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INSTRUMENTAL GESTURE AND MUSICAL COMPOSITION

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Abstract

Real time and gestual monitoring of the production of synthesised sound has been part of the permanent preoccupations of musical informatics since its beginning. The conditions imposed by the standard mode of communication with the computer and by the time taken by calculation at the start of musical informatics placed the musician in a situation far removed from his usual action or description modes, and, in particular, ruled out an instrumental type of relationship. Today, as real time synthesis has been possible for several years, numerous devices are being developed to meet the specific demands of the instrumental relationship efficiently and in a differentiated way.

However, in complete contrast to questions relative to synthesis or compositional models, gestual monitoring has given rise especially to technical developments, with a view to approaching as near as possible given traditional instrumental situations, at the expense of sufficient theoretical reflection focussed fundamentally on the role of the instrumental gesture, its status and its application in an informatic tool for musical creation.

It is, however, apparent that the instrumental gesture is not mere monitoring. In "natural" sound production by acoustic instruments, this gesture participates intimately with the physical phenomenon and directly determines some of its decisive attributes for perception and musicality. It has simultaneously a concrete function : required for sound production, and a symbolic one: the instrument and its accompanying gesture are two causes that combine to produce the sound effect, and, for this reason, the sound effect bears the perceptual indices that are specifically related to the gesture. These indices may remain present and significant in the sound object when this contributes to the composition of a musical structure.

In the perspective of creating concepts and pertinent tools for computer assisted musical creation, it seems vital to us to consider the question of the musical gesture more in depth than from purely superficial ergonomics considerations. The object of this paper is to present, whilst attempting to situate it in the general conceptual framework of composition, a particular point of view taking the instrumental gesture, via the computer, as an object that composition may operate on.

From this we have deduced the functional specificities that should be included in the conception of a musical creation informatic tool.

Introduction

Real time and gestual synthesised sound production monitoring has been part of the permanent preoccupations of musical informatics since its origin. It should be pointed out that the conditions imposed by the standard mode of communication with the computer and by the time required for calculations placed the musician in a position far removed and very different from his usual action or description modes, and if the programming of a synthesis algorithm in a suitable language (like MUSIC V (5), for example), enabled him to approach a certain form of writing in a given manner, the instrumental situation, in contrast, was totally ruled out.

Now that the time delay obstacle has been cleared thanks to specialized synthesis processors, the question of gestual monitoring systems has taken shape in a more concrete form. Today, numerous devices are being developed, based on the MIDI standard, in an attempt to meet the specific demands of the instrumental relation in an efficient and differentiated way.

However, in contrast to questions concerning timbre, synthesis, composition, or compositional models, the domain of gestual monitoring seems to have given rise especially to technical developments, often in order to simulate as closely as possible given instrumental situations, at the expense of an adequate enough theoretical reflection on the basis consideration of the role of the instrumental gesture, its status and its implementation in an informatic tool for musical creation.

It is indeed clear that the instrumental gesture is not a simple monitoring action. In the case of "natural" sound production by acoustic instruments, the gesture plays an intimate part with the physical phenomenon, and directly determines a number of decisive attributes for perception and musicality. It is also one of the ways and means, indissociably linked with tactile and kinesthetic perception, of apprehending and being fully conscious of the sound producing object. This consciousness is an integral part of the interiorized operational mastery of the musician or composer. However, its greatest importance is perhaps conferred by the fact that it is both a concrete - i.e. required for sound production - and also a symbolic function: the instrument and the gesture combine to produce the sound effect, and, because of this, the sound effect portrays indices specifically related to the gesture. These indices can remain present and significant in the sound producing object when the latter, undergoing various representations, processing, structurations, transformations, combinations enters into the composition of a musical structure. Sound composition, to some extent, is an implicit and indirect composition of the instrumental gesture.

In situations where the musician is determined to use a computer and computing science for his creation perspective to prepare concepts and tools is required. It seemed vital to us to consider the question of the instrumental gesture from a more fundamental standpoint than from mere surface aspects of user friendliness or ergonomics. Thought may be free and sovereign, but only exists through the word and the gesture.

With the computer, the instrumental gesture can become object insofar as it may be captured and memorized and then undergo various forms of processing and representations while nonetheless retaining in a confrontation between its seizure and a return to its effective execution, all its vividness.

Our aim here, while attempting to situate it within a general composition conceptual framework, is to present a particular stance whereby the instrumental gesture is regarded as an object to be operated on by the composition.

From this we will deduce the specific functionalities that must be included when making up a musical informatic tool.

I. Composition

1. Material production organisation.

Initially, a distinction must be established between certain terms and concepts used more or less precisely when referring in general to creative activity. Often, in fact, the composer is exclusively referred to when it is a question of the musician as creator. Also a difference is made, for example between composition and improvisation, composition and performance, performance and improvisation. It is clear that for each of the activity evoked by these terms there is, without the shadow of a doubt, a creative activity.

Literally speaking, composition is the act of assembling elements and of putting them into a structural relation. Nevertheless, the production of these elements is a prerequisite, and the modes of production, of an infinite variety, cannot be separated from the creative act. The question of musical creation is more general than that of musical composition.

Let us leave the common meaning of the term "composition" to one side for the moment. It will be preferable to employ the term as one pole in a dialectical relation.

Within any form of artistic creation there are two classes of operations, and consequently two processes and operational means that are complementary and inseparable. These, around the same object that from now on we will refer to as the "material" are acts that, on the one hand, aim at production as substance, and on the other, that lead to its organisation in a complex structure.

This articulation is obvious in instrumental music: the instrument and the instrumental gesture, when playing in improvisation or performance, produce the sound phenomenon which is either a priori or a posteriori the material of

the composer. This can be found in a given form in computer music: the musician defines the synthesis algorithms, the controls to produce the characteristic sound phenomena, and describes and structures the parameters to achieve a complex sound form. However, as we shall see later, in the informatic context it acquires a larger generality.

We should now observe that this material only exceptionally exists in a nascent state. With perhaps the exception of "musique concrète" that operate on naturally given material, in all other cases, if we are concerned with a sound phenomenon, there is a device to produce it. The traditional instrument is the first of these. In computer music, there are a synthesis model and an algorithm that give it substance.

In all cases, the device must be elaborated beforehand: the lutist makes the instrument. With MUSIC V we describe the "instrument" that the "notes" will be played on. This device is a potential generator of a variety of sounds and a given "command" will produce a specific object. The instrument is a class of possible sound phenomena, and the instrumental gesture determines a particular sound event. In one way, the operations of the lutist are prolonged by those of the instrumentalist, and these lead to production of the composer's material sound object.

A first consequence is that the block of operations relative to the production of the material, and this remark is valid for all forms of artistic creations, is subdivided into two categories, that are highly specialised and separated in the context of traditional technologies, and occasionally very close and overlapping with the computer: the requisite conditions to construct the generator device and the actions that correspond to its command.

A second consequence is the very nature of the material production process: the generator device is in fact, characterised by given structured information, that is a temporal, and registered before use. At the precise moment of use, i.e. of issuing a command, some measure of determinism escapes from the instantaneous will of the creator. The creator dialogues with the "instrument" and may adopt two attitudes: - if his idea, his idea of the object to be produced is perfectly preconceived, with a given system, he will look for the command that will achieve it, will have to reconsider the device itself if necessary, and go back and forth between the device and its use. - but inversely, the device, if used in an exploratory fashion may propose objects, although not preconceived by the creator, that he may wish to use in his language.

The generator device has a double function: a productive function, but also a heuristic one linked to the fact that it is, at a given moment, a partner, that is external to the creator.

Let us now consider, within the duality of the acts and processes linked to the production of material, the processes and acts of organisation. In the first place organisation can be regarded as another party to this determinism of the production device and consider it initially as the creator's intervention of his freedom to associate the parts to achieve a new entity, that is total and independent a priori of any material contingences. Above all, artistic creation is the manufacturing, by all means possible, of a phenomenon that is expected to attain the senses and the intelligence as precise targets, i.e. an effect that is only significant in itself without taking into account the conditions that gave rise to its existence or to the effective productive cause.

What the "concret" musician finds in sticking two pieces of magnetic tape together, is the liberty to connect two sound objects that have no relation to each other as regards their style. What determines the scope of music writing is the liberty to associate elements without having to realise them concretely and outside their own time.

In composition, artifice is opposed to the determination of production. Dufourt (3) claims: "The essence of musical thought (but also, we might add, of all esthetic thought), is the subterfuge. Even worse than this: all links of cause to effect, all anticipation undergo distortions, all the filiations are falsified, all the interventions obliterate themselves". But the artifice is an artifice, that is to say that it cannot in any way definitely escape from the contingences of the real. The freedom to connect any two sound objects is total...but even then one must abide by the constraints of the tape, of the limited accuracy of how it is cut, of the adhesive agent that cannot be used a thousand times on one centimeter of tape, etc...The freedom to compose instrumental sounds in writing is total, but here again one must abide by the constraints of a bidimensional graphic representation of the sounds.

In fact, the artifice can only result (and is close to being aleatory, to the nearest light year) in the "encounter of two independent causal chains".

The artifices can be created by applying to the forms and material issued from the first determinist productive step, transformation, processing and grouping models and by arrangements that bear no relation with the initial determinism. Nevertheless, these models answer to another determinism.

The constraints exist, but they are simply of another order and define a space where the arrangement of elements can be completely arbitrary and therefore essentially governed by the creator's intention.

This does not mean to say that the creator's intention is arbitrary. In general this answers to an "inner" system which does not necessarily become explicit before being applied... it applies itself.

By introspection or by a posteriori analysis, a model or formalised system can be associated to this "inner" determination to take its laws into account and to explicitly apply them. The rules of harmony and counterpoint are organisation producer systems but thought always keeps a transcendent part over and above all formalisation, i.e. it cannot be modeled a priori for it is a question of creation.

Finally we should note here that in the traditional situation, if compositional systems can be perfectly formalised, they remain abstract and do not result in material devices capable of operating automatically.

2. Material, production / organisation, Generalisation.

Let us now observe that the computer intervenes in the first instance by its power to generalise the entire group of processes: organisation operations can apply to other entities than a sound phenomenon. Additive synthesis, associated with Fourier analysis enables sound to be composed from its elementary constituents, but conversely, algorithms may operate on existing sound forms and produce variations, transpositions, duplications, together with sequential or simultaneous arrangements, etc...

Hence the notion of "material", if understood to relate to processing, organisation, composition can be enlarged over and above single sound material to cover, for example, elementary constituents or prestructured sound forms.

Moreover, and the concept is more delicate, the notion of a production device can be extended beyond the production of sound material. In fact the composer can formalise a number of rules or laws of organisation and materialise them by modeling in an algorithmic system. His relationship then becomes to some extent to that of the instrumentalist with his instrument. As soon as he explores the "behaviour" of the system and chooses a given organisation at a given moment by prescribing a specific "command", he removes the initial indeterminations proper to the system. The compositional model thus becomes, in his turn, production system and sets up a new dialogue and experimentation order between creator and tool. This objectivisation of the compositional model into an automatic system is virgin territory, made accessible by the computer.

Production / organisation is therefore no longer a duality of operations pre- and post- sound material. The notion of material is relative and the bipole production / organisation corresponds to a hierarchy articulation of two consecutive models, one operating before the material considered and the other after. The artifice then results from the a priori independence of two categories of model.

The computer dissolves the traditional categories and sets up new ones. In this instance we can see that the notion of material may take a broader meaning, but also, that a new concept has sprung to life, that may be referred to as the "materialised model".

3. The materialised model.

For the creation of organised structures from material, in the same way as for its production, we can now therefore use an objective device to model the process. It is objective for it is exterior to its subject. The computer synthesising sound is not an instrument but a "model", a representation. The computer organising sound is not thought of the composer but a model of some of his processes. The "materialised" model is characterised by its own determinations, defined by the creator, but above all by its automatism. Between model and creator a "dialogue" is established, a kind of dynamic "relation". As the case of an instrument, the role of the model is double: it enables production of a preconceived object but also is present as an heuristic catalyser.

At one end of the chain, that of production of elementary material (the sound phenomenon), the materiality of the device is a necessity, and for the higher levels of organisation, it is a fertile new latitude.

A hierarchical relation exists between the production of material and its organisation. More generally, a hierarchy of producer models linked to increasingly higher levels of complexity may bring about an organisation model producing the forms themselves that undergo the processes of variation and subsequent arrangement. However, as each level is reached the dualism between the model's determinism and an extrinsic determinism is likely to intervene. Thought remains sovereign insofar as it remains likely to apply its own systems, beyond all automatisms, that transcend the former.

This material model notion is central for it brings to light a more essential point of view to characterise and "categorise" the acts and processes that go towards, with a given material tool, the creation of a symbolic object.

Production and organisation can be looked after by a material device.

Organisation can thus also be "produced", and, as we have already mentioned, the hierarchical process chains can successively articulate the production of a material, the production of a structure from this, which in turn becomes material for a higher order process. Nevertheless there is a possible distinction between pure production models and organisation models. In the first case the model inputs and outputs are of a different nature. This means respectively gesture, monitoring parameters and the sound signal in the case of the instrument or the synthesis algorithm. The first function of the model is to effect the transformation of one nature to another. In the second case, two input categories should be noted: the "command" inputs that we have already defined - that fix parameters of the process - and an input that receives the material to be transformed. This input and the output may be of the same kind. As far as the organisation is simultaneously element transformation and putting these elements into relation with one another, the model, or the system of organisation, will contain two complementary function categories: "grouping, association (including duplication) functions, that is to say arrangement according to particular rules, and analysis functions, even decomposition of the processed elements. In "concrete" music, or, the more modern "sampling" techniques, filtering the sound signal is a form of decomposition. Its characteristic, its "extrinsic" aspect, is that this decomposition is not symmetric to the production process. The filtering operates on the signal completely independently from the synthesis process. The same applies to segmentation, or the more archaic clipping of a sound tape. As for the corresponding acts and operations, it can now be seen that they cannot be reduced to the single

"composition" process if by this we mean organisation operations.

In fact we have pointed out three complementary forms of action, three distinct categories: actions or operations that enable production model construction, actions to command, to experiment or to monitor these models, and organisation operations or actions.

To conclude we would like to point out that it is possible to talk of a composition process in general by considering that objects to undergo such a process are not necessarily exclusively sound objects, but any thing that can claim object status when one has (and informatics enables this) memorisation, representation, combination and processing possibilities at one's disposal.

In this manner, we can thus consider a particular compositional process operating on the gesture.

II Gesture composition.

1. Gesture and instrumental gesture.

If we call first of all, "gesture" all physical behaviour, besides vocal transmission, by which a human being informs or transforms his immediate environment, we may then say that there can be no music without gesture, for music is not exclusively vocal.

However gesture forms are very diversified. There is no comparison between the composer's gesture when he writes his score, or that of the programmer who "enters" on the terminal keyboard data for synthesis and that of the instrumentalist. In the first case, the gesture is essentially informational and applies, in coded form, to objects that have no direct causal link with the concrete phenomenon that is thus described or evoked. From this category of gesture to the realisation of a perceptible phenomenon, there is a complex correspondence that passes through a succession of logical, abstract or conventional representations. In the case of the computer, the chain is entirely objective, as all correspondences are realised by means of automatised material systems. In the case of musical writing, the subject intervenes to decode the signs and interpret them in function of established conventions.

On the contrary, the instrumental gesture is a direct causal component of the sound phenomenon. Along with the instrumental object to which it is applied, it participates in producing this phenomenon from a physical and energy point of view.

This distinction is trivial but is worth recalling since, these two forms, precisely, are possible and confront each other in the same context with the computer.

For a computer, as a "sound machine", in contrast to all its predecessors, the instrumental gesture is not an objective necessity. Numerous pieces of music have been created with the computer, notably when synthesis was only possible in non-real time, without any type of instrumental gesture intervening. However, if we take a purely ergonomic point of view we can acknowledge the utility and pertinence of the instrumental gesture for monitoring synthesis sounds in real time: certain data structures, let us take an example: the beats in a rhythmic formula can be described by relations, by functions translated into algorithms that are described and communicated to the machine by the standard dialogue mode. It is easy to conclude that in certain cases, all things considered, the most direct, useful, and faithful manner to communicate such data to the machine isto "play" them. The most economical way to communicate gesture type information is gestural. In musical informatics, the instrumental gesture has been re-introduced as a latitude, an improvement, more, an adaptation of the man/machine relationship based on restoring ergonomic conditions similar to those of the traditional instrumental relation.

2 The symbolic function of the instrumental gesture.

However, the instrumental gesture meets a more fundamental requirement. If the musician's ear develops a fascinating faculty to distinguish, discern, and discriminate within the sound phenomenon the relations, rapports, and forms for themselves, and to apprehend the essence of the music, it remains fundamentally determined in this very faculty, by its prime function : identifying, through one of these effects, what arises in the outside world, the cause of the sound phenomenon. Numerous research in psychoacoustics (Mc Adams, Bregman, (6), (7), (8)) has shown in fact that the perceptual system in the complex process of constructing mental images that make up the substance of our perception, does not process the data that are relayed by the senses as a simple direct chain, but infers possible causes from these effects. The sound phenomenon produced by a natural object or instrument is an indelible trace of the gesture and the gesture on this point is indissociable from its significant function. Moreover, even with a total absence of real gestural causality, as this can be achieved by sound synthesis, the ear has a tendency to look beyond the effective causality (the electronic process) for a possible evoked causality, at the same time relative to a producer object and to an effector gesture.

The instrument, in a general sense, and the instrumental gesture, have over and above the practical sound producing role, a function in the ontogeny of auditive perception, well before contemporary conditioning of the ear to its new environments.

Also, control of the sound phenomenon on the level of its symbolic functioning can be based, partly, on an understanding of the causal logic, in which the instrumental gesture intervenes as a determinant component. This is only a contribution to the semiology of musical sound. Artistic creation is, in essence, artifice, as we have pointed out, and in a more general manner, whatever the referents associated with the language elements these are permanently reinforced or thwarted, contradicted, and reconstituted in the compositional process itself.

Finally, the status of the computer in the sound producing process must now be analysed more accurately. It is immediately obvious, if we take the synthesis of a known instrumental sound, e.g. a trumpet sound, that the notion of causality is double-sided : on one side there is the real cause, i.e. the electronic, logical and numerical group of processes, and on the other there exists the "evoked" cause: i.e. the trumpet and its player. As a general rule, there is not necessarily identity between the evoked cause and the real one. The computer in this instance is neither instrument not instrumentalist, but a representation of these, a substitutive, yet another artifice, whose outward manifestation are analogous to the object of reference. Synthesis algorithms make up a representation system, and taken in isolation, have no immediate signification relative to the perceptive processes on the one hand and to natural producer processes on the other.

Psychoacoustics establishes a kind of bridge between the perceptual zone and the algorithms and parameters of control. Insofar as we have just underlined this relation between perceptual and productor processes, it appears fundamental to set as a principle the symmetrical search for a correspondence between the algorithms and synthesis parameters and an archetypical area of the production process.

It is a question of providing the synthesis algorithms and their commands with an explicit sense related to the experience and to the musician's representations on the production process side. This why, from the very beginning of our work (1), (2), we have been attached to the physical model as a synthesis device and to the different forms of instrumental gesture, it means of existence, capture, and processing in the informatic context.

Our approach has meant developing a complete hardware and software system of which one of its prime functions is to reconstitute the conditions of the instrumental experience. In order to do this, we analysed this in the first place as a sensori-motor and multisensorial relationship in which a gesture action provoked three marked manifestations : sound naturally, but also visual and tactilo-kinesthetic. We reintroduced touch as a pertinent component of this instrumental relationship. The concrete realisation of this situation necessarily means building and designing force-feed-back gesture devices (2) and by implanting modular systems to simulate instrumental objects from physical models.

3. Composing the gesture.

We recommend here, as a particular entry point to composition - and it will be easily understood that we mean to complete the group of methods and not to define an exclusive paradigm - adopting an approach based on representation and on a dual complementary control of the causes of the processing representation and control of effects.

Here causality subdivides into two contributions : the gesture and the instrument, and it is in this aim that we may set the principle of the "composition of the instrumental gesture".

In short there are two reasons that legitimate it : the first is that, as we have tried to show, the instrumental gesture takes part in the symbolic function of sound, and the second is that, thanks to the computer, it can attain the status of an object as soon as it can be memorised, represented, processed, and that by the same token can become an object of composition.

III Capture, memorisation, representation and processing of the instrumental gesture

We shall now describe the requisite primitive functionalities, in an informatic tool, to develop such an approach.

1. Gestual Transducers

The instrumental gesture must be given the means to express itself. By definition, it applies to material objects. Therefore, above all, devices connected to the computer are needed to enable the instrumentalist to be free to express his art to the utmost. However, these devices should also pick up the characteristic information of these manipulations and produce a numeric representation that is usable by the computer. These devices are what we call Gestual Transducers.

Given that present state of technology, no universal transducer is possible. Gestual phenomena are mechanical and necessitate material elements that are far bulkier than visual or sound phenomena. Rather than use a single transducer we opted for a varied system of complementary transducers. Thus an instrumental gesture typology was required to determine the classes of gestual transducers.

Instrumental Gesture Typology

Establishing an instrumental gesture typology is difficult to do, given the complexity of gestual phenomena in general, but above all by the fact that it is hardly possible to describe the instrumental gesture without taking into consideration the object to which it is applied. Nevertheless guidelines can be drawn up based on the overall qualitative properties of objects undergoing manipulation.

- Modulation, selection and exciter gestures:

Not all gestures have the same function on an instrumental object.

We shall take for an initial example the manipulation of a violin bow. The instrumentalist's action is a physical component of the mechanical phenomenon that produces the vibration. The gesture is applied to an exciter, communicating a given movement and energy which will be transmitted to a vibrating structure. The instrumentalist is, moreover, the energy source of the sound phenomenon. Force variations and the characteristic displacements of this gesture determine the evolution and the start of vibration. It should be pointed out that the object opposes a mechanical reaction to the instrumentalist's action, which is a source of tactile and kinesthetic perceptions directly linked to the object's behaviour. The instrumentalist/instrument is a two-way liaison. We will classify this first category of gesture as an "exciter gesture". The left hand action of the violinist, on the neck, is of a different nature: It does not produce a vibratory phenomenon but modifies the parameters of the vibrating object, in this case, the string length. There is no, or very little energy used up, and in any case, this energy plays no part in vibration. In this example the modification is "parametric". There is no qualitative change of structure. In contrast, when an organist pulls out the stops, he introduces or eliminates elements in the vibrating system. In the same way the loud pedal allows the pianist to modify the damping system of the piano strings. This modification is "structural". In both cases, we refer to modification gestures, i.e. "parametric modulation" and "structural modification".

Finally, the instrumental object presents itself often as a multitude of elementary devices that are mechanically independent. A component of the instrumental gesture then consists in linking unique or multiple selections of these elements to act upon them. In contrast to the two other cases the spatial organisation of points or zones of access to individual devices can be relatively arbitrary compared to the nature of the producer mechanism.

The fingering of the pianist is perhaps in this category of "selection gesture" the most elaborated.

The function of the gesture in sound production is not the same according to these three categories, and thus they should be kept in mind and marked off in the morphology of the gestual transducers.

In particular, in the case of exciter functions a mechanical retroactive from the transducer to the operator was required to enable the instrumentalist to receive tactile information from the object he was manipulating.

- Hand/Object Liaison :

The relation of the hand (for a manual gesture, but the observation is general), to the manipulated object is not permanent. More precisely, in certain cases (the bow, for example), the gesture is meaningful during its liaison, whilst in others (striking a piano key), the mechanical link-up is part and parcel of the phenomenon. The morphology of the relative transducer in one or the other case will differ.

- Elementary gesture dimensions and trajectories :

Without needing to describe the manipulated object precisely, another determinant qualitative characteristic can be called to mind: the trajectories and the degree of liberty of the access point or zone, i.e. the portion of the object where the instrumentalist comes into mechanical contact with the instrument. An object such as the violin bow, to remain with the same category of examples, possesses six degrees of liberty. A stick or "mouse" has two, whilst a piano key and a potentiometer cursor have only one. Moreover, these degrees of liberty develop according to determined trajectories : for the stick, they operate on a portion of a spherical surface, on a plane surface for the mouse, etc...

Gestual Transducer Morphology

These elements, far from being exhaustive, are extracts from a few reference situations. By transposing them into a new context we can deduce investigation directions to build and design more general transducers. Technological history and present-day resources have led to certain privileged orientations. The piano type keyboard has a very strong influence, more from the fact that it establishes a link with a cultural heritage, than from a genuine ergonomic adequation of user friendliness. The first factor is far from negligible, so we must look for solutions in developing devices capable of maintaining this continuity whilst proposing an opening. The latest devices such as sticks, cursors, mouse etc... are widespread but can hardly be assimilated as acceptable instrumental devices. Photocell detectors, laser beams and other sonars used to detect spatial gestures are unfortunately more often like spectacular cheap gadgets than a serious analysis of the instrumental gesture in its new context.

The above remarks lead us to insist on the fact that the question of transducer morphology is a research area in itself and that we must neither remain firmly attached to traditional devices nor welcome with open arms the latest state-of-the art equipment from current technology. The most important thing today is to succeed in defining a frame of reference, or a kind of "format" where, without being too conditioned, we can simultaneously use stabilised resources, experiment with new situations and endeavour to develop new devices that will be more closely adapted to the intrinsic potentialities of the instrumental gesture.

From the typological elements mentioned above, we have deduced in fact a structuration of gestural transducer systems:

- Gestual Channels:

Pressing a key, manipulating a stick, cursor, or mouse is an elementary act that forms a whole. The characteristic physical variables, forces or displacements that can be associated to this act are in an equal number to the number of degrees of liberty. These variables, however, are dependent. When manipulating a stick, x and y are not controlled. In fact, a bidimensional gesture is executed that could be represented in polar coordinates.

A gestual channel is then a communication channel that carries a unified or multidimensional elementary action.

- Gestual Lanes:

We have reserved this term for gestual channel decomposition elements according to the degrees of liberty. The gestual lanes will be represented by real variables (mechanical), but, as will be seen, their signification will be less direct compared to gestual entities.

- Gestual Units:

We pointed out above that gestual systems can be organised in more complex units grouping a number of similar devices, but which are relatively independent from each other, as for example, all the keys of a piano. Moreover, the same musical environment may group several of these units. For example a percussionist is surrounded by several groups of objects: drums of different volumes, wood blocks arranged in order of size, gongs of different diameters, etc...

Gestual behaviour operates on each of these units. A certain form of coherence stems from their spatial organisation and grouping. It is therefore useful to consider the association of gestual channels as a criterion of structuration in "gestual units". A piano keyboard is such a unit, as each key corresponds to a unidimensional channel.

This structuration into Units, Channels and Lanes appears at the same time specific enough for the representation of gestual data and sufficiently general to take charge of known situations and the development of new dispositions.

Detectors.

Since existence conditions of the instrumental gesture to the computer, are if not completely assured, at least analysed, we can now tackle the second condition : transforming gesture phenomena into numeric information for synthesis process control.

This is the detectors' role. There is a known variety of detectors, i.e. the mechanic-electric transducers offered by today's technology. We have nothing to say on this subject, except that here it is a question of position, speed, force, and pressure detectors, ... etc

The detectors and converters provide a numeric image of the gesture variables, and, in the first place, in the form of numeric signals in equal number to the total number of gesture lanes present in the whole system of the gesture transducer concerned.

However it should be pointed out that these detectors, mounted by necessity on the mechanism of the gesture transducers, will not necessarily provide a direct image of the gesture variables to which they must be applied. They may, for example be situated on the mechanism of the transducer, and for technical reasons, at a point which does not exactly correspond to the liaison point between object and instrumentalist. The detected variable will not be identical to the gesture variable concerned. In the same way it will be impossible a priori to detect any trace of the part of the gesture when the instrumentalist lets go of his instrument.

Nevertheless it is these variables and these alone that provide a representation of the instrumental gesture inside the machine.

Coding and Memorisation.

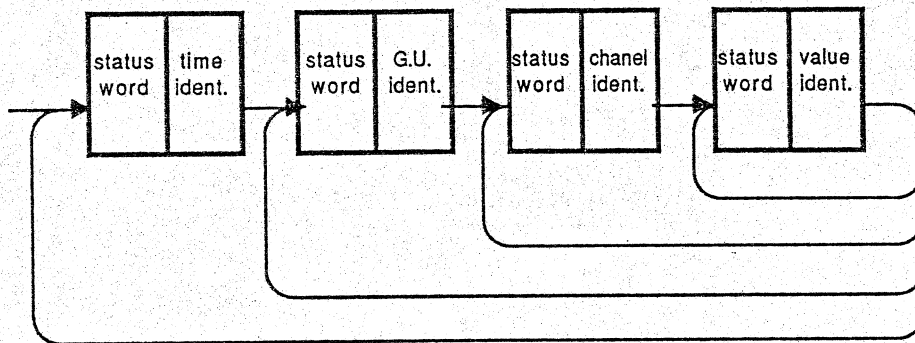
The first use of these variables is naturally real time control of the synthesis processes, and in our case, of the simulation of the instrumental mechanisms, and it is also the last use.

The memorisation of these signals must now be considered with a view to effecting compositional processing of the instrumental gesture.

This is an immediate function in the computer, filled by the numeric storing of signals onto, for example, a mass storage unit. However storage economy will be sought, i.e. the minimum necessary space to keep all pertinent information. The MIDI code meets this demand. However, we have been forced to admit that it suffers from serious shortcomings if one is interested, on the one hand, in the exciter gesture category, for which the pertinent information is to be found in the evolution and fine fluctuations of continuous control variables, and on the other, in the articulation between selection and excitation.

We have developed a code based on the preceding structuration in Gesture Units, Channels, and Lanes. Its first principle, which is nothing original, is to reduce stored information to necessary information. The numeric channels provided by the detectors present themselves as so many sample signals at a constant base frequency. The substitution to this form of coding made up exclusively of samples, for each gesture lane, corresponding to a phase when there is variation on the channel considered, and the date when this variation occurs, is sufficient. But to this information we add respectively the identification words of the gesture unit and the channel on which the variation is produced at a given moment. The data relative to a channel are considered as variant if at least one of the lanes making up the channel varies.

We shall describe this succinctly here, with the help of the syntax diagram below:



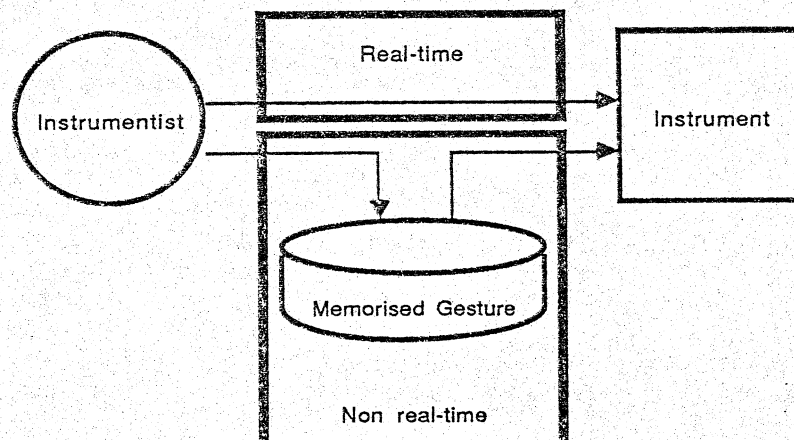
Syntactic structure of gestural message

We should point out that this coding translates a certain symmetry between information relative to the exciter gesture and that relative to the selection gesture. The second of a "factual" nature is represented as well as the first.

2. Representation and processing of the instrumental gesture.

We now have the instrumental gesture in two forms: the numeric signals for the detectors and converters and the coded recordings.

There are then two complementary uses of the gesture detected in this way: in real time, the gesture signals monitor the synthesis and enable instrumental play in its primitive form. In delayed time the instrumental gesture becomes an object to be processed. More generally, by opposing two forms of activity, instrumental activity in real time and compositional activity in delayed time, we can conceive the functionalities of a system relative to instrumental gesture according to the following diagram:



According to this diagramm we can see that the control of an instrument at the moment of synthesis is carried out either by a real gesture that is taking place, or by a stocked gesture and possibly transformed, or by a combination of the two.

The composition of gestures is the entire group of possible operations in a processing chain in delayed time, on the gesture object represented by the preceding records.

All the corresponding operations can then define themselves within the constraints categories below.

- "format" constraint:

A given number of gesture access points determined by the musician correspond to a given instrument or "instrumental scene." The instrument is defined as manipulatable in these points. Moreover, the instrumentalist will have structured his system of gesture transducers into *Gesture Units, Channel and Lanes*.

Once this final information has been determined, it will be noticed that two classes of equivalence define themselves: from the instrument side, the group of instruments that will be compatible with such a format, that is, those for which the same number of access points, the same variable dynamics, and the same structuration in Units, Channels and Lanes is possible. For the gesture objects side, the group of those objects that will equally correspond to the same format.

A given gesture object can be applied to all the instruments of the class defined by its format and reciprocally, a given instrument can receive all the gesture objects belonging to a same class.

Once the "format" has been provided, gesture processing comes back to produce by all means desired a new object that is compatible with this format.

- Transformation coherence constraints:

All transformations are permitted a priori within the above limits. However some over brutal transformations or those too directly determined by the numeric operators may result in the destruction of the gestual coherence of the signals, i.e. this may produce a new object that does not correspond to any real possible gesture. If the purpose is to control the sound effect from this causal logic, this criterion is determinant. We should therefore, in one way or another, bring in the constraints required to guarantee this coherence.

- finally, the total group of possible transformations and combinations may be reduced to a few basic primitives : all edition systems, for example text or image edition, rely, almost universally on these primitives. Also, in fact, on the condition that they are made to operate on adequate representations, everything can be reduced to the following operations:

- . define and designate an element in a whole
- . supress
- . duplicate
- . modify
- . tag, that is, integrate an element in a whole.

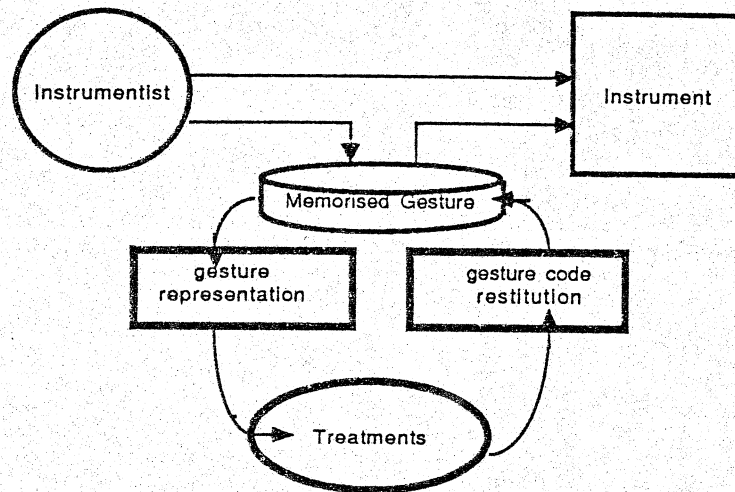
The interest or the particularity of a processing system is not so much the group of operations, as the nature of the objects it operates on.

Therefore, the problem of representation is all the more fundamental.

Here, the representation of the instrumental gesture has two destinations : on one hand to extract the gesture information detected and prestructured of the forms upon which the preceding operations will be applied, and on the other to provide the musician with meaningful reference points, close to the mental representations that he may have of his instrumental action.

The two representations must correspond in order to make the processing operations significant for the musician.

The figure below illustrates the operation chain in question:



The most immediate representation of gesture information can consist in the visualisation of the signals in amplitude/time coordinates. By graphic edition these signals can be manipulated and transformed. However, this is much too simplistic, and more so since such a representation gives no information concerning the perceptual parameters in question, it is not adapted to displaying the pertinent forms of the gesture. We can also notice that between raw gesture signals and the parameters of gesture behaviour, there exists the same anisomorphy as between the perceptual parameters and the monitor parameters of the synthesis algorithms. The representation of the gesture is in this case the dual problem of psychoacoustic analysis. We would point out that this opens a research domain that cannot be approached with the idea of finding immediate and definitive solutions.

In our laboratory S. Gibet (4) has studied and experimented on simple instrumental gestures (manipulation of a force feedback key) a representation method based on the identification of motor mechanisms in question in the human gesture organs (hand, wrist, arm). This method is the object of a complementary communication in this congress, to that of this present conference. By an appropriate analysis of the signals detected and the characteristic signals of the reaction of the instrument on the instrumentalist, it is possible to infer a physical model corresponding to the operator's activity. This physical system evolves and produces the gesture phenomenon under the effect of two "internal" categories of command, one corresponding to an excitation (pure force or pure displacement), the other to a parametric relation (a variation in stiffness) of the identified mechanical structure. This approach provides a natural representation under a more essential form to gesture behaviour in the case of elementary gestures. This method, if perceived and extended seems particularly complementary to the physical modelisation of the producer system corresponding to the instrument itself.

There remains to be added to this, the representation modes dealing with the instrument gesture in the complexity of its articulation in an elaborate interplay.

We will conclude by pointing out that, finally, the primitive processing operations referred to above can, for a given representation mode, be applied directly by the musician, but that the latter can also, in function of the first chapter considerations, imagine and build models to process and of organisation, articulating these operations in an elaborate algorithm.

Conclusion

We have, throughout this development put forward the operational principle between controlling production processes and controlling perceptual processes. This dualism makes a pair to that of the production and the organisation of the material. The term and process of composition have acquired a broader meaning. The interest of such an approach, if real, resides a priori in complementarity and not exclusivity.

In the same order of ideas we have suggested that the functionalities of an informatic tool for musical creation, if they can be defined on the concept level and translate into a sort of minimal nucleus, can, under no circumstances be the object of an immediate and finished realisation. Such a tool can only be conceived as evolving and one that proposes a number of different directions of investigations.

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