

An Interactive System for Musical Improvisation

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Abstract

The paper presents the final results of a project carried out within the Musicological Division of CNUCE/C.N.R. since 1985. The project is concerned with the development of a software package for jazz improvisation. It has two purposes: automatic composition and study of the extemporizing techniques. The analytical methodology of the project is based on the semiotic assumption which connotes the music as a kind of language with proper syntactic and stylistic features. Through some principles of transformational linguistics, the objective is not to verify the application of linguistic models to the music but the possibility of creating grammars for music generation and study.

INTRODUCTION

The jazz project, having developed since 1985 within the Musicological Department of CNUCE (C.N.R. Institute), forecasts the development of a software tool for the study of musical improvisation.

The package of programs has essentially two purposes: the automatic generation of harmonic-melodic improvisations and the creation of a structure designed to facilitate the study of underlying procedures of jazz improvisation.

THE RESEARCH FIELD

The first problem which had to be confronted was the delimitation of the research field.

The term "improvisation", in its own rather wide meaning, has been understood here in the sense of free musical composition arranged by a system of rules.

Opting for Jazz, which as a system is still culturally in use, meant the indispensable advantage of being able to work with extremely rich creative material as well as having the possibility of wide and relatively sure verification.

In general, Jazz is based on series of basic harmonic structures, more or less recurring, on which melodic improvisations are "constructed".

Among the various harmonic structures, called standard, which are repeated from one piece to another and often with the only transposition procedure, we have considered the twelve bar blues structure as one of the most representative: it is registered in the jazz tradition from its origins

up to the present day, and presents precise characteristics in its harmonic and melodic language which allow it to be clearly identified linguistically and stylistically.

Furthermore, our research has assumed the Be-Bop style which is not only particularly rich but also has a considerable harmonic and melodic development.

THEORETICAL SUPPOSITIONS

The origins of theoretical suppositions for the project are to be found in the musical-semiotic field; the musical language, understood as an organized system of signs, is subject to certain principles derived from transformational linguistics in order to comprehend the syntactical and grammatical rules that underlie a defined idiom. Going through the texts has made possible the definition of a particular idiolect, allowing to operate on an omogeneous situation. Furthermore, this textual research, carried out at various levels, has allowed the elaboration of a series of syntactical-grammatical rules which have then been formalized into derivational tree-structures.

These structures have been implemented by using programs and subprograms. According to this research methodology, the computer becomes an indispensable means of verification, in as much as it is able to recognize the exactness of the underlying rules only with the judgement of the "educated listener" on a series of automatic generation. By constant correction of wrong procedures, it is possible to obtain a sufficiently correct grammar of the language analyzed in order to supply satisfying results.

At this point the support to the study becomes valid because the set of rules proposed to the eventual listener has already been tested and will be able to supply precisely those indications which will get back the particular idiom in question.

FORMALISATION OF THE PROBLEM

The project has been subdivided into two sections: one for the generation and the other for the assisted interactive study.

The harmonic-rhythm has been worked out on a series of texts, predominantly transcriptions by B. Powell, C. Christian, D. Reinhardt, A. Tatum, T. Wilson, G. Shearing, T. Monk, with analysis concentrated on pieces where the accompaniment presented a chords progression which could almost be defined in "choral" form.

The analysis, based on a segmentation process (with criteria which will be probed further in the section on melodic rhythm), was then compared with the instructions examined from various manuals (Coker, Mehegan, Zano, De Rose, etc.) allowing the elaboration of a certain number of four bar structures. Sintactically, the various combinational possibilities have been controlled using probabilistic derivational trees.

In this phase the option for four bar structures is due to exclusively stylistic reasons; in fact this method has been able to safeguard certain characteristic of the accompaniment, for example the recurrence of certain figuration, their variations, the change of accent, all characteristic elements of the jazz style.

With regard to meter, the analysis has revealed the clear predominance of 4/4 with sometimes alternating 3/4. In the software system besides these two options also 12/8 is present, mainly to compare the rhythmic structures of binary and ternary phrasing. Considering also the fact that the original blues structure was actually in 12/8.

With respect to harmony, historically blues develop a chord progression that recognises his kernels in the I - IV - V succession often with plagal cadence returning on the first. The number of

bars, initially irregular, or at least without a rigorously fixed plane, is quickly arranged on the 12 measures. In rather elementary way we could organize the basic blues structure as follow:

I - I - I - I - IV - IV - I - I - V - V - I - I

From a strictly harmonic point of view this are the minimum elements necessary to respect the blues form as intended in at least its traditional sense. These elements have been elaborated, above all, from the Be-Bop style on with a game of insertions and substitutions that, respecting the nodal points of the I, IV, V degree, tend to enrich their expressive capabilities. While going through the text, a whole series of possible configurations were verified and, once analyzed and listed, were then compared to the manual indications.

This job allowed the construction of a tree structure, steel of derivational character, which synthesizes bar per bar the various solutions; the probabilistic incidence of each chord has also been revealed.

In each bar there are never more than two different chords present, even if there is the possibility of syncopated rhythmic progression able to produce anticipations and delays and thus obtaining in certain situations measures with more ore less than two chords.

The analysis of the melodic part has been based on a segmentation process in order to reveal the probable incidence of variuos figurations in a parallel way to the procedures adopted in the harmonic part. The unity of the "rhythmic figure" based on the minimum value of a quarter note has been taken as a basic rule. Practically, it has been carried out by subdividing the improvisation into rhythmic cells all beginning on the beat, and respected in their unity in the case of major values and of slurs.

Therefore, many units of duration oscillating between a quarter and a maximun of eight quarters have been obtained, recurring within the language and which constitute the lexicon from a rhythmic point of view. Having recognized the lexical unities, the job has been articulated into more successive phases, each one suitable for the verification of different aspects: recurrence of figurations, estimation of possible incidence, combinations of unities, their results etc.

In this way, a syntax for the improvized melodic discourse has been defined, allowing the formulation of a series of underlying rules.

All this, riorganized by syntagmatic indicators of probabilistic derivational character, has allowed the representation, or better the structural description of all the melodic-rhythmic paths.

In the passage to the programming part the generation of the rhythmic structure is subdivided into three sections: the first generate the initial fragment, the second the central nucleus and the third the final fragment.

The program, at the moment of generating the rhythmic structure of the melodic section, is able to read the harmonic generation and adapts the second to the first, avoiding incorrect and stylistically unverified procedures. At this stage, to allow the pitch generation the analysis of the actual melodic path has been arrived at.

The creative melodic process has been articulated in three levels which shall be called "principals" for convenience, even if, obviously, all the intermediate stages are also given.

The first sees an improvisation developed on a single scale from the beginning to the end of the harmonic progression, in our particular case the so-called "blues scale", or at times, on certain modes like, for example, the dorian mode.

The second level sees instead the passage across various harmonic functions present within the progression; in this particular instance those of the I, IV and V degree with therefore improvisational support on all the variuos scales relative to each functions. The most recurring scales even here are the blues and certain pentatonics besides which certain modes predominantly dorian, lydian and mixolydian; are given examples of the diminished scale.

The third level, without doubt the most evolutive, bases the creation of the solo on the entire harmonic path, creating a correlation between every chord and the appropriate family of scales.

In the programming phase, even respecting stylistic norms, we have tried to supply the greatest possible choice among the various expressive modules, intending also to recreate the possible mental paths of an improviser.

It has been developed the possibility to pass from one level to another trying to avoid the loss of coherence in the musical discourse.

At this stage, a pitch is assigned to each value of the rhythmic generation, thus concluding the job of melodic creation. The program is able to opt not only for the kind of scale, but also for its length, duration, beginning and finishing note, skip notes, repetitions etc, covering all the various possibilities in the melodic ambit.

OPERATIVE POSSIBILITIES

All the analysis, as mentioned in the introduction, has been finalized to create a basic competence for automatic generations intended as means of verification for the correctness of the theoretical suppositions. This "competence" has been made available to the possible user by means of the second section of the project which, for convenience, has been called the "study" part.

In reality, a clear boundary line does not exist between the two sections, at least from the listener's point of view: the division is used in order to allow a gradual and coherent passage from the definition to the solution of the problem. In fact, the user finds only one "object" in front of him: he must only establish whether to delegate the choices completely to it, therefore carrying out a passive function, or to interact with the machine. Like any performer, he is able to define the modulation of the piece, its meter and tonality; and even define the number of progressions he wants to carry out and decide for a complete generation, both harmonic and melodic, or only a partial generation.

However, the most interesting part is that which allows the partial or total definition of as much the harmonic path as the melodic one, by a reduced and practical set of commands.

The user is able to verify his own musical intuitions on a truly wide base of harmonic paths whose stylistic-grammatical correctness has been already tested with the help of the variation or substitution of certain elements of the path (even all of them). It is allowed to operate with pre-created elements for understandable practical reasons, like organizing structures as he likes.

At this point the versatility of system becomes intuitable, allowing any student to free himself from those instrumental-technical bonds which so often slow down the phase of theoretical learning by purely manual problem. Not that with this we want to ignore the function carried out also in theoretical learning by certain problems of specifically instrumental character, especially in jazz; however, it is certain that a clear intellectual "scaffolding" can only be useful.

Moreover, the application of the system both from the melodic and harmonic point of view also allows those who do not practise instruments of a "polyphonic" nature, like the piano or the guitar, to verify their own ideas without having to turn to outside help; by this, meaning other musicians or the study of another instrument.

Certain commands are forecasted for the comparison between harmonic generation in four quarters and melodic generation in twelve eights besides allowing the phase-shifting, measurable in hundredths of second, between the two sections; all of this, clearly, finalized to the study and analysis of those elements that contribute to the definition of swing.

Therefore, the system is practical also for the teacher, helping him as much in the solution of specific problems as in following individual students of the same, or more, class of different instrumental study, closer and homogeneously.

THE PROGRAM STRUCTURE

The software tool is implemented in the programming language VS- FORTRAN.

Structurally, it is divided into two principal sections (harmonic and melodic) which in turn are organized into secondary sections (rhythmic-harmonic, harmonic, harmonic-variations, rhythmic-melodic, melodic, melodic-variations).

All the various automatic generations of each section are in sequence and are related to the number of progressions requested, and to the other initial parameters.

Each section, both the primary and the secondary, requires a certain number of suitable choices for definition of the various stylistic components of the piece.

According to the system of rules and to the assumptions on which the generation is based, the requested choices in each section are carried out with asymmetric trees of probability which, as seen, respect the derivational criteria imposed by the analysis of the problem. In practice, these choices are carried out with a particular subroutine of random numbers generation working with linear distribution (TKASO).

The general structure foresees the use of a main program (TTJAZZ) which provides both the management of the user interface and the control of the two main subroutines for the creation in turn of the harmonic part (TTJZAL) and the melodic part (TTJZML).

Rhythmic-Harmonic section:

This is the first section to be generated.

A specific subroutine (TTJZRA) provides the creation of the entire rhythmic path, choosing between rhythmic groups of 4 bars stored up and organized by a suitable database subroutine (TTJZGR).

When the beginning of the melodic improvisation starts in upbeat an empty bar is placed before the first progression of the harmonic part in every piece. After the last bar of the last progression, a new bar is added to allow the production of the final cadential group.

The constituents of the group produced are read and decodified into a series of note-pause events. A specific duration value is associated with every event.

Harmonic section:

This section is inserted above the rhythmic-harmonic section and uses the following parameters: the number of progressions and general tonality. It also uses other parameters which are directly derived from the previous section. These parameters allow interrelation between the two sections.

For each of the "n" progression a different sequence of 24 chords is created; it follows the relative generation tree (TTJZAA) so as to correspond two chords for every bar, according to the rhythmic figuration produced for that bar.

One or two suitable chords are added to the "nth" progression to allow the generation of the final cadence.

All the chords produced in this section make use of four outputs of the eight voices available.

Harmonic-variations section:

The harmonic-variations section can modify the arranged chord sequence produced by the section immediately preceding it.

This section is closely connected with the user's features in order to modify the harmonic path using the "PATH" subcommand. Therefore it uses the whole series of initial parameters attached to this subcommand.

In the extreme case we would not have more than one new chord for every half-bar according to the syntax.

After decoding the parameters of the new chord, the exact index of the sequence where the chord will be inserted, is calculated; the new chord takes the place of its equivalent produced automatically. It is inserted into the sequence for a number of times equal to the number of rhythmic figures, not pauses, fit in its relative half-bar.

Rhythmic-melodic section:

It constructs the rhythmic framework necessary for the consequent development of the actual melody.

It interacts with the rhythmic-harmonic section allowing the necessary homogeneity of the generation. Among its principal input parameters there is the metronomic value that causes a substantial difference in the rhythmic structure, according to the chosen speed.

The rhythmic-melodic section operates on a subdivision in three parts of the piece: the beginning, the central core and the finale.

Each of these parts is developed on suitable trees of choice with clear expansion or contraction on the central part to conform to the number of progressions.

There is a range of 128 different possibilities for the choice of single rhythmic units catalogued in a special database subroutine.

Melodic section:

This makes up the main part of the program: it constructs the melodic development of the improvisation.

The interaction is present with all the other previous sections. The initial choice (carried out at the beginning of the performance) is made between two possibilities:

1) the reading of the chord relative to each bar listed in two fields, one containing the degree of the chord (NG = number between 1 and 12) and the other containing the kind of chord (NT = number between 1 and 11). Consequently, the identification of the possible scale is related to the two read numbers (NG x NT possibilities) and to a probabilistic tree of choice.

2) notes generation on appropriate scales (TTJZSM) with eventual possibility of ranging over the relative "functions" of each bar. This means that each bar will have certain correct scales available which, when required, can be transposed to adapt them to the function of the bar being carried out: the function of IV degree for the fifth and sixth bar, the function of V degree for the ninth and tenth bar and the function of I degree for all the others.

Using a map created from the preceding section, the number of available notes for a certain bar is calculated and then iterated in order to choose the type and the contour of the path from note to note.

Forecast: repeated note - superior skip note - inferior skip note - superior scale - inferior scale (TTJZPM).

The melody moves within a range of four octaves without going over its limits.

Melodic variations section:

The Melodic Variations section can modify the scales sequence for the improvisation.

Opposed to the harmonic-variations section, this does not subsequently correct the melodic content but it is totally integrated in the melodic section. For each note this case (melodic variation) may be considered only if a particular scale for that bar is specified.

The new scale (chosen by the user) dominate the scale chosen automatically.

Up to a maximum of one scale (chosen from the present ones or created with the chromatic scale) per bar may be assigned using the "SCALE" subcommand.

Output:

The output can be of two kinds:

- 1) midi output: the program produces a midi file containing musical data in hexadecimal code. Such files can be played by any midi synthesizer with possibility of timbric independence for the 8 voices.
- 2) graphic output: the program produces a graphic table following the standart Teletau code from which it is possible to obtain the musical score quite easily.

CONCLUSIONS

To sum up therefore, the general objective of the project is placed within the field of study of musical improvisation, trying to supply a suitable means for the aims requested by the learning.

In this light, the possible developments are finalized with an always greater flexibility in order to offer the user the maximum of possible options.

There is a project for a section which will can even allow the control of rhythmic structures - an aspect which up to now had been neglected.

Taken into equal consideration, has been the idea to offer the user the control of the structures that rule the melodic expression in order to allow him the study of another considerable sector within the Jazz ambit.

The improvement of the user interface has also been considered, both in making the commands more flexible, and also by inserting possible utility options, like, for example, the creation of maps of the generations to consult at request, in order to facilitate further the management of the macrostructure.

A successive implementation of the software on Personal Computer is forecast, to make the package far more useful as to institutions and schools as to individuals.

In conclusions we fill that we can assert that the system presents good practical and specifical assets for the study of the jazz idiom, allowing also in this sector the exploitation of the vast possibilities offered by the computer.

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