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METHODOLOGICAL STRATEGY FOR OPTIMIZATION OF PRODUCTION PROCESSES OF POP MUSIC, BASED ON COMPUTATIONAL MODELS

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Abastract. The design of a methodological strategy consisting of computational models, musical technology and basic rules of harmonic composition is proposed. The strategy integrates different tools such as programming languages, algorithms and reuse libraries for the extraction of strong characteristics from the samples produced by an interpreter, as well as the execution of discrete stochastic processes that execute melodies limited by basic rules of composition of Pop music. generated melodies are converted into series that are later played in a controlled way, by a MIDI device (digital interface of musical instruments) and bounded by musical composition rules that reduce melodic monotony. To specify the integration of all the elements as a system that generates iterations, use open control protocols between programming languages and tools that allow the interconnection and communication between the different technological components that make up the strategy. Once the process of generating melodic fragments is complete, these are transmitted to an audio manager and copied to each channel of the manager in a standard MIDI format. This information, in addition to being editable, provides the producer with the possibility of reusing these tracks as raw material for work to generate greater situations and creative possibilities when developing a Pop music production process.

Keywords: Rules of musical composition, Recovery of musical information, Stochastic Models, Music production, Musical Fragments.

UNA ESTRATEGIA METODOLÓGICA PARA LA OPTIMIZACIÓN DE PROCESOS DE PRODUCCIÓN DE MÚSICA POP, BASADA EN MODELOS COMPUTACIONALES

Resumen. Se propone el diseño de una estrategia metodológica compuesta por modelos computacionales, tecnología musical y reglas básicas de composición armónica. La estrategia integra diferentes herramientas como lenguajes de programación, algoritmos y reutilización librerías para la extracción de características fuertes a las muestras producidas por un intérprete, así como la ejecución de procesos estocásticos discretos que generan melodías acotadas por reglas básicas de composición de música Pop. Las melodías generadas son convertidas en series que posteriormente son reproducidos de forma controlada, por un dispositivo MIDI (Musical Instrument Digital Interface) y acotadas por reglas de composición musical que contribuyen a disminuir la monotonía melódica. Para garantizar la integración de todos los elementos como un sistema que genera iteraciones, se utilizan protocolos de control abierto entre lenguajes de programación y herramientas que permiten la interconexión y comunicación entre los diferentes componentes tecnológicos que conforman la estrategia. Una vez concluido el proceso de generación de fragmentos melódicos, estos son transmitidos a un gestor de audio y copiados en cada canal del gestor en un formato de tipo estándar MIDI. Esta información, además de ser editable, brinda la posibilidad al productor de reutilizar estas pistas como materia prima de trabajo para generar mayores escenarios y posibilidades creativas, cuando se desarrolla un proceso de producción de música Pop.

Palabras clave: Fragmentos musicales, MIDI, Modelos estocásticos, Music Information Retrieval, Reglas de composición musical, SMI

Introduction

Despite the fact that there are innumerable technological tools that support pop music production processes, the flexibility of activities that are part of the development of this type of productions does not stop presenting challenges that must be strictly planned and addressed from a methodological strategy. Problems such as the integration of different computing tools, interaction between applications, generation of editable music content in standard formats, the reuse of strong features extracted from the collections stored in the audio manager, and the transmission of editable data to the digital audio manager, make these challenges can be faced from the use of a plan that generates value to the music production process, and that also involves tools that systematize activities that traditionally consume many technical and human resources.

The creators of this type of sketch are not without challenges when it comes to materializing each creative idea. Activities such as recording sounds and capturing musical instruments are traditionally done with expensive equipment and acoustically designed spaces for capturing voices and musical instruments. It is important to note that after completing some activities, many hours must be spent editing the captured samples, in addition to this, the person responsible for managing the audio manager must have experience in managing this type of project. It is important to mention that on many occasions it is the case that the person who handles the audio manager does not have extensive musical knowledge and this can also limit small projects that do not regularly have a large group of people working in the elaboration of it. All these elements make traditionally consume many technical and human resources in the development of these production processes.

The relevance of developing a methodical plan that guides the integration of different technological tools becomes important when study activities are made more flexible and alternative technologies to traditional ones are used in the production process. The integration of different tools, connected by means of communication protocols, and the automatic generation of melodic fragments become a support for the music producer, since with the transmission of data represented in instruments, scales, arpeggios and effects in the channels of the manager, the producer is given the possibility to explore different scenarios and settings that allow obtaining different production results. However, the challenge lies in taking advantage of these technologies as a strategic and structured solution within the complex process of pop music production.

Some guidelines to solve problems in sound generation processes or the combination of any of these forms for musical production purposes are described in this section, for example, the proposal of (Thorogood, Fan and Pasquier, 2019) where they seek to reduce costs sound recording, database retrieval and artificial generation of sounds in order to produce soundscapes. In the design of (Turchet and Barthet, 2019) a ubiquitous intelligent guitar system for collaborative musical practice is proposed. The researchers seek the convergence between collaborative and social technological tools that interact within the field of computer ecosystems interconnected on the internet for music, a concept proposed by Turchet et al. (2018). The authors defined this concept as the set of devices interconnected with each other and with computing capabilities to achieve a musical objective. To contextualize the technological concepts discussed so far, we will begin by defining the concept of MIDI protocol on which Rumsey and McCormick (2004, p.97) affirm that it is "a standard for the serial communication of control information between musical devices". Another technology that is part of this proposal is the concept of human-computer devices and, more specifically, intelligent musical instruments (SMI), these elements will be defined as a device with computing characteristics and with the ability to connect to data networks, designed for musical purposes. Digital tools such as audio managers and programming languages are integrated through Open Sound Control (OSC) protocols, a protocol for interconnecting applications, digital musical instruments and computers. Middleware applications are tools for the interconnection between different applications.

By detailing the configuration of this strategy, it can be stated that it is a combination that integrates tools and techniques in order to generate melodic fragments bounded by basic rules of musical composition. These fragments are generated by automated systems that were designed for this strategy. The present proposal is made up of computational models, music technology and basic rules of harmonic composition. The strategy integrates different tools such as programming languages, design and reuse of algorithms and libraries for the extraction of strong characteristics from the samples produced by an interpreter, as well as the execution of discrete stochastic processes that generate melodies bounded by basic rules of music composition. Pop. The fragments generated are converted into series that will later be reproduced in a controlled way by an SMI device. A gradual summary of how each of the parts are integrated can be summarized as follows:

- Perform a sample analysis, extracting the strong features to a digital file.
- Convert scales into vectors and apply permutation techniques.
- Process stochastic matrices and find resulting vectors.
- Make adjustments to the resulting vectors according to basic rules of musical composition.
- Control events in the system through some human computer interface.
- Transmit the results to the manager in an editable format.

Method

Components

To guarantee the integration of all the elements that make up a methodological strategy as a system that generates iterations, open control protocols are used between programming languages and tools that allow interconnection and communication between the different technological components that make up the strategy. Once the melodic fragment generation process is complete, they are transmitted to an audio manager and copied to each channel of the manager in a standard MIDI type format. This information, in addition to being editable, gives the producer the possibility of reusing these tracks as raw work material to generate greater scenarios and creative possibilities, when developing a Pop music production process.

Need for a strategy?

The need to use a strategy that supports and generates value in the elaboration of musical compositions is based on the fact that even for the most inspired musician, the passage of time and the weight of their previous productions, begin to limit their creative capacity. From the 60s and 70s, articles that would be references for research in automatic composition were published: Pattern in Music by Herbert Simon and Richard Summer (1993) and Analysis of Tonal Harmony by Terry Winograd (1968). In particular, Simon and Summer's studies attempt a systematization of the mental processes in the listener, based on the structure of tonal music, applying a rigorous methodology in the processing of information. Some researchers (Hiller, 1979; Inoñán, 2010) have experimented with Markov chains, a simpler and more controllable mathematical model, consisting of a special type of discrete stochastic processes in which the probability of an event occurring depends on the immediately preceding one. In the work of Hori and Sagayama (2016), the researchers make a variation to the viterbi algorithm, generally used to minimize the complexity of playing a phrase on string instruments. The change introduced in the work of these researchers consists of a variation of the algorithm called Minimax Viterbi algorithm in order to minimize movements in the most complex sentences to execute, and maximizing the transition probability supported by models of hidden Markov chains (HMM). A proposal for musical composition based on complex systems, where the author uses chaotic systems for the automatic generation of music, given that "they facilitate the manipulation of the melodic monotony and generate different musical fragments, varying a little the initial conditions of the chaotic system" (Coca, 2009, p.16). A technical summary of this methodological proposal is represented in Figure 1.

Figure 1. Schematic diagram of the methodology for generating melodic fragments.
Note: Source. Author's own creation

Basic rules of harmony

The generation of melodic fragments with a certain discursive coherence is based on a combination of basic rules of musical composition, together with models and computational techniques. The purpose of this set of elements is to parameterize algorithms that partly seek to break the melodic monotony of its own caused by randomness. The rules of musical harmony are treated in this work as a set of equivalences or parameterizations of a system. This compendium of rules has one of its main references in the 1900s with the proposals of Heinrich Schenker and Arnold Schoenberg, considered contradictory, which, however, led to a change that allowed the classification of every chord formed by the superposition of 3 to 12 notes from a bass or root note. Functional harmony is defined as a set of simultaneous notes that generally accompany the melodies, guaranteeing coherence in speech.

Functional Harmony

The concept of functional harmony is the one adopted in this work to establish parameterization rules in a system. According to Galbis (2006): "when we speak of harmony we refer to the vertical aspect of music, the simultaneous sounds that we call intervals and chords and their possible linkages" (p. 50). In the 1900s, according to the Harvard Dictionary of Music (2001), Hugo Riemann invented the term functional harmony in his proposal Theory of tonal harmony (1897), defined as the main note that is called the tonic. This is the main idea that is applied to music composition algorithms, key components of the entire methodological strategy that is developed throughout this work. When on a guitar a musician places his fingers in two or more positions on the neck, he performs the construction of a chord. Chords in their basic construction are determined by rules of functional and traditional harmony, where the central axis of the chord is the tonic and it is accompanied by two more tones that are defined as degrees; a third, known as through, and a fifth known as dominant. These degrees are defined in functional harmony as follow:

- Grade (I) = = Tonic
- Grade (II) = Supertonic
- Grade (III) = Through or Modal
- Grade (IV) = Subdominant
- Grade (V) = Dominant
- Grade (VI) = Superdominant
- Grade (VII) = Sensitive or subtonic

Chord generation

Another important element for the reproduction of melodic fragments are the chords, in the field of harmony they are called the major consonant triad for the chords made up of a major third and perfect fifth; consonant minor triad, made up of a minor third and a perfect fifth, and a diminished triad, made up of a minor third and a diminished fifth. The combination of the above grades in chords of three sounds, composed of two superimposed thirds and constitute the basis of the traditional tonal system. These chords are necessary for the formation of scales and are described as follows: perfect major chord (3rd major + 3rd minor), perfect minor chord (3rd minor + 3rd major), diminished chord (3rd minor + 3rd minor), chord augmented (major 3rd + major 3rd) and major chord with decreased 5th (major 3rd + decreased 3rd). (Roca and Molina, 2006). The basic configuration of a chord is made up of the root or fundamental tonic note, the third or through and the fifth or dominant, configuration that is called a triad.

When a three-sound chord is played on the tonic of a major scale, a major chord is being played, and in the same way if the musician's performance is on a minor scale, the chord will be minor. The differentiation between one chord and another occurs in the third tone, which, as its own name indicates (through or modal), tells us if the mode is major or minor.

Scales Generation

Another determining harmonic element is the scales, a set of tones that can be simulated in vectors to make their melodic manipulation more flexible and execute with a certain randomness; Depending on the configuration of this vector, major and minor scales can be formed, as well as variations thereof. Assuming the same time scale, twelve values are considered represented in tones and semitones, Harte (2010) represents it in the following set: {C, C♯, D, D♯, E, F, F♯, G, G♯, A, A♯, B}, consisting of the twelve pitch attributes as used in Western music notation. An equivalence of each value in this set of tones and semitones can be identified as a set of integers {1,2, ..., 12}, where 1 refers to the key C, 2 refers to the key C♯, and so on. The way a major scale is defined is a list of seven tones and semitones (T-T-T-S-T-T-T), where semitones make the difference between a major or minor scale. A binary vector is the one that decides the logic of tones and semitones, an example is the vector of ones and zeros "[1,1,1,0,1,1,1]" that represents the major scale where one represents a tone and zero represents a semitone. The vector representing the minor scale would be left with a zero in the third position and in the sixth position “[1,1,0,1,1,0,1]”.

Extraction of strong features

The MIR system that was designed for this project is in charge of extracting the main tone of the sample and then compares the error that the program throws against the tone in which the musical fragment was designed. The basic idea of the algorithm is to find key distances to the main pitch; specifically, perfect fifth intervals, relative major and minor, and major and minor parallel. The MIR system that was designed for this project is in charge of extracting the main tone of the sample and then compares the error that the program throws against the tone in which the musical fragment was designed. The basic idea of the algorithm is to find key distances to the main pitch; specifically, intervals of perfect fifth, relative major and minor, and major and minor parallel see Figure 2.

RELACIÓN CON LA CLAVE CORRECTA	PUNTOS (c_i)
Igual	1.0
Quinta perfecta	0.5
Relativa mayor/menor	0.3
El mismo pero un modo diferente mayor/menor	0.2
Otra	0.0

Figure 2. Relation with correct key.
Note: Source. (https://www.music-ir.org/mirex/wiki/2019:Audio_Key_Detection,2019)

Music composition techniques

The reproduction of melodic fragments must not only be limited by rules of musical composition, musical techniques are also used to structure them. The permutation of musical series is a musical composition technique used since the beginning of the 20th century and called serialism, which was inspired by twelve-tone, another musical composition technique created by Arnold Schönberg and which is based on the 12 tones of the chromatic scale. Among the most recognized composers of the serialist technique are Alban Berg and Anton von Webern (Romero, 2004). This musical technique facilitates melodic manipulation when generating synthesis in a programming language.

Synthesis techniques

A stochastic matrix is formed from the strong characteristics extracted from an audio fragment. The matrices programmed in methods such as a syntactic structure are Markov chains, a specific case of stochastic processes; They are a tool within the field of operations research that allows analyzing the behavior and governance of certain types of stochastic processes.

According to Kolman and Hill (2013), they state that "A Markov chain is one in which the probability that the system is in a particular state in a given observation period depends only on its state in the immediately preceding observation period" (p.119). Each of these chains consists of n states defined in a transition matrix T. This matrix will be generated by a synthesis system specially designed for this work in the ChucK programming language, its creators Kapur and others (2015) define it as: “ChucK is a programming language specifically designed for creating music and sound synthesis in real time” (p.3). In this type of matrix, the probabilities and changes of state are generated by algorithms that are part of this synthesis system. The probabilities of change are represented mathematically as the product of the dimensions that make up this matrix, while the values of the matrix will be generated randomly and cannot be negative. In this proposal an adjustment is made to guarantee that the sum of each row is equal to 1. The arithmetic applied by the algorithms between the stochastic matrices and the musical scales produces vectors that contain melodies already affected by parameters and composition rules. This generalization allows finding all the other state vectors, but to develop this process a series of threads are required, which were built as software components. This system is a logical tool aimed at audio synthesis and composed of modules that interact with each other in order to generate melodic fragments. This tool takes as raw material the patterns or metadata generated in the other recovery system, also designed in the context of this research, this tool is responsible for the recognition of strong characteristics to digital audio samples.

Logical structure of the synthesis tool

The tool aimed at musical synthesis is a design composed of modules that are classes or complex syntactic structures. These structures run on a virtual machine in different threads or synchronized programs running to ensure real-time efficiency. These threads or threads run serially or in parallel. A model that describes this system and its components is represented in Figure 3.

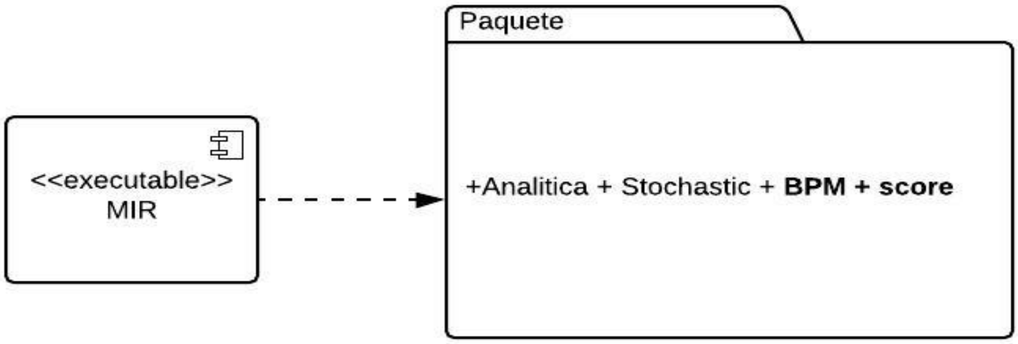

Figure 3. System component diagram.
Note: Source. Author's own creation

A 30-second digital audio fragment is analyzed and as a result it produces a main tone corresponding to a key of a major or minor nature, immediately the methods that execute algorithms within the synthesis system generate major scales, chords, modes, stochastic matrices, filters and vectors.

Classes and methods

A package with four complex structures is developed for the generation of stochastic transition matrices. These matrices are composed of random numbers and meet the conditions required by a matrix of this nature. This syntactic structure, cardinally and communicationally correlated, is the basis for the grouping of the main calculation and generation methods. In Figure 5 the classes, methods and relationships of the syntactic structures that function as directives for all the synthesized instruments that can intervene in the composition of fragments are represented. See Figure 4.

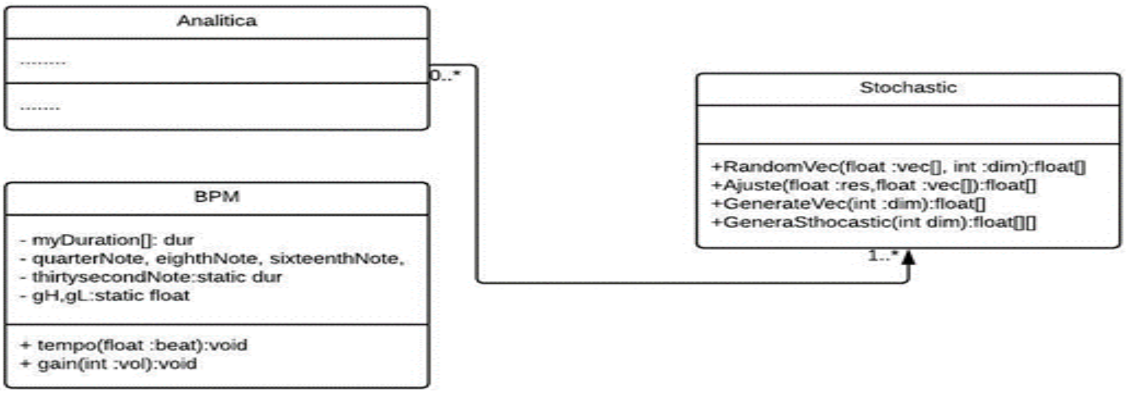

Figure 4. Diagram of main classes.
Note: Source. Author's own creation

A synthesis module executes an orchestrator object that instantiates objects of the generation classes and of a class corresponding to a melodic instrument. Once it is placed in execution, it begins to launch generation methods until writing a melodic and persistent vector, behaving as a database for all the musical instruments of reproduction and different objects in the synthesis system. The following diagram describes the communication between software components when generating a melodic fragment, see Figure 5.

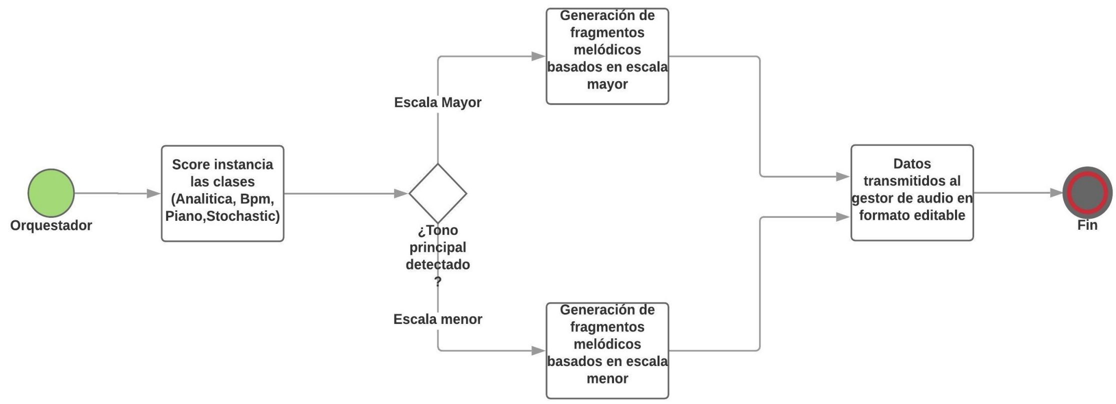

Figure 5. Diagramo of main clases.
Note: Source. Author's own creation

Information contained in the metadata

All the tools previously explained, which interact with each other, work in order to transmit information to a digital audio manager in a standard and editable format. As can be seen in Figure 3, which illustrates the general composition of the strategy, each of these techniques and tools provides important data and information to generate melodic fragments, which must then be transmitted to the audio manager in MIDI and digital audio formats. WAV.

There is communication between the strong feature extraction system and the synthesis system; communication between these two systems is achieved through metadata, and the composition of the file format for the results generated by the different modules of the MIR system is described below, see Figure 6.

Módulo	Archivos	Descripción
Análisis Tonal	Nombre_Key.txt	Tonos presentes en ventanas de
	Nombre_KeyEnergy.txt	Energia de los tonos en ventanas de tiempo
	Nombre_KeyMain.txt	Tono principal
Seguimiento del Beat	Nombre_Beats.txt	Instantes de tiempo de ocurrencia de los beats
	Nombre_Tempo.txt	beats/min
Reconocimiento de Acordes	Nombre_Acordes.txt	Acordes en ventanas de tiempo
	Nombre_Tiempos.txt	Instantes de tiempo de los acordes
Estimación	Nombre_F0.txt	Frecuencias fundamentales en ventanas de tiempo
Frecuencia Fundamental	Nombre_Onsets.txt	Instantes de tiempo de los onsets del audio

Figure 6. Definition of the file format for the results generated by the different modules of the MIR system
Note: Source. Author's own creation

Generation of scales

A set of methods is used for the generation of scales, chords and modes. These algorithms use a vector of ones and zeros that represents the difference between the intervals of a scale, which means that one (1) represents a difference of two positions and a zero (0) a difference of one position, see Figure 7.

Octava	C	C#	D	D#	E	F	F#	G	G#	A	A#	B	
0	0	1	2	3	4	5	6	7	8	9	10	11	
1	12	13	14	15	16	17	18	19	20	21	22	23	
2	24	25	26	27	28	29	30	31	32	33	34	35	
3	36	37	38	39	40	41	42	43	44	45	46	47	{0,1,0,1,1,0,1}
4	48	49	50	51	52	53	54	55	56	57	58	59	
5	60	61	62	63	64	65	66	67	68	69	70	71	
6	72	73	74	75	76	77	78	79	80	81	82	83	
7	84	85	86	87	88	89	90	91	92	93	94	95	
8	96	97	98	99	100	101	102	103	104	105	106	107	
9	108	109	110	111	112	113	114	115	116	117	118	119	
10	120	121	122	123	124	125	126	127					

Figure 7. MIDI positions vs musical NOTES.
Note: Source. Author’s own creation

Program logic makes the decision to add a pitch or semitone during the scale generation cycle, while a constant K randomly selects the mode of a specific musical scale. A first method to describe is the generation of major scales, bearing in mind that musical composition rules must be set for major scales. The method developed in this work builds a numerical chain represented in a vector of integer elements, this vector is equivalent to a list of MIDI values positioned according to the classification of the scale found in generation. Describing the generation of a larger scale, this algorithm makes decisions according to the position of the vector that is in initialization. Similarly, the generation method on a larger scale is represented below, see Figure 8.

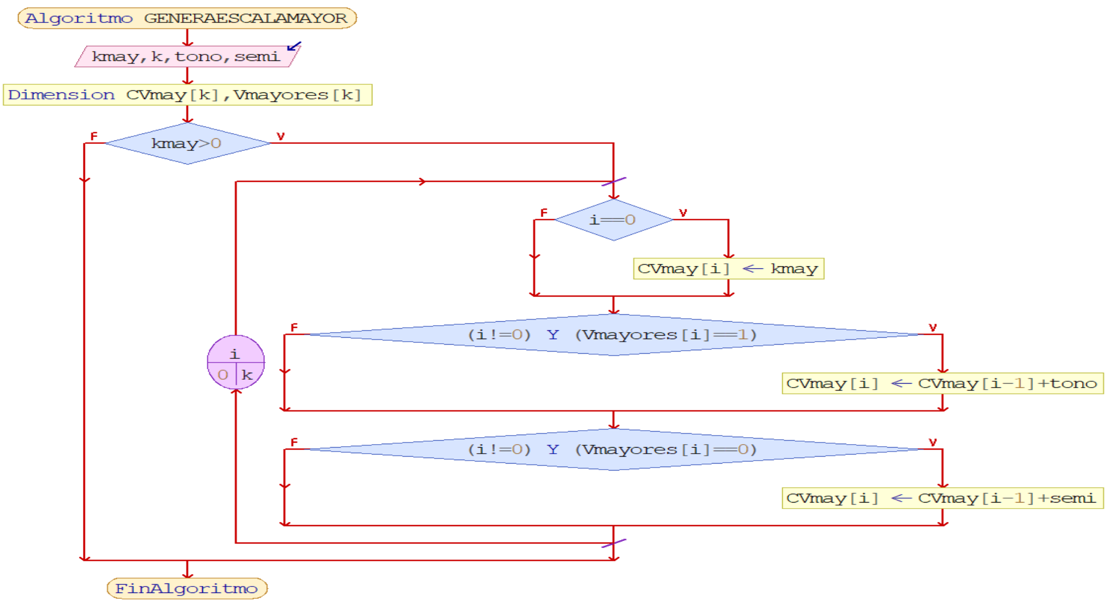

Figure 8. Algorithm for generating the major scale.
Note: Source. Author’s own creation

Chord generation and nodes

In the case of major and minor chords, triads are generated made up of the three basic tones to which VII and IX are added, to which the algorithm randomly reproduces with less intensity. This algorithm initializes the value of the pitch depending on the value of each position of a vector. For example, the major scale corresponds to positions 0, 3 and 4 of the vector, which are equivalent to major chords. Positions 1, 2 and 5 correspond to minor chords. Finally, position 6 of the vector corresponds to the diminished chord. In the case of chords corresponding to the natural minor scale, it is important to note that the algorithm for generating these chords initializes the value of the tone depending on the value of each position of a vector. The positions (0,3,4) of the vector are equivalent to the minor chords; the positions (2,5,6) are equivalent to the major chords and, finally, the position (1) of the vector corresponds to the diminished chord. See Figure 9.

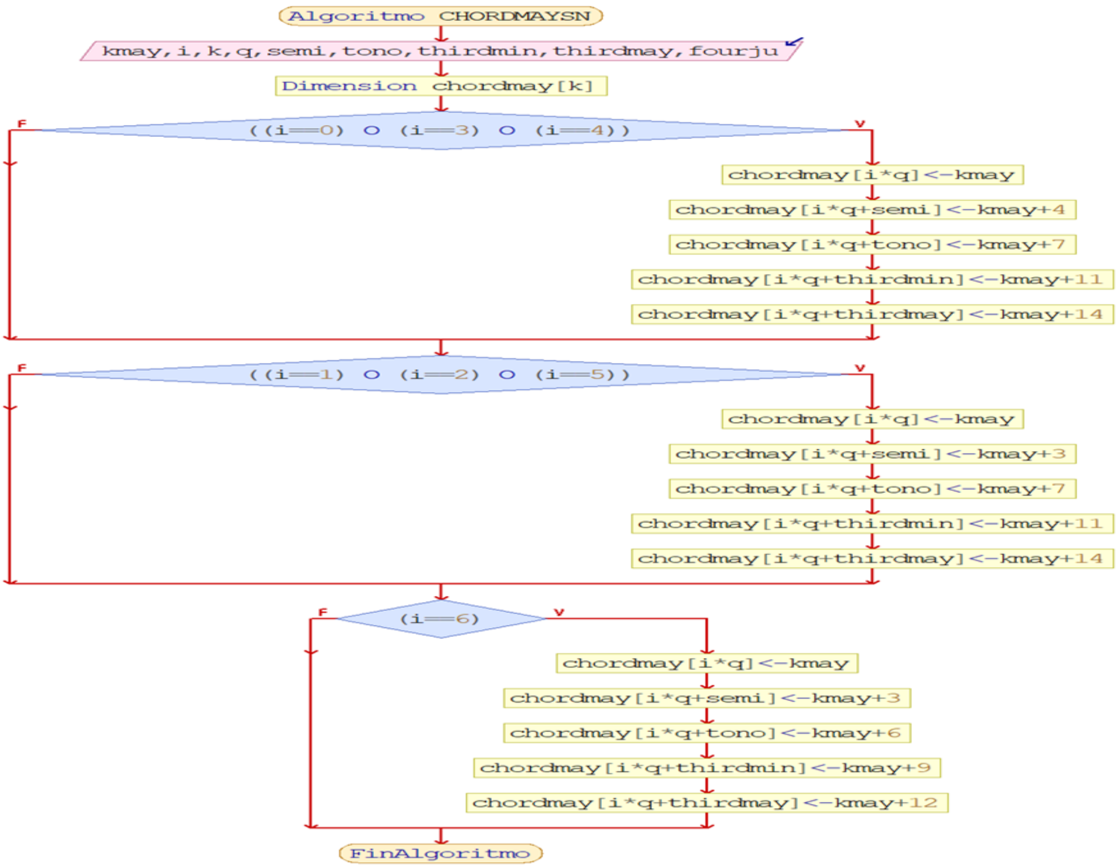

Figure 9. Mode generation algorithm.
Note: Source. Author's own creation

The generation of modes in musical scales is another musical technique that contributes to the recreation of a major or minor scale. Despite the fact that the major and minor scales summarize the characteristics of the modal scales, when recreating the scale or executing its reproduction, differences between a modal context and a tonal context are accentuated Balderrabano (2019). For this case, this algorithm generalizes the modes for the major and minor scales: it basically receives as input data the mode and a numerical interval constant, which corresponds to the summation constant to transport the received scale to each of the modes. See Figure 10.

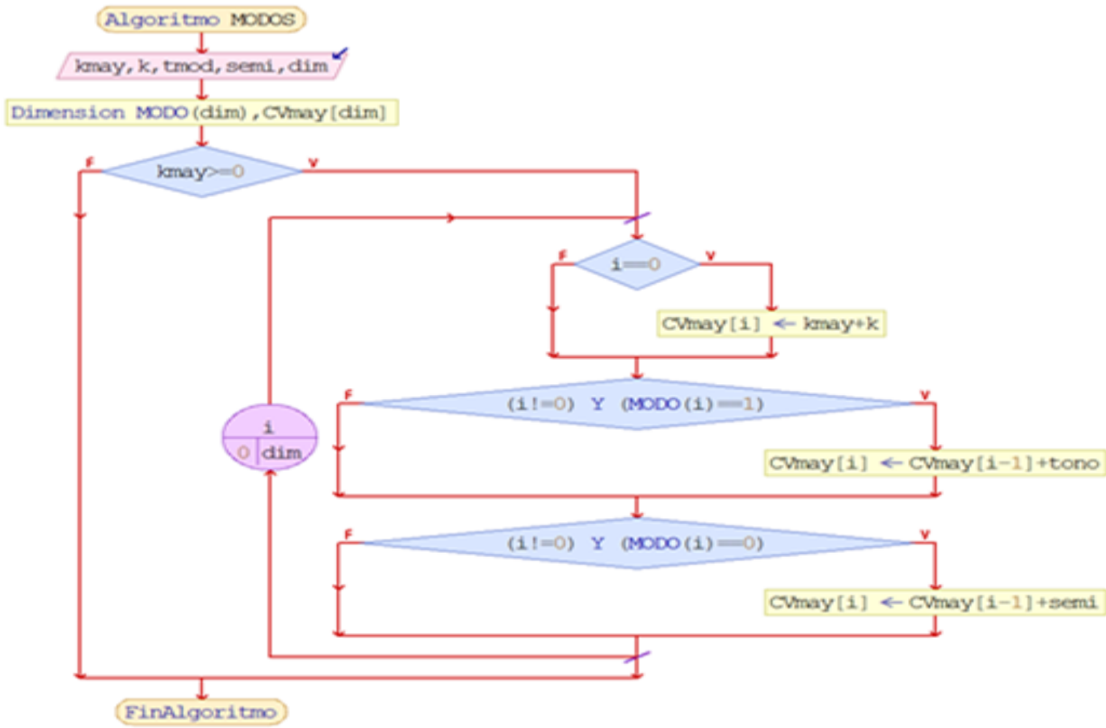

Figure 10. Modal scale generation algorithm.
Note: Source. Author's own creation

Generation of melodic fragments

The generated products are melodic fragments consisting of chords, petriodes, phrases or semi-phrases, which are generated for each time interval, and are divided into intervals that are multiples of the initial time detected for a digital audio sample. For this case and as the algorithms of this work are programmed, the smallest value for each phrase will depend on the detection of the time to the audio sample that the strong characteristics extraction system performs, and on the division that the music performs when time in half notes, eighth notes and sixteenth notes, each figure is a multiple of the fundamental time. Figure 11 represents the sequence of activities, messages and processes until reaching the production process. Once the information is translated by a Middleware software, which works between the programming language and the channels of the audio manager, the information is transmitted until it reaches the editor channels in MIDI data format. The producer edits the data of each channel using the editing and transformation tools of the digital audio manager.

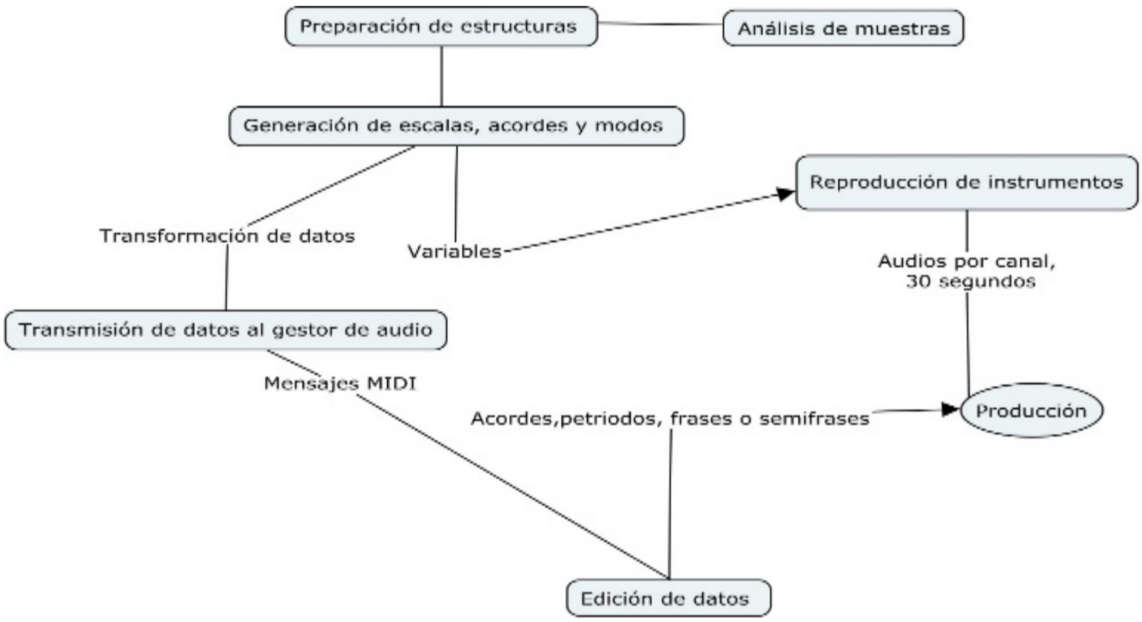

Figura 11. Iteration between processes, activities and messages.
Note: Source. Author's own creation

Data transmission an audio manager

The data transmitted on the channels becomes the raw material for the producer to create, recreate or experience different scenarios. This raw material becomes other intermediate artifacts, such as sound effects, arpeggios, prolongations and everything that creativity and knowledge allow the person in charge of the digital audio manager to edit. The actuation of MIDI devices and human-computer interface devices adds a little more sensitivity to the fragment generated by the computer system. These devices trigger arpeggios and effects that read the information generated by the system, but, in this case, the qualities of these performances depend on the added device and the expressive sensitivity of the player.

Perceptual evaluation of melodic fragments and their simplification

The perceptual evaluation of these melodic fragments requires a tool to collect the opinion of a sample of experts, for this purpose a digital form is designed that collects data and perceptions applied to a population of musicians, producers and engineers, who after listening to the reproductions generated by these fragments, record their perception in a questionnaire that is composed of discrete polytomous variables.

The instruments used to analyze the information collected in the questionnaires are technological tools for data analysis and are consolidated in the current market. For example, the statistical package for social sciences "SPSS", designed by the software house IBM is currently one of the leading applications on the market since the 80s SPSS (2020). Another tool used for analysis of results is the "XLSTAT" package, an application that is installed within the Excel functionalities and is anchored within its own menus using the XLSTAT data sheets (2020).

To analyze and simplify the results recorded in the questionnaire, a multivariate statistical technique is used, in this case the factor analysis technique is used, which is a simplification method in subsets of variables, these subsets represent the most relevant ratings made by the evaluators. they also identify the variables that the experts considered with the greatest interest.

Elements of the evaluation model

In the musical environment, improvisation is known as the art of producing or conceiving a part of a song or piece, which can be a melody or an arrangement without previously planning, based on some available resources Erkkilä (2000). One of the most popular models for musical evaluation was the one implemented by Swanwick (2002) called CAP (Composition, Audition and Performance), a model that was later adapted by Alberola [20] who made her own version. In this new model, Alberola considered that the essential elements for the evaluation of a musical performance are fluency, sound, posture, notes and rhythm.

The statistical method

In this case, a statistical technique called factor analysis is applied, a multivariate analysis method that has advantages over other statistical methods, since an immense set of data is not necessary to execute data analysis processes finding good reliability measures, also with this The method seeks to explain the variability based on the number of factors that are evident after data processing. This technique also groups variables belonging to each of the relevant factors, and reveals the importance that the respondents confirm of each variable when answering the questionnaire.

Results

In the case of this work, and taking into account that the interpretation is carried out by a computational model, the following proposal is elaborated, consigned in Table 3, where only four elements are included: sound, notes, rhythm and edition. The population of experts who supported the evaluation of this computational strategy was made up of a group of 20 experts: 10 musicians, 5 producers, and 5 engineers, who recorded their opinion in a data collection and perception tool. See Figure 12.

EVALUACIÓN DE FRAGMENTOS MELÓDICOS V 0.0 - 2019
Objetivo: La encuesta que usted diligenciará a continuación evalúa su percepción de un fragmento melódico generado por un modelo computacional, por lo cual es indispensable que sus respuestas sean justas y neutrales. Le solicitamos marcar con una X la calificación que mejor refleje su opinión frente a cada criterio a evaluar, siendo 1=Muy deficiente, 2=Deficiente, 3=Aceptable, 4=Bueno, 5=Excelente.
1.Sonido
a) La reproducción de los sonidos son claros, no confusos y consistentes.
b) Se oyen claramente las distintas alturas y combinaciones de instrumentos.
c) Se oyen claramente los distintos acordes y tonos.
d) La duración de la reproducción de este fragmento melódico es ideal para recrear nuevos escenarios.
2. Notas
a) Los acordes que acompañan a las melodías reproducidas por este modelo computacional son correspondientes y sonoros.
b) Los fragmentos melódicos reproducidos por el modelo computacional son coherentemente discursivos, lo que quiere decir que son coherentes y consistentes en el tiempo que dura su reproducción.
c) El fragmento melódico reproducido por el modelo computacional no es monótono, presenta variabilidad y dinamismo durante el tiempo que dura su reproducción.
3. Ritmo
a) Las notas musicales y acordes se reproducen con ritmo y a tiempo entre los diferentes instrumentos.
b) El fragmento melódico reproducido por el modelo computacional no es monótono en ritmo, presenta variabilidad y dinamismo durante el tiempo que dura su reproducción.
4. Edición
a) La información trasmitida por el modelo computacional es fácilmente transformable y reutilizable.
b) Los sonidos reproducidos por este modelo computacional propician la creación de nuevos fragmentos de canciones o escenarios.
Sugerencias u observaciones:

Figure 12. Melodic fragments evaluation form. Note: Source. Author's own creation

A first analysis carried out on the (N = 20) ratings made by the experts or producers shows that the considerations made are narrowly differentiated, since the values of the standard deviation oscillate between (SD = 0.089 and SD = 0.150), of Similarly, the measurements of the mean oscillate between (M = 3.70 and M = 4.03). Out of a total of (N = 20) cases, none were excluded, nor was it necessary to carry out the elimination of a case, which means that the elimination of a case would not lead to an improvement in the correlation percentages of the data matrix.

Assuming that most of the variables present significant interrelations, it is affirmed that the relationships exist because the variables are common manifestations of "unobservable" factors in a direct way. In this analysis, the aim is to arrive at a calculation of these factors, summarizing data, clarifying the relationships between the variables and without excessive loss of information (Mahía, 2011). The factor analysis process provides an image of the deep structure of a set of variables to be processed. Once this set of variables is processed, it is optimized to a simpler structure, with fewer dimensions, from which the same information is obtained by generalizing the understanding of the data obtained throughout the sample. In this way, the model is simplified, eliminating redundancies expressed in high correlations between variables, resulting in a set of variables in structural factors. Asensio (2015) states that "factor analysis simplifies the multiple and complex relationships that may exist between a set of observed variables $X1, X\ 2, \ldots\ Xp$." (p. 165).

The summary of cases processed in the present sample yields a good Cronbach's Alpha reliability measure (coefficient used to measure the reliability of a measurement scale). In this case, the measure is ($\alpha = 0.886$), therefore, all of the 20 cases are processed for 11 variables. The results of the reliability test are summarized below in tables. González Alonso & Pazmiño Santacruz (2015) define Cronbach's Alpha as an indispensable indicator to evaluate the degree of correlation between the variables of an instrument. It is also important to highlight that the first two factors explain more than 50% of the total variance. This allows us to affirm that the highest number of ratings made by experts is confirmed in the first two components. See Figure 13.

	Iniciales	Sumas de las saturaciones al cuadrado de la extracción					Saturaciones al cuadrado de la rotación		
	Total	Varianza	Acumulado	Total	Varianza	Acumulado	Total	Varianza	Acumulado
Compo1	5,247	47,7	47,7	5,247	47,7	47,7	3,124	28,404	28,404
Compo2	1,171	10,645	58,345	1,171	10,645	58,345	1,96	17,817	46,221
Compo3	1,096	9,96	68,305	1,096	9,96	68,305	1,921	17,464	63,685
Compo4	1,008	9,163	77,468	1,008	9,163	77,468	1,516	13,783	77,468

Figure 13. Summary of the explained variance.
Source. Author’s own creation

The cumulative sum of the first four components accumulates a total of V = 77.468%, this means that the vast majority of explained variance is contained in these four components. When performing an exploratory factor analysis based on the underlying theory that the factors are independent, Choque (2014) states that: “VARIMAX is a method that seeks to redistribute the variance throughout all the components in the load matrix” (p.103).

The selection of the weights of the variables that make up each factor will be carried out manually, selecting the variable with the greatest weight in each factor. Once the variables with the highest value have been grouped within the matrix, they are highlighted as the subset that makes up each component, as illustrated in Figure 14.

COMPONENTE	1	2	3	4
NOTAS2	0,91	0,199	0,086	0,056
EDICIÓN2	0,79	0,023	0,297	0,329
EDICIÓN1	0,75	0,412	0,307	0,13
SDURACIÓN	0,7	0,323	0,076	0,015
RITMO1	0,5	-0,03	0,414	0,25
NOTAS1	0,19	0,885	0,294	-0,08
SCLAROS	0,38	0,654	-0,06	0,401
SACORDES	0,17	0,6	0,274	0,547
NOTAS3	0,06	0,231	0,864	0,137
RITMO2	0,39	0,128	0,79	0,062
SCOMBINA	0,14	0,07	0,128	0,915

Figure 14. Components formed from the survey.
Source. Author's own creation

Although the results of the factor analysis show the same number of factors as those initially proposed in the evaluation tool, they undergo a new organization and are composed of other variables. These factors show that underlying structure that emerges after exhaustive data processing. The new organization is presented in Figure 15:

Factor 1	Factor 2	Factor 3	Factor 4
X16=NOTAS2	X5=NOTAS1	X7=NOTAS3	X2=SCOMBINA
X11=EDICION2	X1=SCLAROS	X9=RITMO2	
X10=EDICION1	X3=SACORDES		
X4=SDURACION			
X8=RITMO1			

Figure 15. Resulting factors.
Source. Author's own creation

Discussion and conclusions

After a total of six rotations of the data matrix, the total variance explained in all factors tips the balance towards the first factor, where 28,404% is confirmed. This percentage reaffirms in a very important way the possibilities of editing and reuse, given the influence of each of the variables in this first factor of possibilities and flexibility to create new scenarios. This allows us to affirm that this rating is significant and is qualitatively and quantitatively close to what is proposed in the objectives of this methodological strategy. The other factors independently define a variance of approximately 17% for each one, which allows us to conclude that the variables grouped in the first factor were the most relevant for the people who filled out the evaluation instrument. A rearrangement of the variables in each of the factors allows generating a more organized view of the structure that makes up each factor. The evaluation of melodic fragments is grouped into factors, and at the same time each factor groups different variables. In the case of Factor 1, which is the most relevant for making the pop music production process more flexible, the variables that make it up are (X4, X6, X8, X10, X11); Factor 2 evaluates the dimension of clarity and loudness in the different tones and chords, this factor was made up of the variables (X1, X3, X5); Factor 3 evaluates the dynamics in the reproduction of the fragment and was composed of the variables (X7, X9), and Factor 4 evaluates the mix between the different instruments and is only made up of the variable X2. See figure 16.

Factor 1, Posibilidades yflexibilidad	X=Promedio Aritmético, confirma un V=28,404% de la varianza	Categoria
X4	3.7	Aceptable
X6	4	Buena
X8	3.7	Aceptable
X10	3.9	Aceptable
X11	3.8	Aceptable

Figure 16. Resulting factors.
Source. Author's own creation

The design of this methodological strategy allows the integration of different methods and technologies that, when put together, manage to generate editable and reusable information in a different setting than the one proposed in the initial composition by the producer. It is also important to highlight that this micro architecture designed in the synthesis system, allows execution with human-computer interaction devices; devices that, by generating events within the synthesis system, are a more expressive option to the monotony that by its very nature tries to impose randomness.

Chuk being a relatively young programming language with a strong focus on audio synthesis, it does not enjoy strong popularity in many art or engineering schools. For this reason, there is not a huge community of developers in the world that share a wide set of libraries with a mathematical statistical approach. This shortage of free access libraries makes the development of this type of projects using this language longer and more careful.

For the development of this work, it was not convenient to make use of all the strong characteristics extracted from audio samples. By extracting many variants of energy from a sample, from any extraction technique, important close-ups to the original sample are achieved. This situation is not favorable for the objectives of this work, therefore, caution must be exercised with the amount of characteristics extracted.

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