

The Pianotechnie or the Art of Digitizing Musical Scores for Instant Interpretation on the Metapiano

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Abstract: The Metapiano is concentrated in only a nine piano keys. It can be played with a few fingers, or even with one finger. As its name underlines, the Metapiano goes beyond traditional instruments, because it stores the notes that will be performed by the musician. In practice, the music is analysed in terms of its melodic, harmonic and contrapuntal relations. Only the pitches of the notes and their relations are codified and stored digitally, according to the rules of the Pianotechnie. This musical structure can be set in music and sound by playing the restrictive number of keys of the Metapiano. The musician, who knows the musical score, applies rhythms, tempo, articulations, accents, dynamics, and agogic phrasings to this structure, and interprets the music with his own style. An unusually short time takes place between the "notage", i.e., the coding of the score and its immediate interpretation on the Metapiano. To interpret a musical score without going through the usual long learning phase proposes to reverse the questions of "what" and "how". This inversion leads the musician to immediately consider various possible interpretations of a given musical piece and to realize them instantly.

Key words: keyboard, key, piano, finger, interpretation, notage, coding, Metapiano, Pianotechnie.

1. Genesis of an instrument

Our research has focused on finding the performance minimal conditions to control the expression and the interpretation of a musical score. To this aim, we have explored the possibilities offered by a very common interface: the key of a piano [8]. Historically, the keyboard represents the most efficient device to reach the maximum possibilities of controls with the simplest access: the key. Compared to voices, wind or string instruments, on which sound is to be controlled continuously, the key of a keyboard has only two instants of control, the moment of depression, and the moment of release. On the piano, the possibility of varying the intensity of attack is the third actor for control. Moment of depression, moment of release, and instantaneous intensity are the only few play settings necessary to create, execute and interpret a musical piece. This deserves to take a closer look. On a score a figure of note is printed in a single place, focusing symbolically the beginning, duration and ending of a sound. This notation positions only the beginning of the note. The duration and end of the note are not represented graphically. We know when a note starts; we have to think when it stops (Figure 1). Thus, the usual notation does not treat equally the start and the end of a note. This may explain the

overwhelming attention given to the attack of a sound and the lack of attention to how this sound finishes. If many pedagogical works and piano methods focused on how to attack a note, a very few emphasize the achievement of its stop. About this we will quote a controversial formula that E. Bernard made in 1918: "It's not how you press a piano key that can affect the quality of the production... the beauty of sound depends only on how the sound continues to be heard. So it is the damper and not the hammer vested in this role [3]." Such a reversal of roles leads to further examine the play of a note on a piano.

1.1 An instant play mode

To play a note means browse through the cycle made of the three phases linking depression, sustain, and release of the key. This cycle acts on the underlying piano action [6]. During the depression, the hammer approaches the string, hits it and leaves it vibrate; during the release, the damper absorbs the vibrations of the string and the resonance of the soundboard. Two instant finger actions successively put into play two independent parts of the piano action, the hammer mechanism and the damper mechanism. Both devices covered with the same material, the felt, generate two opposing actions: the vibration and the damping of the sound.

1.2 Key stroke

The gestural intensity is transmitted to the sound; it is a specific parameter of the piano playing. The intensity can be expressed (in the artistic and technical meanings) only during the key depression, that is to say, in a moment. This is why the attention given to the attack of a note in the piano playing is leading. Anticipating, and pre-hearing what will be expressed during the key press is a necessity. After it is too late to revise: the player has successfully reached the good sound level or missed it. The intensity mastery results from a lifelong learning linking gestural energy and sound intensity. The player develops a memory of that couple gesture/intensity in close relation with the piano action on which he works, and with the intensity of sound produced. This is the touch sensitive component that is unique to each piano and pianist.

1.3 Key sustain

The note, once issued according to a desired time and intensity, can only decrease. It evolves towards extinction when the key is maintained depressed. No action is possible on the irreparable decay of the sound, other than an attentive listening to its disappearance. When the key is released, the damper accelerates the natural muting of the vibrations to silence. The moment chosen to damp a sound is not indifferent as it can occur at any levels of decay. This decrease is directly related not only to the pitch of the note but also to its intensity. Low-pitch sounds have a very long decreasing while the treble ones spontaneously decay very quickly. Similarly, for any pitch, the greater is the intensity of the attack, the longer is the decay. In playing and listening to the sustaining of a piano note we can perceive its degradation following two perspectives: how long or short it is depending on the intensity of the attack; how slow or fast it is, according to its pitch in the note range.

1.4 Key released

If the sound attack is produced with the expectation of a desired intensity, the dampening acts, meanwhile, through a perception of the fading of this intensity. The time of release is chosen during a listening phase. Press a key asks to anticipate the magnitude of the sound; release the key requires estimating the degree of decay. When releasing a finger, the damper is approaching and lying on the vibrating strings. The minimal time required for extinguishing the sound and return to silence depends on the damper quality and the resonance of the soundboard.

Thus, finger actions and listening phases alternate in the sequence of the attack, the decreasing sustain, the dampening and the silence that follows. The expression (technical and aesthetic) that the musician wants to give to a note is the result of attack intensity and maintaining duration of the key only, and this, in that he has anticipated the birth of this note and has estimated its decay to accelerate its decline.

| | | | | |
|--------|---------------------|----------------------|-------------------|-----------|
| Note | Beginning | Duration | End | |
| Key | Press down | Sustain rest | Release up | |
| Action | Hammer percussion | String vibration | Damper amortizing | |
| Sound | Stroke | Decay | Dampening | Resonance |
| Play | Anticipation action | Listening estimation | Action | Listening |

Figure 1. A note according the reading, the instrument, and the play.
 On the musical score, the figure of a note gathers in one place all three phases of the note.

1.5 One key to interpret

But, at the keyboard, play one key, a single note, is not music. What happens when successive beats are sequenced on this single key? The rhythmic and repeated play on the key makes a sequence of sounds, each with their own duration and intensity. On this single pitch we can rhythm a famous aria, a melody, or a march known by ear. The rhythm and the intonation giving some accents are enough to recognize the air. Tapping, drumming, strumming with a finger on a key, a note, the rhythmic of the "Marseillaise" shows how the notes corresponding to the accented phonetic syllables "en-fants" and "pa-trie" (metric accent) are naturally increased; how we may extend some notes (vowels) for a pathetic expression (agogic accent); how rhythm can be modulated while being respected (*accelerando*, *ritardando*, *rubato*); how we articulate the sequence of notes (syllables) by detaching,

or otherwise, seeking to link them (*staccato*, *legato*); how is given to tempo a war-like appearance or, on the contrary, a pastiche lyrical impulse; how we finally organize rhythms, durations and intensities in agogic phrasing and dynamic, highlighting a peak of the melody (the “tri” syllable in the word “pa-trie”), its highest point, followed by a final cadence (“...i-e”). All these “intonations” (intonation in the sense of the tone of the spoken voice and not the correctness of the singing voice) are transmitted via the touch, successive touches, and movements of the key to the sequence of sounds and become actors of interpretation. Intonation is used here in the sense of the prosodic intonation which structures the discourse, marks a question, an exclamation, or an exhortation, etc., indicating the state of mind of the musician but does not affect the structural sequence of notes. This is the tone that highlights the musical sentence written and modulates it through sought accent phenomena, subtle fluctuations in duration, rhythm, tempo, and articulation of notes. This tone is the “how” of the play that gives the performance its interpretation value.

But the word intonation has several meanings. Intonation, taken now in its strictly musical meaning, indicates precisely the pitches of the music played or sung, and the relationships the pitches have with each other. On the piano keyboard, to play a musical note, is above all, to give it the right pitch, that is to say, select and hit the correct key among the 88 keys. No mood is involved in the virtuosity of the selection. The gesture must be strictly accurate and fair, a gesture that involves fingers, hands, forearms, arms, the whole body on the wide extent of the 88-keys keyboard. No deviation is allowed; any deviation causes a fault without any possibility of correction.

1.6 A matrix of pitches

This intonation then represents the “what” of the notes, their pitches only. In a musical score, this “what” is the sequence of notes in melodic lines, their superposition in harmonic chords, their distribution in lines and contrapuntal voices. The partition to play is a structure of notes organized in a sequential and synchronous way that the musician must accurately unroll during the execution. On the piano, a fixed sounds instrument, every pitch is assigned to a particular key. Establishing relationships between the pitches means establishing relationships between the keys. The intonation and the pitches organization can be summarized in a tablature of key numbers. As a matrix with m rows and n columns, the pitches of the score can be transcribed into key numbers arranged in melodic lines and in harmonic columns. The two meanings of “intonation” therefore distinguish interpretation and execution. On one hand, a key for the intonation and expression, i.e., an interpretation key; on the other hand, a matrix for the intonation of pitches, an execution key matrix. A temporal and dynamic gestural control, on the one hand, and a physical melodic and harmonic memory on the other hand. Is it possible to interface the control and the matrix and to direct, with a single key, a musical score transcribed into its only pitches or numbers of key? Is one key sufficient to interpret a musical score?

1.7 The Unitouche (The one key)

In 1846, Jean-Baptiste Acklin, the son of an organ factor in Grenoble and organist himself, filed a patent for “an Unitouche or mechanism that would play the organ or

piano with one key [1].” The instrument and its principle are described in journals and books of the time. Thus, Count Pontécoulant wrote in his “Organography”: “The mechanism invented by Mr. Acklin is the piercing of the paper where we usually put notes... By placing the paper in the device and touching a key, following the rhythmic movement, it plays the written air [13].” In “La Revue Musicale”, in 1849, the same Pontécoulant continues: “It suffices, to run an air, to put the Unitouche into movement, according to the rhythm of the given air. We can therefore, by changing the tempo or the rhythm, change an *adagio* into an *allegro*, or convert a waltz into a polka... People who cannot read music can play well-known airs: the Unitouche provides entirely the fingering. The Unitouche uses a scoring system that involves piercing the paper: this notation is easy and accessible to everyone [12].” The invention of Acklin was intended to fill the churches that did not have holders for their organ, with an “assisted-interpretation” device. The player of the Unitouche, knowing the music to play, was moving a perforated notes score with a single key. This notation, devoid of rhythm and time, was operating the keyboard of the organ. By manipulating the Unitouche in rhythm and duration, the substitute organist made advance a plainsong or a fugue, note by note, with all the subtleties of his own desire. The mechanism adapted to piano was transmitting also the intensity of every stroke on the Unitouche to the different keys of the piano put into action [2].

1.8 Two keys to articulate

Is one key sufficient to interpret a partition? Can the musician find in the Unitouche all usual means of execution and expression to interpret a musical piece?

On the Unitouche, the velocity is necessarily reduced. The repetition rate of a finger on a key cannot reach the speed of a pianist with his ten fingers. Playing one key allows only limited speed. In doubling the key, this limit disappears. Playing alternatively two fingers with a fast beat, like a trill, allows all extreme virtuosity.

Adding a second key brings the greater expression possibility of the piano that is lacking in Unitouche: the *legato* playing. With a single key, the musician cannot link a sound to another as a singer or a wind instrument do in one breath. We have seen above that the repeated manipulation of a single key did alternate hammer percussions and damper muting with a necessary inserted silence. Between release and new press of the key, a pause necessarily separates the sounds. By the play of fingers, trying to link in the shortest possible time the release and the key press, the musician can minimized to the extreme this pause, but he cannot eliminate it.

By manipulating two keys, the musician connects two periods: the “play time”, and the “rhythm time.” The play time is the time between pressing and releasing the same key, i.e., the sound duration of a note. The rhythm time is the time between two successive depressions, i.e., two strokes of notes in sequence. Play a single key allows only one relationship between the two times: the play time is always shorter than the rhythm time. Silence is necessarily generated between the successive cycles of the key. However, play on two keys allows all possible relationships between the two times. The play time can be smaller, equal or greater than the rhythm time (Figure 2).

- The play time is lower than the rhythm time: the key is released before pressing the other, this inserts a pause. There is a gap between the two cycles of keys.

- The play time is equal to the rhythm time: the key is released and the next key is simultaneously pressed. A perfect exchange between the two phases of the cycles is achieved.

- The play time is greater than the rhythm time: during an overlapping moment both keys are depressed. There is a superposition of two key cycles.

These three ways of playing two successive keys show the importance to be given to the release of the keys, to the end of the notes, and to the sound stop. This is the articulation of the musical discourse that is concerned with the releases of the keys [6].

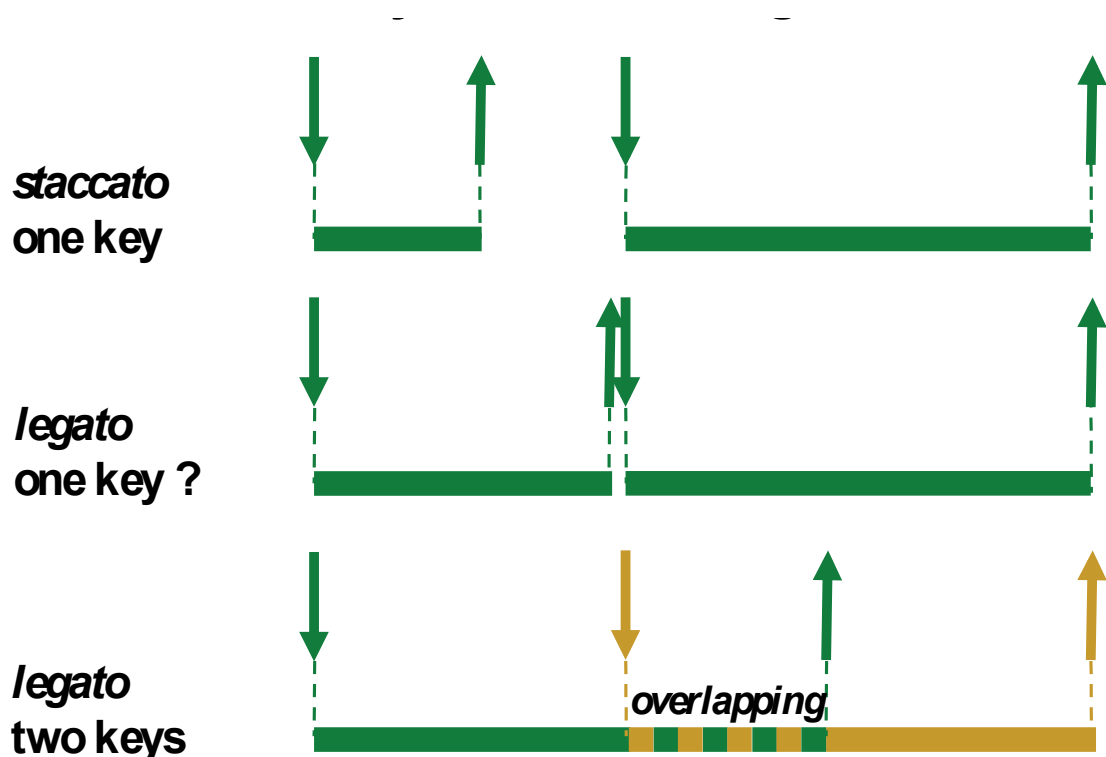


Figure 2. *Staccato* and *legato* according to the key cycles.

The sounds can be separated by a pause (*staccato*), or perfectly exchanged without superposition (theoretical *legato*), or overlapped with more or less mixing time (*legato*). The *spiccato*, *portato*, *Louré* and *legato*-variant plays change the duration of silence between the sounds or the duration of their overlapping.

The sequence of two *legato* notes, two keys, adds a new phase to the cycles of keys: the overlap. Are in sequence, a first press followed by a sustain, then a second press and a second overlapping sustain, the first release, the second sustain alone and the last release. During the overlapping phase, a sustain transfer is realised from one finger to another finger into the two key depresses.

To play a simple sequence of two sounds, the musician may alternate his attention to sounds and actions of fingers in eight phases: anticipation of the first sound level, down-finger action, estimation of the decay of the first sound and anticipation of the new sound level, down-finger action, perception of overlapping

sounds, and estimation of dissonance or consonance between these two sounds, up-finger action, estimation of the decay of the remaining sound, up-finger action.

Alternating *legato* and *staccato* creates the articulation and participates, in the foreground, to the expression of short rhythmic formulas. For long *cantabile* phrases, the *legato* playing, including under a same slur the successive notes, gives the illusion of a continuous phrasing, interrupted only by breathing. Again, the management of the start and the end is to consider not only for the entire musical phrase, but also for each of its constituent notes.

The addition of a second key to the Unitouche significantly increases performance, allowing a faster execution, a variety of articulation and the realization of *cantabile* phrases. A question may still be raised: how is it possible to generate synchronous sounds at different volume levels by playing only one key? The issue of prioritization and setting in value of musical voices will be developed later on.

2. The Metapiano

The Metapiano was inspired by the principles of the integration of the partition and the mechanical movement of one key of Mr. Acklin's instrument. But with the benefit of digital resources available today, the Metapiano goes beyond the traditional piano because it contains all virtual interpretations of the works it has in memory. Its keyboard-interface makes all of them tangible (Figure 3).



Figure 3. The metapiano.

The Metapiano is a keyboard reduced to nine keys, emitting what is played on its keys. The maximum distance between the emitting keyboard and the receiver is about twenty meters. The musician can interpret while walking or sit on a orchestra seat to listen to his play on stage.

Seen from the front, the new keyboard has its keys divided into six whites and three blacks. The section of the octave E, F, F#, G, G#, A, A#, B, was chosen because it has the advantage of symmetry and responds either to the play of a right-handed or left-handed musician [7].

F. Chopin in his draft method for piano advocated “the position of the hand by placing your fingers on keys E, F#, G#, A# and B: the long fingers will occupy the higher keys (black) and the short fingers the low keys (white). You must place the fingers that touch the high keys on a same line and those on the white keys as well to obtain relatively equal levers, which will give the hand a curve that gives a necessary flexibility that it could not have with the fingers extended. A flexible hand, wrist, forearm, arm, all will follow the hand according to the order [4].”

The Metapiano is portable and lightweight (800 g). It can therefore be played standing or strolling, but a hand is occupied to wear it. To use both hands, you must play sitted; a stand sustaining the keyboard. The use of the pedals is essential to play the piano; the sitted position, releasing the feet, is favourable. An usual pedal board, with two pedals, sustain and soft, is played the usual way. The Metapiano, without wired connections, is H.F. transmitter. The temporal and dynamic informations generated by the movement of the keys are sent to a computing device. The pedal board, also connected to the device, sends the positions of the pedals. A sampled piano (Ivory, Synthogy) responds to keys and pedals movement and is broadcasted by a Bose L1 amplification system.

Without musical scores, the Metapiano cannot play. It is a musical instrument that incorporates the scores that are to interpret. The musical scores must first be translated into tablature according to the pitch of the notes, into key numbers, in matrices organized into melodic lines and harmonic columns. A writing interface was developed for the "notage" works (coding notes). Other implementing interfaces, for interpretation, for recording and reproduction, have also been created. The whole program was developed on Max / MSP Cycling'74.

3. The Pianotechnie

The term Pianotechnie was inspired by the work of Father Engramelle published in 1775: “The Tonotechnie or the art of notating the cylinders and everything that is likely to notage in mechanical instruments concerts [5].” This didactical book is intended for the “noteurs” of mechanical music instruments, such as serinettes, cylinder organs, clock chiming, organs and automatic harpsichords. These old-time recording and reproduction instruments are all designed around two principles: a pinned cylinder as memory and a keyboard as reading device [9]. Engramelle teaches to the “noteurs” the techniques to record music on a physical medium, the means to fix the performance, the effects of the music for the notation and his personal observations on the play of musicians. The “noteur”, obliged to express everything in detail, must “take care of an infinity of things that the printed score do not show perfectly or even not at all, on which however depend the effects that give the character and the expression [5].” The Pianotechnie, likewise, proposes a protocol and tasks for scanning a musical score in a computer memory, and for interpreting it *ex tempore* on the Metapiano.

3.1 The “notage”

The "notage" is to integrate the pitches of the musical score to play in a matrix with two inputs, a set of cells arranged in rows and columns. This matrix stores the organisation relative to the pitches of the work, i.e., the order of appearance and disappearance of notes, their synchronism and their distribution into polyphonic voices. A row of the matrix gathers the pitches belonging to a musical voice. A column of the matrix superimposes the synchronous pitches of an chord produced by different musical voices. The pitches are stored melodically and harmonically. The first task of the Pianotechnie is to analyse a musical work according to melodic, harmonic and contrapuntal links between the notes. For a string trio, choir, quartet, octet works, etc., to separate the voices is obvious. For a piano score, polyphonic in its nature, the musical voices that superimpose and mix through the two staves are to be individualized. The necessary analysis to set the work in voices can then be difficult. But the classical works compositions are based on the principles of harmonic and contrapuntal voices. Separation solutions are always possible.

Thus, in a four-part work, the soprano will be No 1, the alto No 2, the tenor No 3 and the bass No 4. For a string quintet, first violin, second violin, viola, first and second cellos will be Nos 1, 2, 3, 4, and 5, respectively. A piano sonata will be set in voices as if it were a work of chamber music, the voice from above is part 1 and, depending on the number of voices, the bass will be part 4 or 5.

The Midi numbers of keys are used to define unambiguously each pitch: 60 means the middle C of the keyboard, the do-3. To name a note and the voice it belongs to, two numbers are required. Thus for the same middle C, 1 60 belongs to soprano, the first violin of a quartet, or the top part of a sonata for piano; 4 60 belong to the cello of a quartet.

A “status” associated to these two numbers forms a triplet. The “status” refers to the behaviour of a note during the key movement. Four statuses are enough to cover all possible behaviours of notes (Figure 4):

- [] for a note following the cycle of the key
- [<> for a note escaping the key off of the cycle of the key
- [< for a note sustained during several cycles of the key
- [> or]> to stop a sustained note after several cycles.

3.2 The note behaviour

Here are some examples: [] 1 72 is the specific triplet of a do-4 belonging to the first violin of a quartet. Exactly following the movement of the key, it begins with depression and stops when released.

[<> 4 48 is a do-2 belonging to the cello. It begins with a depression of a key, and ceases itself in an obliged *staccato*. It escapes the release of the key. The superposition of these two types of behaviour allows interpreting a first voice *legato*, while the second voice executes a *staccato*.

[< 3 60 is a do-3 belonging to the viola of a string quartet. It begins with a depression of a key, but does not respond to the release. It sustains itself during the following cycles of the key. This type of behaviour is necessary to produce the polyphony, a voice holding a note while another voice plays several notes. It will be necessary to stop this sustained note at a later cycle of the key.

[> 3 60 is the stop of this do-3 programmed to stop the sustained note at a later keystroke.

]> 3 60 is the stop of the same do-3 programmed to stop the sustained note at a later key release.

The choice of a particular status determines the start and stop of each pitch. This choice results from an in-depth analysis of the relationship between the notes of the printed score, and the rendering proposed during interpreting on the Metapiano.

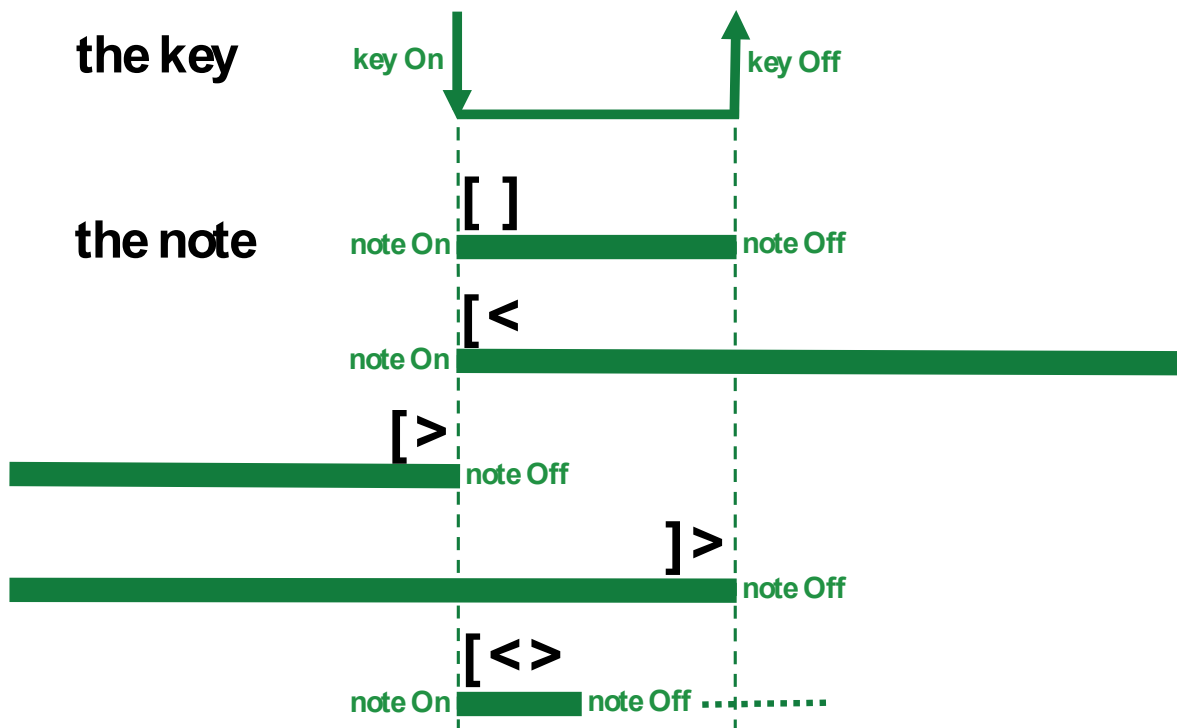


Figure 4. Key movement, behaviour, and note status.

3.3 Duration and intensity of the notes

The matrix of pitches is built, step-by-step, in superimposed rows and in successive columns. Only the pitches, as triplets, are stored in horizontal melodic line lines and in vertical harmonic chords. The notation of the partition shows only the pitches of the notes and the interactions they may have with each others. Real or relative durations of the notes are not taken into account. During the performance, the play on the key will provide real-time duration, rhythm and tempo.

The notation of the musical score does not take into account the intensity of the notes. During the play, the stroke energy of the finger on the key is transmitted in real time via the notation to notes, and sounds. All shades of intensity required by the musician depend on his dynamic play on the keys and on the gesture/intensity couple he has developed and stored in his memory for years. Each key press gets a chosen energy, unique intensity that is applied to the matrix either to a single note, or to different pitches of a chord. A unique intensity for several voices cannot give to

the polyphony its transparency and intelligence. It is necessary to highlight some voices at selected moments to give thickness, depth or perspective to the musical discourse. We operate on the intensity ratios that we wish to establish between the voice by integrating in the matrix additional balance data, or offset relative to a particular voice. The unique intensity of the keystroke which previously was applied uniformly to all pitches of a chord is now distributed by producing different intensities for each voice of the harmony. The levels setting is made according to the desired aesthetic balance between voices, either punctually or according to a phrase. The level balance, once established, follows in proportion the nuanced play on the key. In a *pianissimo* play the voice, enhanced by an offset, will sound *piano*. In a *mezzo-forte* shade the same voice will sound *forte*. Whatever the shade of overall intensity played, the relative balance between the voices is preserved.

3.4 The score “notage”



Figure 5. Scherzo. *Allegro molto*, (mes. 1-16), piano sonata Op. 26. Beethoven.

The beginning of this scherzo (Figure 5) of the piano sonata Op. 26 is clearly written for three voices that coded 1 (upper voice), 2 (middle voice), and 4 (low voice). The vast majority of notes is underlined by a particular expression, slurs, *staccato* dots, piano shades (*p*), and four *sforzandi* (*sf*) that punctuate the regular "carrure" of four measures.

The first column of the matrix (Figure 6), the first step contains the triplet [] 1 68 of the first note to interpret (the A of the upper voice). This is a note of a cycle, it starts at the keystroke and stop at the release of the key. The note contained in the next step has the same status []. These two notes will be, depending on the play of the performer, linked or detached. The slur written by Beethoven specifies the composer's intention. The player will have to link these notes through two keys to achieve a *legato*.



| | | | | | | | | | | |
|---------|----------------------|----------|----------|----------|----------------------|----------------------|-----------|----------------------|----------|----------|
| soprano | [] 1 68 Ofs 1 20 | [] 1 70 | [] 1 72 | [] 1 74 | [< 1 75 | | | [> 1 75 [] 1 77 | [] 1 74 | [] 1 75 |
| alto | Ofs 2 13 | | [< 2 68 |] > 2 68 | [< 2 67 |] > 2 67 [] 2 70 | [] 2 72 | [] 2 68 | [] 2 68 | [] 2 67 |
| tenor | Ofs 3 -64 | | | | | | | | | |
| basse | Ofs 4 15 | | [< 4 65 | | [> 4 65 [] 4 63 | [<> 4 55 | [<> 4 56 | [<> 4 53 | [] 4 58 | [] 4 51 |

Figure 6. Scherzo. Piano Sonata Op. 26., Beethoven.
Musical score and matrix notage put in parallel.

The next step (1st measure, 1st beat) contains three synchronous notes: [$<$ 4 65, [$<$ 2 68 and [] 1 72. Only the top one note follows the cycle of the key, the other two notes are sustained, each waiting an ending triplet to stop. The following note, in the upper voice, is denoted by [], indicating the freedom to chain it *legato* or *staccato*. During these two linked notes of the first voice, the other two voices are sustained waiting a code that will stop them. We chose to stop the voices 2 and 4 in different ways. Beethoven's writing shows a distinction between the voice 2 and the voice 4, only the voice 4 has a *legato* slur. To permit this subtlety during the interpretation, we do stop the voice 2 at the release of the next step with a $] >$ 2 68, while a sustain of the voice 4 is imposed until the next step with a $] >$ 4 65. So the interpreter, according to his finger play, will generate or not a small silence in the second voice, the bass being bound by the notage.

In the step that follows (the 2nd measure, the 3rd beat) the status [$<>$] of voice 4 produces a short *staccato* whatever be the played on the key. The real duration of the *staccato* may be extended punctually or globally by additional data.

The construction of the matrix of pitches is so continued, step by step, column after column, status after status, according to the analysis of melodic, harmonic and contrapuntal relationships.

The representation of the same Scherzo Op. 26 by Beethoven (Figure 7) removes all the figures of notes, leaving only the signs of expression, i.e., the *legato* or *staccato* articulations and nuances of intensity *p* and *sf*. This is the "gestural" score

to be interpreted on the few keys of the Metapiano by the musician who knows the rhythm of the piece.

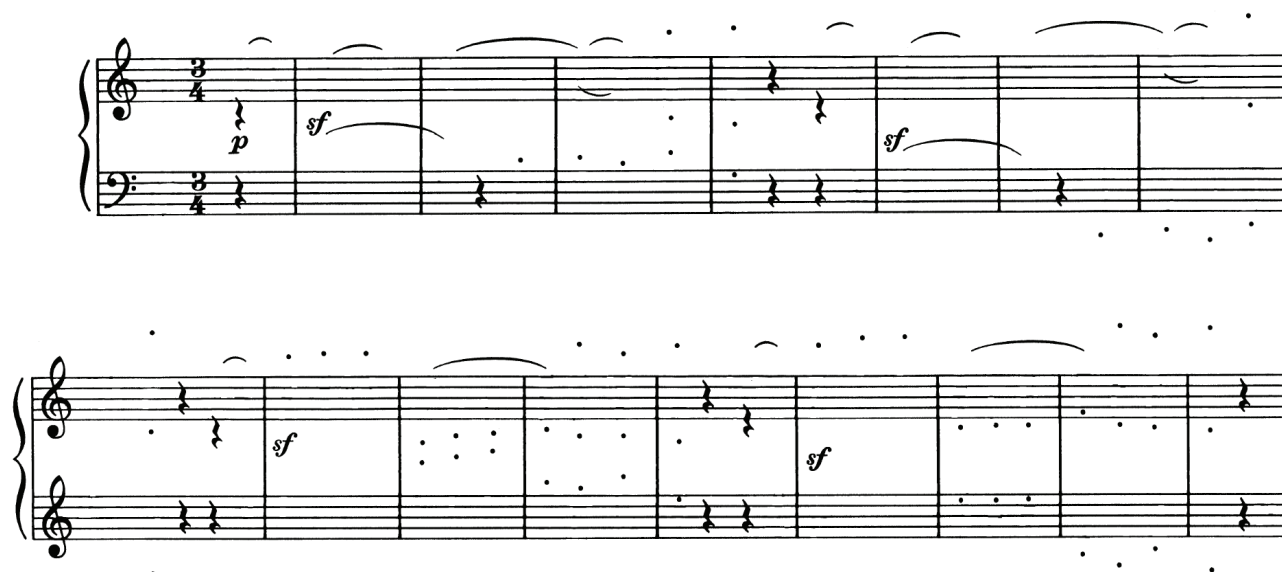


Figure 7. Musical score without any pitches.
Scherzo. *Allegro molto*, (mes. 1-16), Piano Sonata Op. 26. Beethoven.

3.5 The musical repertoire for Metapiano

We have made a repertoire of musical scores recorded according to Pianotechnie rules and ready to be interpreted *ex tempore* on the Metapiano. Piano works: J.-K. Fischer, 48 Fugues for keyboard; Bach, Partita No 5, Preludes and Fugues, Contrapunctus VIII, Art of Fugue; C.-P.-E. Bach Variations The follies of Spain, Rondo Woq 61; J.-B. Cramer 84 Studies for Piano; Reicha 36 Fugues Op. 36; I. Moscheles 24 Etudes for piano Op. 70; R. Schumann Fantasy Pieces Op 12, Beethoven Etüden, S. Prokofieff, Visions fugitives Op 22; G. Puccini, String Quartet Crisantemi; Satie, Debussy, Milhaud, Schönberg, Stravinsky, and Kurtág several piano pieces.

The major part of pieces playable on the Metapiano is: L. van Beethoven Sonatas, Klavierstücke, Variations, and the complete 17 string quartets.

4. An interpretation *ex tempore*

The Metapiano and its matrix notage were developed simultaneously from studies on a physical control (the key), a musical instrument (the play and the sound of the piano) and the musical work (the partition and its separate voices).

A single sensitive control, a key, allows putting into action two devices triggering and dampening the sound through its simple alternating movement at two instants. This single command is sufficient to drive and express the musical discourse. The addition of a second key to the command gives the capacity to double the speed of the play, to allow a good *legato* phrasing, and provide overlapping or non-

overlapping articulations according to the discourse needs. Here, we have demonstrated the essential role of the key when released.

On a piano, the main play mode is instantaneous in two moments. This play is similar to a discrete system implementing the beginnings and endings of notes with a specific timing. Duality and immediacy of play, but also dynamic modulation of the sound during the attack and inexorable decline during the sustain are the essential play modes. Indeed, two listening strategies can alternate between an inner active listening which anticipates the sound level at the attack and an external passive listening which evaluates the degradation of sound, and stop it. To quote Edouard Bernard: "...(*We must*) apply to the sounds, encompassed in a musical line, the rules of sound perspective... the vanishing point of which is in the silence [3]." We must therefore play, and interpret in the perspective of declining. Here again, the moment of the key release is critical.

The structural analysis of the musical score allows specifying and coding the interactions between the notes in order to organize them into pitch sequences issued one after the other, with or without overlap, or assembled into sets of synchronous pitches emitted in chord. On any musical score, the distribution into polyphonic voices allows to put in level the different voices, to get one closer, or on contrary, put another away, in a sound perspective essential to the understanding of the musical work that is to interpret.



Figure 8. Nine keys for ten fingers and one string quartet!

On the Metapiano, to play a quartet with one or a few keys is unusual (Figure 8)! We have to learn an original play mode, not consistent with the practice and the usual references of a keyboard we usually have. In the usual situation the instrumentalist expresses his musical thought by the gestural channel of his two hands and of his ten fingers. His musical concept must submit and overcome with the requirements of independence, coordination, equality and balance of both hands

as of ten fingers. The unique musical thought, is distributed to the ten fingers that enter in contact and handle the keyboard. On the Metapiano, on which only one touch would suffice, the musical conception goes through the single channel of a finger on a key, a key that contains a complete potential keyboard. The usual mastering of the independence of hands, fingers or voices must be replaced by the capacity of concentrate mentally superimposed hands, fingers or voices into one key movement. This play mode, condensed in its finger practice, and expanded in its musical effects, can be acquired relatively easily for easy musical pieces with basic rhythms. To interpret a complex score of chamber music with its virtuosity, its speed or slowness, its rhythmic complexity, its ornamentation, its different voices, its polyphonic writing, and finally its expression, we must work!

On the Metapiano, the keys have lost their function of pitch selection to only keep their function of expression for the rhythmic, the dynamic, and the phrasing articulation. Each key offers the same expression potential onto the sequence of programmed pitches. Since we have more than one finger and since, for centuries, we, musicians, have developed and acquired almost a genetic dexterity on keyboards, should we not play with more fingers on more keys to take advantage of digital technique? Indeed, the rapid succession of fingers, the training in repetition, the speed of a trill or ornaments, links “two in two” of the “coulés”, the control of dynamic equality or its variations, the execution of accentuation and the management of the tempo, rhythm and agogic variations, all these elements of the play acquired by the pianists during their technical work are serving the interpretation. The expressive potential they contain is immediately usable. On the Metapiano, the play only keeps the expressive side of the execution, leaving the running devices manage the practical side of the memorization and the execution of pitches. The acquired technique of the fingers being set in service of the only expression, it is wise to benefit the panoply of fingerings that have been developed on a keyboard. The fact remains that, this play on a few keys requires a finger adaptation and relearning, on one hand, and a revision of the concept of performance and interpretation, on the other hand. If the musical gesture is reduced to depressing, maintaining and releasing a key, the expressive control, however, spreads to different parts of the musical work. Such as a controller of musical process with single input and multiple outputs, the Metapiano gives the musician access to a kind of musical interpretation of which only the conductor has the privilege. The interpreter directs the music rather than plays it, but unlike the conductor, he keeps the instrumental control through his fingering.

The long technical work of learning and memorizing a musical piece “in fingering”, and the long time needed for the development of an ideal interpretation, usual to pianists, are now replaced by the analysis, and the coding of the musical work, dividing, on one hand, the structural aspects of the score and the physical aspects of the play on the keys, on the other hand. The notage becomes pedagogy of interpretation. In fact, during the notage, the musician can discover the musical score, analyse it, structure it, store it, put it in sounds, play, and express it. He may record and hear, within an unusually short time, his interpretation, or even his multiple interpretations. The Metapiano and its Pianotechnie operate a shortcut between a printed score on one side and its artistic performances on the other. To

consider immediately several interpretations of one piece is unusual. Perform into sounds *ex tempore* what we hear internally, express it without the technical constraints, choose among the possibilities that suggest writing, knowledge and taste, is in a way, to improvise his interpretation. Such an immediate freedom of interpretations, on the spot, inspired by the moment, is it not what every musician aspires to have?

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