannot hope to achieve the Utopian ideals of permanence and transcendence, it nevertheless conserves the

[2] The examples of musicians who have tried to translate physical phenomena into a musical representation are few. Even J. C. Risset, a composer with scientific training, in his work *Moments Newtoniens*, which is a homage to Newton and attempts to represent certain of the physicist's famous laws, recognised that he could not try to take the real laws and their resulting calculations as a literal model. On the contrary, to express the law of gravitation he turned to the common perception of a scale descending from high frequencies to low ones; this is a common image but does not, in fact, conform to any objective scientific truth.

[3] Even if a composition is inspired by an image, this in no way obliges an intention to make the image audible to listeners. Paradoxically, it is not possible to solidify into sound what can be solidified in words or images.

[4] The 'out-of-time' ('*hors-temps*') in Xenakis' music is typically part of the musical body. Scales, such as the Pythagorean which divides the octave into many parts through a precise ratio of divisions, are an example of this 'out-of-time'. By contrast, 'in-time' represents the ornamentation of the above-mentioned scales.

[5] For a more complete discussion of what I mean by repetition, the reader is encouraged to consult my thesis (in French), *De la répétition comme object de la fascination dans la musique*, Université Paris VIII, Paris (1985).

[6] Deleuze, G. 1968. *Différence et Répétition*. PUI, Paris.

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dynamic characteristics essential to music. The multifaceted nature of memory in music must be respected without giving up too much to predictability. One must remember that there is a disassociation of the mnemonic functions in music: on one side the structural functions and on the other side perceptive functions. Repetition suspends time and, thus, guarantees a virtual continuity of identity in time. The thematic model, which should permit mnemonic cohesion by periodically validating the links between the past and the present, has lost its evocative power when represented within the context of contemporary music. This loss allows for a new dimension in musical form that lies within the margins of traditional forms.

This new dimension, basically a close focus on the dramatic narrative, places a strong emphasis on figurative representation[7] and a more abstract approach to time. The aesthetic of disappearance that was referred to earlier, and of reminiscence, is a theoretical concept that is designed to correspond to a particular progression of memory in time. This progression has a discursive tendency, or perhaps deductive; this new dimension is exploited in my recent works and consists of an equivocal representation of lines, points and local forms (as opposed to large form). I consciously borrow from my professor Joji Yuasa the term 'plasticity' to designate that universe which is at once a choreography of objective sound and of 'sonic material', as defined by Iannis Xenakis, which takes its form in space–time. This is coupled with the emotional instability which results from a mode of deductive thought flowing from algorithmic composition. This is not to suggest that algorithmic composition excludes in principle the dimension of affect; on the contrary, it is on this level of the technique of algorithmic composition that the emotional form must be evaluated. An algorithmic realisation is faced with the task of unveiling the hidden connections between the inexpressive data returned by its operations and their musical and emotional incarnation.

3. THE AESTHETIC OF DISAPPEARANCE

I will briefly explain the principle fundamental to my research by describing a schematic visual example of the progressive transformations that intervene in the development of this process.[8] Visual and verbal images translate relatively easily into concepts. Musical images, however, often suggest things to the listener without making it possible to represent these impressions as concrete ideas. As a result of this the different steps of appearance and disappearance seem debatable in their final interpretation by a listener. One of my considerations is, of course, to know if a listener can identify with this more abstruse type of musical expression. One must simply assume that the state of abstraction is only an intermediary level which may appear grossly overexposed and arbitrary at first contact, but must be present so that a level of emotional depth below this surface can patiently relink the abstraction to a concrete reality. This is the wager I place in writing these works.

The above example represents a visual comparison of a sensory phenomenon that I seek to represent musically. By forcing perception to assimilate auditory images, a manifest transformation is produced in the concept, such that sounds which are not measured by a changing focus have only an undifferentiated formal value. The described steps need not appear systematically in the same order; they can appear in groups of two or three, and in a different sequence, steps refer to the distance between the object and the observer. These variations demonstrate the dielectic approach which may be used to highlight the strategy of disappearance. At least one variable remains common between any two steps, that of speed. This results from the fact that speed is a factor common to both time and distance. In this context, speed becomes the principal vector for activating auditory perception and musical sensibility.

From a practical perspective, the aesthetic of disappearance rests on a particular treatment of events:[9] the use of events in time, their contents, and their trajectory. An event can only take form when it is

[7] A figurative representation designates an abstract sonic representation where the message is, however, limited by a specific duration and a characteristic profile.

[8] The following example will later serve allegorically as an illustrated musical translation of my theory. However, this is not an attempt to establish a visual–musical correspondence, but rather to describe by a means other than music a demonstrative example of a similar phenomenon in music.

Consider a black and white rectangle of small size on a black background within a large dark space: (i) At a distance of 150 feet one cannot distinguish the nature of the rectangle, much less determine its colour. In this case one sees only a point of white on a uniformly black background, without being able to identify what it represents. We will call this the first step of appearance. This reveals the indeterminate flux in which some contours do not necessarily return a total form. (ii) At a closer distance (60 feet) one distinguishes more clearly the global form of the observed object. The white point is now integrated into the black mass which is now, also, distinct from the ambient obscurity of the space. One can precisely perceive a geometric form with two dominant colours. Concept takes on form. This is the second step of appearance. The total form is identified as well as the figures of which it is composed; the details of those figures, however, remains vague. (iii) At a distance of 3 feet one perceives very clearly a black and white rectangle on a black background. Every trait of the geometric object is clearly identifiable. This is the third step of appearance where form becomes stable in the mind. (iv) The last step is called the step of disappearance. One progressively distances oneself from the object, thus losing more and more a view of the exact configuration of the silhouette. However, since the form has already been perceived, that perception is held in memory and the form resists as much as possible its immanent disappearance.

[9] An event represents an episode characterised by a certain duration.

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exposed to a strategic presence. I will now elaborate the poetics of event in my music. I view four phases in the representing of events:

- slow and formless appearance followed by immediate disappearance,
- rapid appearance, form then held followed by progressive disappearance,
- instant appearance of the complete form followed by immediate disappearance, and
- progressive disappearance of a form that appeared in its totality.

These phases can appear chronologically, in disorder, or need not even all be present within a given cycle. Thereby the sonic profile of an event may change according to the states in which it appears and disappears in time. The event's content, invariably linked to the phase in which it appears, is clearly marked by the limits of the phase. The entire problem is to offer the listener's perception an effective means of integrating the particularities of an event so that they will be spontaneously perceptible when heard. Even if it is not really possible to make explicit the sense of an event which appears complete, it is still possible, by varying the repetition at different states of appearance, to evolve a form toward a more precise definition. An event in its first phase (the least distinct of the four) will have a slower dynamic profile than in its second or third phase. This occurs for at least one reason: the further one is from the source the longer it takes to identify a newly presented form. To translate this phenomenon, it is necessary to reduce information to a certain simplicity. This mimics the fact that the farther one is from the source the fewer are the points that may be discerned. Inversely, the more one approaches the more points may be seen. The third phase, that of the most precise representation, implies that the event will be at its maximum density and richness. Here it must be stated that the sort of qualifiers used in describing the above event mechanism, simplicity, richness, density, to cite a few, may be translated into music in diverse ways. Thus it is necessary to reduce the possibilities, by characterising ever more precisely each one of these movements.

To aid identification, I determine the profile of each event by three principal characteristics: its place within the musical construction, its physiognomy and its isomorphy. The place of an event concerns the moment and circumstances of its appearance, its stability and its disappearance in space–time. The physiognomy makes reference to the particular texture of the event as well as what that expresses or evokes to or in the listener through its form. The isomorphy refers to the traits provoked by association, similarities between various events through parametric analogies; for example, the same pitch or the same rhythm expressed differently. This is a relational characteristic. These three modes of occurrence represent different states. They indicate the reality of the events based on different, constantly shifting frames of reference.

The result of all this is that when an event disappears it will never again appear in the same manner; for an event to appear identical in two different apparitions is impossible since time cannot be repeated and sound can never touch perception a second time with the same intensity. The appearance is a necessary corollary to the temporal logic of the disappearance, even in its unrealised intermediary forms. From a psychoacoustic point of view, the following phenomena are produced:

(1) That which has effectively disappeared was possible to have been perceived in a certain form with a certain sense.
(2) Perception forms an emotional-value;[10] thus, representation implies an evaluation.
(3) The above evaluation has a tendency towards becoming a concept.
(4) The degree of conceptualisation reached depends on the collision of other concepts and their respective assimilation with the newly formed concept.

It is of course clear that the musical configuration is extremely dependent on the connection of events and their sequence within the larger musical movement. The different event-phases imply the existence of a periodic evolution of the events in time. The strategy of appearance becomes a movement in four phases:

(1) the speed at which a phase regenerates, within and outside of a segment,
(2) its successive evolution,
(3) its resistance to disappearing (conservation), and
(4) its dissolving (through the act of disappearance).

This description is not exactly a theoretical model; it is, rather, a descriptive and explicative model that relates to *Network*, and to a lesser extent *Segment* and *Clue*.

4. ALGORITHMIC COMPOSITION

The repetition implicit to this system poses the problem of predictability. How can one retain the identifiable nature of a model without preserving it as an identical form? Musical intelligibility will thus rest on the possibilities of integrating informational references for the listener; these references will permit objects to be disassociated from each other, compared and, also, allow the interior and exterior dynamics of the objects to be captured from one to the next.

[10] An emotional-value designates an abstract unit arising from the concurrence of the listener's perception and the subjective identification he proposes.

In order to maintain a close control of the evolution of each event in my system, I apply a particular dynamic categoric to each parameter. The idea of maintaining a rational organisation of the parameters used by the orchestra seems well suited to the use of stochastic procedures. The complexity with which I was faced when I finally began to classify the varied material that I had selected to compose *Network* had reached such a degree that it was clear that a technique for globally managing the details of the work was necessary. After having already defined the theoretical principles relating to the strategy of the events, I then had to begin creating a large group of laws concerning the parametric structure. Firstly, laws relating to rhythm – states of repetition of the rhythmic cells, linear and nonlinear subdivisions, as well as linear and nonlinear reduction of those cells. Pitches had to be defined on the horizontal and vertical axes; divisions of time within each section into particular moments of differing lengths, short (instant), medium and long, as well as many other such controls had to be formulated. The need to find an elementary algorithm became primary because it would be able to control both global and local structure, thus preserving a structural homogeneity in the different classes of operations.

I do not truly subscribe to the term 'algorithmic composition' in the sense in which that term refers to a conception of composition solely in terms of calculation. The justification for my less than total adoption of the term lies in the already stated point that, for me, composition contains, in addition to the calculable element, an act of theoretical systematic and conceptual research; all of these aspects join together in the compositional system. I recognise, however, that any systematisation such as described is, from a certain perspective, algorithmic. I will now explain what I mean by this point. Many composers are embarrassed by the notion of an algorithm; they feel that the term, in and of itself, forces a rigid inflexibility, which is inherently antimusical, into the act of composition and the music produced. In fact, the use of algorithms in music is neither more nor less than the directed management of a series of operations toward a specific goal; it is, in gross, a class of operational rules specific to a given calculation. This calculation can be generally applied to the variables that the user selects, thus leading to the best possible result.

In my case, I turned to algorithmic calculations in order to aid in making probabilistic calculations, which would give a predictable orientation to the states I sought to represent. It was based on the results of these operations that my musical material could be generated. I will mention, finally, that among the mass of parameters found in orchestral composition (the number of instruments multiplied by all sorts of possible combinations), some are much more difficult to model than others. I would even say that the formalisation, a term that is almost the same as algorithm except that is expresses more directly the transformations that will be applied to the model once within the musical domain, can only be applied to a limited number of variables.[11] Thus, only a part of the elements involved in musical composition can be directly controlled by an algorithm, while for the rest algorithmic control is more delicate. In general, the more that a parameter[12] has a high degree of formalisation the more easily it may be memorised by the listener and modelled by the composer. This is simply because it is easy to perceive sounds when they contain aspects that may be separated from a particular scale. This is the case for the pitch of a sound (either melodic or harmonic in nature) as well as for the durations (rhythms). These parameters represent the first-order parameters. They are in contrast to second-order parameters like timbre, envelopes, or all sorts of dynamics, which are not possible to isolate as specific objects independent from their context. They must be grouped with first-order parameters to lock them into the proper scale. In the same way, third-order parameters must be woven into events; these parameters include aspects such as sequential representation in time (local and global durations[13] of events and series of events), expression markings, textures, registers, etc . . . .

Algorithmic composition was thus applied to the calculation of probabilities; this same algorithm, a simple program in C, will be used to generate a list of numbers which can be applied to different parameters. Turning to the laws of probability, the stochastic universe comes out of two factors: firstly, a desire to globally treat first-order parameters, toward which I wished to maintain a certain neutrality (in other words, a refusal to create series of notes or rhythms according to intuition or sentiment) and, thereby, avoid falling into a feeble sentimentality and revindicating a certain objectivity; and secondly, to control with relative precision the movements of parameters, regardless of their type, in order to obtain a greater malleability and to finally organise the mass of information produced by the orchestra, so as to better

[11] One must remember here a similar phenomenon in serial music, especially in the total serialism of Boulez who once, in the middle of the 1950s, attempted without success to serialise all aspects of the sound. Certain parameters, such as accents and dynamics, are not really 'parametrisable' for the above-mentioned reasons of inadequate formalisation.

[12] Here the parameter referred to concerns a sound and not, as I explain later, a more general parameter which can be applied to the local event structure.

[13] It is customary to speak of two spatial and temporal dimensions in contemporary music: a local dimension which concerns immediate information and makes use of relatively short durations, thereby giving the contents value as an event, and a global dimension which refers to a series of events which circumscribe multiple processes, taking place in longer durations and being contained in sections of a work.

highlight the particular topology of my events. In each of the three proposed pieces I have, therefore, used the same algorithm; its treatment is, however, different in each case.

5. MUSICAL INTERPRETATION

The program, written by Richard D. Moore,[14] contains two parts: one deals with statistical weights and the other with permutations. The first part inscribes within a structure ($S = \{1\ 2\ 3 \ldots n\text{-elements}\}$) a precise number of elements, numbers or characters, then evaluates their total and gives them statistical weights based on a mean percentage of one hundred. The statistical law may vary, e.g. Gaussian distribution, Cauchian distribution, aleatory walks, etc.... The statistical curve will be changed as a result of this choice. My choice was to stay with the same function, a random function based on a predefined linear list of numbers (from 0 to 56,000). What mattered for me was not the algorithmic and computerised speculation that aims to enslave composition to a poetic technocrat from a foreign domain, but the means of elaborating data in a way that only a program could equal. Through this procedure I obtained a larger matrix of results which did not, however, bring me to suspect an eventual disparity in the treatment of data. At this point it remained only to assign a specific weight to each element in the structure (i.e. in the structure $S = \{1\,2\,3\,4\}$, I assign the following weights: $1 = 25\%$, $2 = 25\%$, $3 = 25\%$, $4 = 25\%$. The probability that 1, 2, 3 or 4 will be the value returned is equal. If, however, the selected weights are $1 = 75\%$, $2 = 20\%$, $3 = 3\%$, $4 = 2\%$, I will obtain an output containing a very large proportion of 1, a much smaller proportion of 2 and practically no values of 3 or 4). It is important to note that the above-mentioned laws of probability are based on a very large number of generated values; it is generally easier to have the machine generate a large number of values which may later be reduced for easier manipulation. The second part of the program simply permutes the values of the structure. In permutating these values the weights for each element may be modified. Rather than further develop the program, to begin with I sought to place into my probabilistic structure ($S = \{\ \ \}$) various different elements. I will later explain the types of variables with which I used this stochastic process.

After exhausting this algorithmic model and wishing to integrate a greater portion of repetition into the output, I subsequently used another algorithm inspired by Markov chains, which generates lists of elements with the selected steps. This is done according to both the probability of phagocitation (elimination) to the left or right of a given list of variables and the number of times the chosen steps are repeated. This algorithm produces results which are more and more similar (eventually becoming identical) the further that one is from the initial step. I illustrated this algorithm in the piece *Attirance*, by applying Markov chains to melodic pitches in an effort to develop melodic 'ritornellos', which would become more and more complex. Today this algorithm accomplishes other functions: once an element has been repeated more than two times, a new, outside, element replaces it. In order to polish a method such as this, there is, in effect, no limit to what constraints might be added to the algorithm.[15]

My most recent developments have proceeded in parallel with the above-mentioned work: I have created many different subalgorithms with the help of a new program, PatchWork 2.0, developed at IRCAM, and more generally with the language LISP. The graphical interface – the image – has made it possible for me to create, with relative facility, programs, or 'patches'. I shall now summarily comment on the patch which generates the steps of the appearance of objects. I begin with an initial series of elements stored in the first module 'const': (*a b c d e f g h i j k l*). There is then a second module in which are written three series of orderings (what would be called, in my own terminology, three steps) of the elements of the original series (*a b c d . . . l*): ((1 2 9) (1 2 9 6 10) (1 2 9 6 10 4 7 8 3 11)). The first series, for example, is read in the following manner: 1 for the first element, 2 for the second and 9 for the ninth. One can see that for each group in parentheses the numbers of the previous group are repeated. We thus find ourselves with a specific type of figure which appears progressively from its first PatchWork to its complete representation. This example does not contain the step of disappearance. That step would require a different group of orderings in which certain elements of the PatchWork group would be removed. Following this basic level, certain elements of appearance or disappearance are slightly modified if they repeat more than a certain number of times (module test). PatchWork and LISP form an extraordinary sort of musical calculator, which, besides the functions it directly performs, guarantees a permanent interaction between the user and the tool. The possibilities for modelling various different categories are practically unlimited.

[14] In the summer of 1989 I developed a series of algorithmic laws and, in the midst of confusion, had earlier in the year taken R. D. Moore's interesting seminar on algorithmic composition; thus, I sought out Mr Moore and presented him with my dilemma. After having evaluated the problems I had raised, he wrote a program for me and converted me, from that moment on, into a believer in the computer's role in music.

[15] Researchers at IRCAM are currently working on the development of an autonomous system using constraint modules. This system of constraints allows most basic compositional operations to be executed.

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