

Armonización a 4-voces: Un enfoque y análisis desde el punto de vista de la Computación Evolutiva.

F. Fernández de Vega

Grupo de Evolución Artificial.
Universidad de Extremadura.

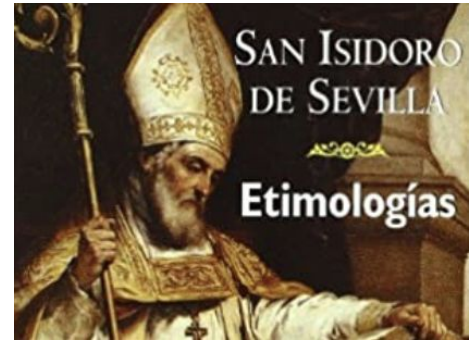


Project PID2020-115570GB-C21

¿Música e Inteligencia Artificial?

Matemáticas:

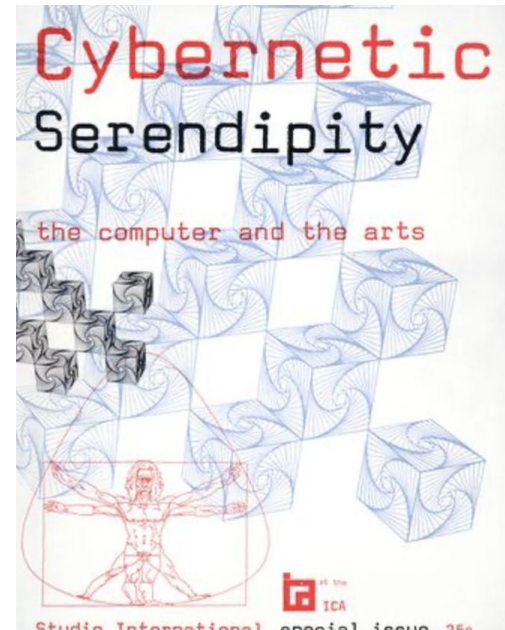
- Aritmética.
- Geometría.
- Astronomía.
- Música.



¿Creatividad Computacional?

- Música, Arte y Diseño asistido por la Inteligencia Artificial.
- Un área con mucho potencial.
- Primeros trabajos a finales de los 60:

https://monoskop.org/Cybernetic_Serendipity



¿Creatividad Computational?





Open problems in Evolutionary Music and Art

McCormack, J. (2005, March). Open problems in evolutionary music and art. In *Workshops on applications of evolutionary computation* (pp. 428-436). Berlin, Heidelberg: Springer Berlin Heidelberg.



Open problems in Evolutionary Music and Art

Aesthetic Selection: **Open problem #2:** To devise formalized fitness functions that are capable of measuring human aesthetic properties of phenotypes. These functions must be machine representable and practically computable.

What is art?: **Open problem #3:** To create EMA systems that produce art recognized by humans for its *artistic* contribution (as opposed to any purely technical fetish or fascination).

Buscando la inspiración...

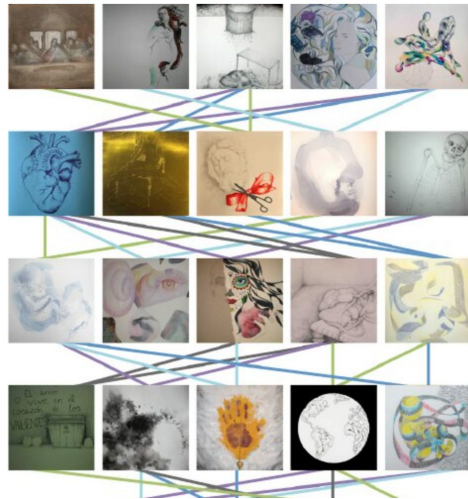




Buscando la inspiración... desde la evolución

- Interactive EA.
 - Fitness Evaluation.
 - Selection.
 - Crossover + Mutation.
- Unplugged EA.
 - Fitness Evaluation.
 - Selection.
 - Crossover + Mutation.

Algunos trabajos previos



ACM GECCO 2013 Evolutionary Art, Design and Creativity Award

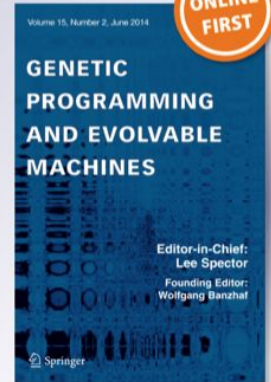
*Unplugging Evolutionary Algorithms:
an experiment on human-algorithmic
creativity*

**F. Fernández de Vega, C. Cruz,
L. Navarro, P. Hernández, T. Gallego &
L. Espada**

**Genetic Programming and Evolvable
Machines**

ISSN 1389-2576

Genet Program Evolvable Mach
DOI 10.1007/s10710-014-9225-1



 Springer

XY

“...Although the ultimate goal may be the creation of artificial intelligence that is capable of producing high quality works of art without human intervention (...) Personally I'd rather man stay ahead and in control of the very aspects of life that make it worth living, and rely on machines to help us with those things that they are currently best at, relieving us of the mundane and tedious, rather than taking over our most enjoyable pastimes and leaving creativity to man and God!”

M. Mumford, Fellow of the Royal British Photographic Society. Excerpt from XY foreword, Parlamento de Extremadura, 2014. ISBN 978-84-96757-50-9.

Algunos trabajos previos

Evolutionary Art

Evolutionary Algorithms have been frequently employed as a means for artistic creation and design, in which human artists guide the creative process, through aesthetic and conceptual evaluation, and computers are in charge of applying more repetitive genetic operations. The success of this interactive version of the evolutionary algorithm is well documented, although researchers are still struggling to find a way for properly encoding good aesthetic measures. But other possibilities exist for computer mediated artistic creation, such as applying an opposite approach: instead of allowing human beings to guide the artistic process, we could establish the main evolutionary algorithm steps as a path to be followed by human artists, such that every step is performed by his hands and brains, while the evolutionary algorithm is the framework that dictates how to progress.

This approach, that we refer to as the Unplugged Evolutionary Algorithm, was applied to produce the collective work XY, recipient of 2013 ACM GECCO Art, Design and Creativity award, as well as XYZ, a new collective artwork that has allowed us to better understand artists way of expressing creativity from the evolutionary algorithm point of view. The work is made up of sixty individual paintings and can be accessed at: <http://xyz-project.herokuapp.com/>. We hope the approach will not only be useful for researchers to learn from artists, which eventually could in the future allow improvements to available algorithms, but also provide new methodologies for collective art production.

F. Fernández de Vega, C. Cruz, P. Hernández, L. Navarro, V. Albarrán, L. Espada.

The front cover image was generated using the Unplugged Evolutionary Algorithm



Top: Generation 2-1
Bottom: Generation 10-1

<h1>SIGEVOLution</h1> <p>newsletter of the ACM Special Interest Group on Genetic and Evolutionary Computation</p>	<p>Volume 8 Issue 3</p>
 <p data-bbox="1690 349 1870 947">in this issue</p> <ul style="list-style-type: none">Evolutionary ArtThe Evolution of ThingsBook ReviewsUpcoming Events and CFPsPhD Opportunities	



Back Gallerie Project - Vancouver

Back Gallery Project is pleased to invite you to attend and exhibition by the collective group:

XYZ - Virtual Connections

Opening Reception: Tuesday, July 26, 5-7 pm
Open to the public: Wednesday, July 27, 1-5pm

602 E Hastings Street
Vancouver, BC V6A 1R1
T. 604.336.7633
www.backgalleryproject.com

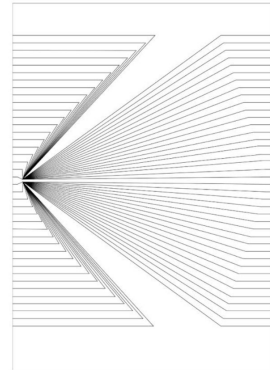
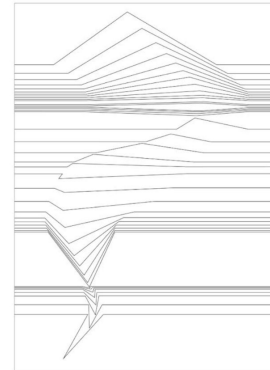
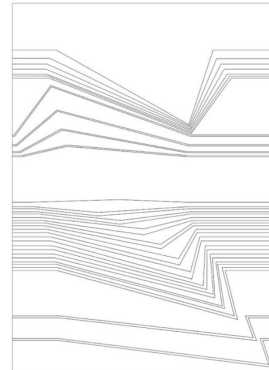
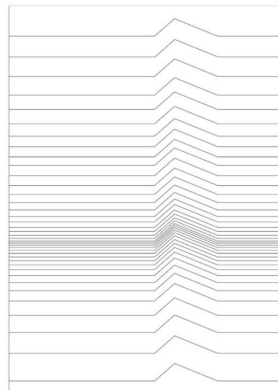
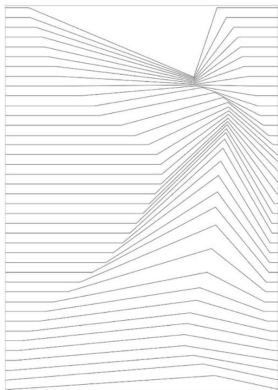
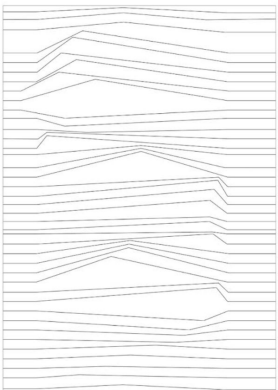
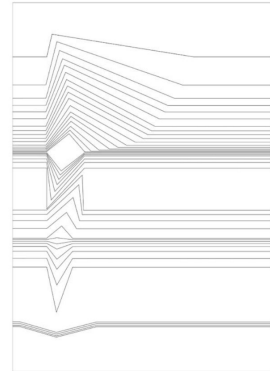
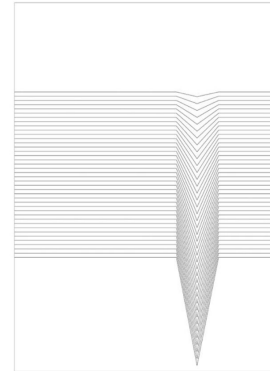
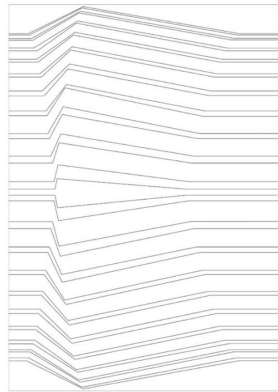
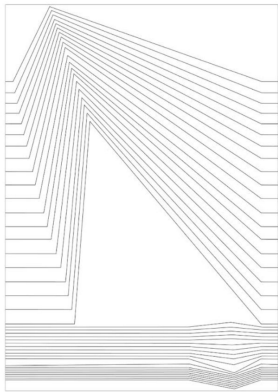
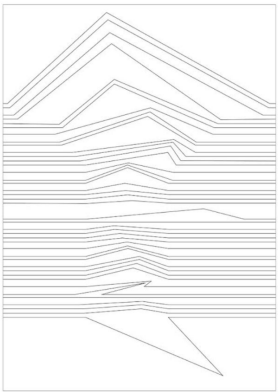




Show Your World

330 Me gusta • 335 seguidores

To Cry Out of Happyness - MC Gallery - Manhattan - New York



To cry out of happyness



To cry : Emotion in lines.



Gala Event "Show Your World" 2017, Part 1

Galerie Louchard - Paris





Música como área para la IA

Muchos problemas que atacar (MIR):

- OMR.
- Detección de ritmo, compás, género...
- Generación de audio
- Generación de partituras
- ...

ISMIR

[Conferences](#)
[Transactions of ISMIR](#)
[Women in MIR](#)
[Resources](#)

[About the Society](#)
[Membership](#)
[Community Statistics](#)
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Who are we?

The International Society for Music Information Retrieval (ISMIR) is a non-profit organisation seeking to advance research in the field of music information retrieval (MIR)—a field that aims at developing computational tools for processing, searching, organizing, and accessing music-related data. Among other things, the ISMIR society fosters the exchange of ideas and activities among its members, stimulates research and education in MIR, supports and encourages diversity in membership and disciplines, and oversees the organisation of the annual [ISMIR conference](#). More details on the society and its mission can be [found here](#).

ISMIR Conference

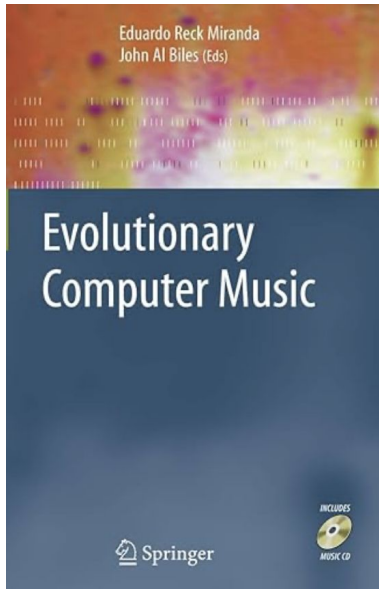
The [ISMIR conference](#) is held annually and is the world's leading research forum on MIR. More details on past conferences and links to the freely accessible proceedings can be [found here](#).

Upcoming Conferences

- [ISMIR 2024](#), November 10-14, San Francisco, CA, United States
- [ISMIR 2025](#), South Korea



Evolutionary Music?



evomusart 

**13th International Conference
on Artificial Intelligence
in Music, Sound, Art and Design**

April 2024

part of evo* 2024

Evolutionary Music?

hoofazce.wordpress.com

Inicio principal - Google Drive Charla Madrid 2024 - Presentaciones de Google Junio | 2011 | La Biblioteca de Alejandria

Evolución de la Música

Inicio | 2011

Título: Proceedings of the First International Workshop on Evolutionary Music, EcMusic 2011

Autor: F. Fernández de Vega, C. Cotta (Eds).

Editorial: University of Extremadura.

New Orleans es una ciudad con una curiosa mezcla cultural y estética. Aunque Norteamericana en su ubicación, un paseo por el barrio francés nos hará dudar de la tierra que pisamos. Las numerosas referencias a su origen Español jaloman las calles principales del French Quarter, los personajes cuyos restos reposan en la más antigua catedral norteamericana, Catedral de San Luis, erigida en 1720, nos remiten al mismo origen Español. Pero los murales que adornan el interior de la catedral hacen referencia a la historia de Francia, con San Luis promulgando del VII cruzada.



New Orleans

o enero 2014
o diciembre 2013
o noviembre 2013
o octubre 2013
o septiembre 2013
o agosto 2013
o julio 2013
o junio 2013
o May 2013
o abril 2013
o marzo 2013
o febrero 2013
o enero 2013
o diciembre 2012
o noviembre 2012
o octubre 2012
o septiembre 2012
o agosto 2012
o julio 2012
o junio 2012
o May 2012
o abril 2012
o marzo 2012
o febrero 2012
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o octubre 2011
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o julio 2011
o junio 2011
o May 2011
o abril 2011
o marzo 2011
o febrero 2011
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o diciembre 2010
o noviembre 2010
o octubre 2010
o septiembre 2010
o agosto 2010
o julio 2010
o junio 2010
o May 2010
o abril 2010
o marzo 2010
o febrero 2010
o enero 2010
o diciembre 2009
o noviembre 2009
o octubre 2009

2 de 4 coincidencias

No seguro — sigevo.org


Inicio | 2011 | La Biblioteca de Alejandria

7 -Evolutionary Music

Music provides a perfect area of research for Evolutionary Computation. A number of problems are present and still open to new proposals, such as:

- Generative Music Composition.
- Evolutionary Music Modeling.
- Rhythmic structure and Key analysis.
- Music Transcription.
- Music Improvisation.
- Music Genre classification.
- Music mood analysis.
- Optimization of Music Performance.
- Sound synthesis.
- Machine learning methods for audio content analysis .
- Automatic tagging of audio signals.
- Content-based audio retrieval.
- Music information retrieval.
- Music recommendation.
- User interfaces for music management and retrieval.
- Intelligent audio effects.
- Audio restoration.
- Etc.

ECMusic 2012, the 2nd workshop on Evolutionary Computation and music, aims particularly at providing a place - both physical and virtual- where the research is not only shown but also performed. It follows the success of the first ECMusic, that was held in [New Orleans in 2011](#) . Authors will thus be encouraged to send both regular papers describing new approaches and results, along with audio records allowing to appreciate the quality of the works. A CD will be compiled and distributed- among the audience with the results published in the workshop.



F. Fernández de Vega

He is associate professor at University of Extremadura. He has co-edited several special Issues dealing with Parallel and Distributed Bioinspired Algorithms and the book entitled Parallel and Distributed Computational Intelligence, Springer, 2010. He has also organized the International Workshops on Parallel Bioinspired Algorithms (2005, 2007, 2009) and International Workshops on Parallel Architectures and Bioinspired Algorithms (2007 -). He has published more than 150 peer reviewed papers in conferences, books and journals.

1 de 2 coincidencias

And beyond.



Música y Algoritmos Evolutivos

Trabajos previos

sharpmony.unex.es

I+D+i

Para el equipo de trabajo de Sharpmony es fundamental que la I+D sea algo más que un montón de documentos guardados en cajones. Estamos convencidos de que la investigación que realizamos en Inteligencia Artificial y Computación Paralela y Distribuida debe ser aplicada para conseguir resultados que beneficien a la sociedad.

Sharpmony es la primera aplicación que hace uso de más de 20 años de experiencia. Si estás interesado en nuestros resultados previos de I+D aplicados a la música, quizá te interesen estos artículos que hemos publicado en los últimos años

Francisco Fernández de Vega, J. Alvarado, A. Sánchez, M. Serrano, E. Pacioni:

[Evolutionary Algorithms: A new hope for the future of music teaching](#). ACM GECCO (Companion) 2023: 65-66

F. Fernández de Vega:

["Enseñanzas profesionales y superiores de música asistidas por la Inteligencia artificial"](#). Publicado en Educación, Investigación y Formación Musical: Miradas, Experiencias y Reflexiones desde los diferentes ámbitos y niveles Educativos, 2023, Dykinson. pp. 128-134.

R. Miragaia, F. Fernández de Vega, G. Reis, T. Inacio:

[Evolving a Multi-classifier System for Multi-pitch Estimation of Piano Music and Beyond: An Application of Cartesian Genetic Programming](#). Applied Science, March 2021, 11(7).

R. Miragaia, F. Fernández de Vega, G. Reis:

[Evolving a Multi-classifier System with Cartesian Genetic Programming for Multi-pitch Estimation of Piano Music](#). SAC '21: Proceedings of the 36th Annual ACM Symposium on Applied Computing, March 2021 Pages 472-480.

M. Morita, F. Fernández de Vega, J. Villegas:

[Aplicación de técnicas de aprendizaje profundo al reconocimiento óptico de partituras SATB](#). CAEPIA 20/21, September 2021. Pages 411-416.

F. Fernández de Vega, J. Alvarado, M. Morita:

[CAEPIA-App Competition: Sharpmony: A Computational Intelligence based tool for 4-part harmony](#). CAEPIA 20/21: Competition on mobile Apps with A.I. techniques. September 2021. Pages 1009-1012.

Francisco Fernández de Vega:

[Revisiting the 4-part harmonization problem with GAs: A critical review and proposals for improving](#). CEC 2017: 1271-1278

Francisco Chávez de la O, Francisco Fernández de Vega, Francisco J. Rodríguez Díaz:

[Analyzing quality clarinet sound using deep learning. A preliminary study](#). SSCI 2017: 1-7

Francisco Fernández de Vega, Carlos Cotta, Eduardo Reck Miranda:

[Special issue on evolutionary music](#). Soft Comput. 16(12): 1995-1996 (2012)

Gustavo Reis, Francisco Fernández de Vega, Anibal Ferreira:

[Automatic Transcription of Polyphonic Piano Music Using Genetic Algorithms, Adaptive Spectral Envelope Modeling, and Dynamic Noise Level Estimation](#). IEEE Trans. Audio, Speech & Language Processing 20(8): 2313-2328 (2012)

Armonía a 4 voces: SATB



SATB harmony

Beginning with a melody (soprano voice) students must build the remaining 3 voices:

- Alto.
- Tenor.
- Bass.

Handwritten musical notation for SATB harmony. The notation is organized into three numbered sections:

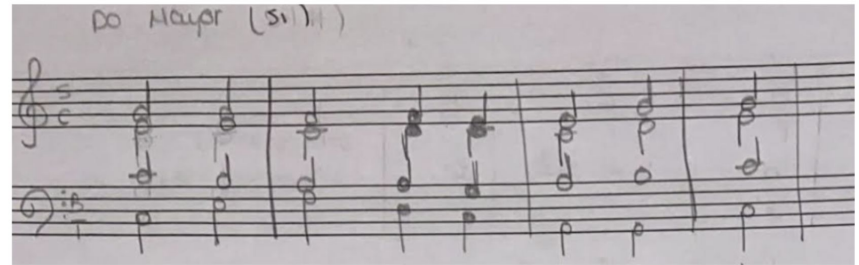
1. A single staff with Roman numerals: I - IV - V - I.
2. A single staff with Roman numerals: I IV V I. Below the staff are four chords: a triad (I), a dyad (IV), a dyad (V), and a triad (I).
3. A four-part setting for Soprano (S), Alto (A), Tenor (T), and Bass (B). The Soprano part has a melody of quarter notes: d, d, d, d. The Alto part has a melody of quarter notes: p, p, p, p. The Tenor part has a melody of quarter notes: d, d, d, d. The Bass part has a melody of quarter notes: p, p, p, p. Below the four staves are Roman numerals: I - IV - V - I.



4-part harmony

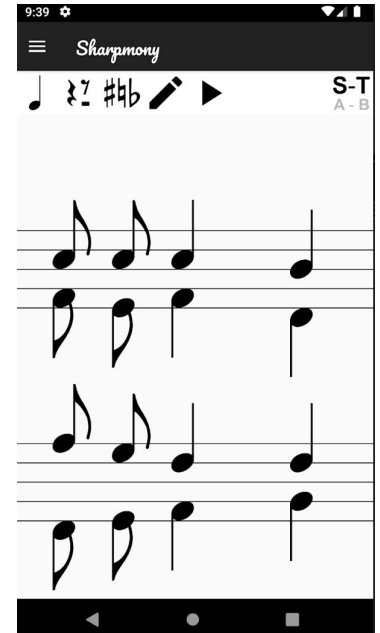
Students must learn harmony rules to build 4-part scores:

- Parallel Fifths
- Direct 8th
- Leading voice resolution
- more than 30 different rules/cases



Available tools: Sharpmony

- A tool for learning 4-part harmony.
- Check 4-part harmony exercises.



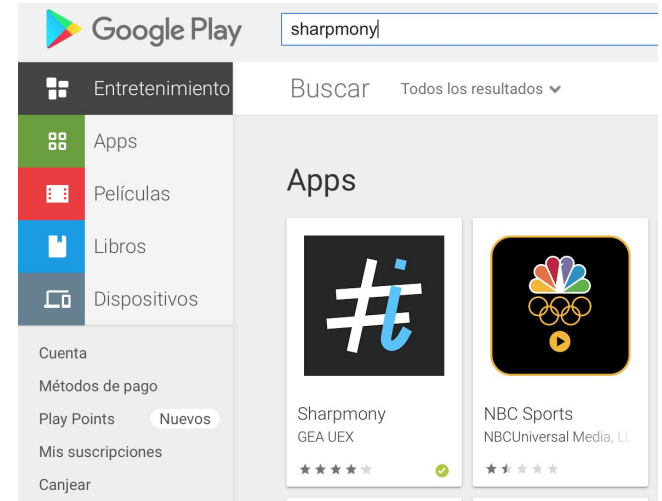
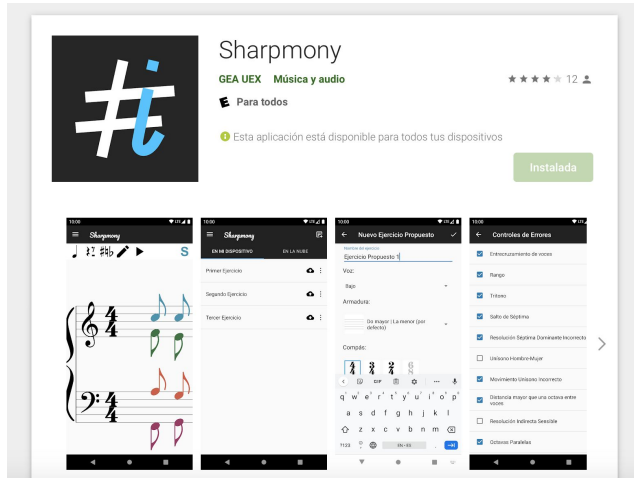
Main goals for Sharpmony

- To help music teachers and students.
- It provides an APP, a Web, and a Artificial Intelligence Cloud system to check exercises.
- We aim at providing teachers with automatic composition tool.



Sharpmony

- APP para estudiantes y profesores (disponible en Google Play).





Sharpmony

Web + Cloud System for Conservatories
teachers and students.

Consola Admin. Sharpmony Usuarios Académico Reportes de Errores Ajustes Cerrar Sesión (paco)

[Inicio](#) / Ejercicios

Buscar texto en revisiones

Seleccionar acción en lote

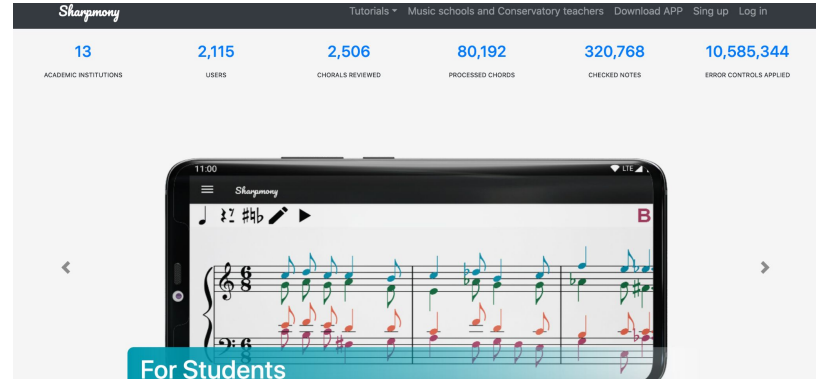
Mostrando 1-50 de 1.741 elementos.

<input type="checkbox"/>	Usuario	Nombre	Estado	Fecha ↓↑	
<input type="checkbox"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>		
<input type="checkbox"/>	armoniamontijo	Ejemplo 01 Entrecruzamientos de voces	Corregido	31/08/2021 13:23	👁
<input type="checkbox"/>	armoniamontijo	prueba serie séptimas de dominante	Corregido	29/08/2021 18:48	👁
<input type="checkbox"/>	armoniamontijo	prueba serie de séptimas de prolongación	Corregido	29/08/2021 18:33	👁

Sharpmony

Web + cloud: Sistema cloud con herramientas de Inteligencia Computacional:

- Kernel with harmony rules (fitness function).
- Includes secondary dominants and modulation.
- Augmented sixth, Neapolitan and diatonic seventh chords allowed.
- Sixth and Seventh chord progressions.
- Color codes for errors detected.
- Compatible with musicXML files.



- ⇒ **NARANJA:** Entrecruzamiento de voces ✓
- ⇒ **AMARILLO CLARO:** Distancia mayor que una octava entre voces ✓
- ⇒ **ROJO:** Octavas Paralelas ✓
- ⇒ **ROJO:** Quintas Paralelas ✓
- ⇒ **VERDE OLIVA:** Acorde incorrecto o no perteneciente a la tonalidad ✓
- ⇒ Rango ✓
- ⇒ **AZUL:** Disonancias ✓
- ⇒ **DORADO OSCURO:** Falsa relación de cromatismo ✓

Sharpmony Harmonic Manual


The harmonic error controls available in Sharpmony are shown below. The information includes the CONTROL that allows you to activate or deactivate its use in the APP, the COLOR used to mark the errors found in the score, explanatory text of the harmonic rule and its exceptions and finally graphic examples that explain how the marked error appears in the score.

- Overlapping voices (ORANGE)
- Interval wider than the 10th among voices (DARK TURQUOISE)
- Parallel octaves (RED)
- Parallel fifths (RED)
- Direct fifths or octaves (LIGHT PINK)
- Wrong chord or chord not in the key (GREEN)
- Voice ranges (CHOCOLATE)
- Dissonance (BLUE)
- False relation (DARK GOLDEN)

← **Nuevo Ejercicio** ✓

Nombre del ejercicio _____

Armadura:

 Do mayor | La menor (por defecto) ▾

Compás:

4/**4** **3**/**4** **2**/**4** **6**/**8**

Número de compases: _____ 10

☰ *Sharpmony*

S-T
A-B





Nuevo Ejercicio



Nombre del ejercicio

Evolucionar

Tipo de Ejercicio:

Revisar Armonizar

Armadura:



Do mayor | La menor

Do mayor La menor

Compás:

4
4

3
4

2
4

6
8

Número de compases:



Sharpmony



EN MI DISPOSITIVO

EN LA NUBE

Evolucionar



Estado de la armonización

Generación: **4**

Nº de errores: **42**

CERRAR



4-part harmony Evolution

The idea is to use Evolutionary Algorithms to find a good enough 4-part harmonization for a melody.

The last attempt published in 2017 (FFV, Revisiting the 4-part harmonization problem with GAs. CEC 2017).



The image displays three systems of musical notation for a 4-part harmony in G major, 4/4 time. The first system shows a melody in the treble clef and four-part accompaniment in the bass clef. The second system continues the melody and accompaniment. The third system shows the melody and accompaniment ending with a double bar line.

4-part harmony evolution



The image displays a musical score for a 4-part harmony evolution. It consists of three systems of music, each with a treble and bass clef staff. The first system shows a progression of chords in the right hand and a corresponding bass line in the left hand. The second system continues this progression, with some notes in the right hand being marked with a flat sign. The third system shows a final chord progression, with the right hand staff ending with a double bar line and a repeat sign, and the left hand staff also ending with a double bar line.

Several approaches to find solutions:

- Evolving first a suitable progression, and then the notes for the voices.
- Solutions with 10-40 errors after more than 6 hours running an experiment.
- 11 rules included in the Fitness function.

The problems in the problem

Sharpmony tool includes nowadays about 50 different controls per chord.

These controls are used in the new version of the fitness function.

Sharpmony Harmonic Manual

The harmonic error controls available in Sharpmony are shown below. The information includes the CONTROL that allows you to activate or deactivate its use in the APP, the COLOR used to mark the errors found in the score, explanatory text of the harmonic rule and its exceptions and finally graphic examples that explain how the marked error appears in the score.

<input checked="" type="checkbox"/>	Overlapping voices (ORANGE)
<input checked="" type="checkbox"/>	Interval wider than the 10th among voices (DARK TURQUOISE)
<input checked="" type="checkbox"/>	Parallel octaves (RED)
<input checked="" type="checkbox"/>	Parallel fifths (RED)
<input checked="" type="checkbox"/>	Direct fifths or octaves (LIGHT PINK)
<input checked="" type="checkbox"/>	Wrong chord or chord not in the key (GREEN)
<input checked="" type="checkbox"/>	Voice ranges (CHOCOLATE)
<input checked="" type="checkbox"/>	Dissonance (BLUE)
<input checked="" type="checkbox"/>	False relation (DARK GOLDEN)

Wrong note duplication (FUCHSIA)

In some situations, specific notes can not be doubled in a chord:

- **A) Minor flatted 5th (diminished triad).** The root cannot be doubled when the chord is in the root position or second inversion, given that it must follow an established resolution.
- **B) First inversion triad chord (6):** the note in the bass cannot be doubled. Yet some exceptions may apply
 1. First inversion of the minor flatted 5th: only the note in the bass can be doubled, it is the only one without a mandatory resolution.
 2. First inversion triad chord: The note in the bass can be doubled if there was a mandatory movement required for the bass note in the previous chord that led to this note.
- **C) Seventh or Ninth chords:** None of the notes in the chord can be doubled. Some exceptions may be applied:
 1. In a Dominant seventh chord in root position, the root may be doubled if the 5th is removed, so that the chord is incomplete.

Sharpmony will detect and mark wrong notes doubled using FUCHSIA color.

Boxes and text in the following example have been added to the correction provided by Sharpmony.

The image shows a musical score in 4/4 time with a key signature of two sharps (F# and C#). The score is written for piano with treble and bass staves. Several measures are highlighted with red boxes and labeled with letters A through C1. Labels A and B are placed over the first two measures, B2 and B1 over the next two, B3 over the fifth, and C1 over the sixth. The notes in these boxes are marked with a pink color, indicating a 'Wrong note duplication' error. The bass line includes fingering numbers (5, 6, 7) and a '+' sign. The treble line includes a '+' sign.

Results

Musical notation for measures 1-3. The key signature has one flat (B-flat) and the time signature is 4/4. The notation includes a treble and bass clef. Above the treble clef, the following chord symbols are indicated: I, Fa M, v4o, I6, IV, I, V, V, I, III*, VI, V6, I, II, II*.

Musical notation for measures 4-7. The notation includes a treble and bass clef. Above the treble clef, the following chord symbols are indicated: V, V, V6, I, I*, IV, II, I6, IV, VI, VI, II, II*, V65.

Musical notation for measure 8. The notation includes a treble and bass clef. Above the treble clef, the chord symbol I is indicated.





Results

The new controls applied to the best solution found in 2017 shows more than 50 errors.



The image displays a musical score in 4/4 time, consisting of three systems of piano accompaniment. The first system (measures 1-3) shows a melody in the right hand and a bass line in the left hand. The second system (measures 4-7) is heavily annotated with colored markers: red, green, cyan, magenta, yellow, and blue, indicating various errors or corrections. The third system (measures 8-9) shows a final chord in the right hand and a bass line in the left hand, with a Roman numeral 'VI' above the right-hand staff.



Results

6 Errors after 4 hours evolving 4 individuals.: mutation+selection applied.

The image displays three staves of musical notation, likely representing the evolution of a piece over time. The first staff shows the initial piece with a green highlight. The second staff shows the piece after 4 hours with a yellow highlight. The third staff shows the piece after 8 hours with a blue highlight. The notation includes treble and bass clefs, a key signature of one flat, and a 4/4 time signature. The music consists of chords and single notes, with some notes highlighted in green, yellow, and blue to indicate changes or errors over time.



The problems in the problem

The larger the number of constraints applied, the smaller the number of solutions available.

The new version allows new kind of chords, such as diatonic-seventh chords, Augmented Sixth chords and Neapolitan chord. Therefore a larger search space to look around.

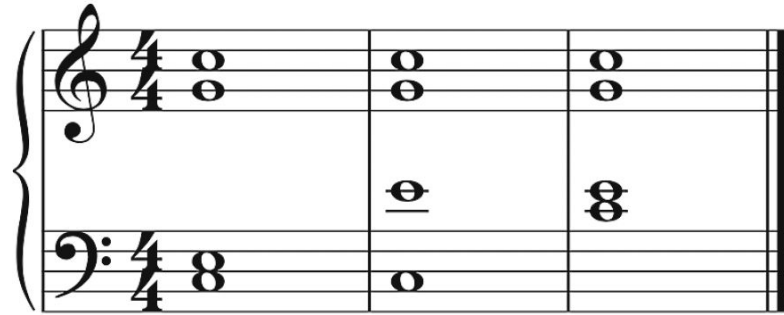
The difficulty increases significantly.

The image displays three staves of musical notation in 4/4 time, illustrating various chord voicings. The first staff shows a sequence of chords with notes highlighted in red, green, and blue. The second staff, starting at measure 4, shows more complex voicings with notes highlighted in red, green, blue, and purple. The third staff, starting at measure 8, shows a VI chord with notes highlighted in blue and purple. The notation includes treble and bass clefs, a key signature of one flat, and a time signature of 4/4.



Configuración de acordes

Un ejemplo: DO-MI-SOL



The problems in the problem

Considering 2 consecutive 4-note chords:

- Given that each note can be assigned to 2 possible octaves each, and that not all the notes may be present in the chord, thus allowing repetition of notes: more than 200 possible configurations per chord may be used.
- Moreover: 7 diatonic degrees (chords), + 6 secondary dominants + 3 augmented sixth chords + Neapolitan chord + Ninth chords: more than 20 different chords available per note.
- Considering a single key: 2855 possible chord disposition available.

The image displays three systems of musical notation for piano accompaniment, illustrating chord progressions. The first system shows a sequence of chords with notes highlighted in red, green, and blue. The second system continues the progression, with notes highlighted in red, green, blue, and purple. The third system shows a single chord with notes highlighted in blue and purple, labeled with a Roman numeral VI. The notation includes treble and bass staves with various note values and rests.



Nuevas ideas y resultados

- Evolving a progression first is a must. Then the evolution of voices begins.
- Still, several hours are required for finding a solution (> 24h).

En el Trabajo Fin de Máster del estudiante Elia Pacioni, hemos intentado mejorar mediante:

- Paralelización.
- Precálculo de valores de fitness.
- Mutación dirigida.



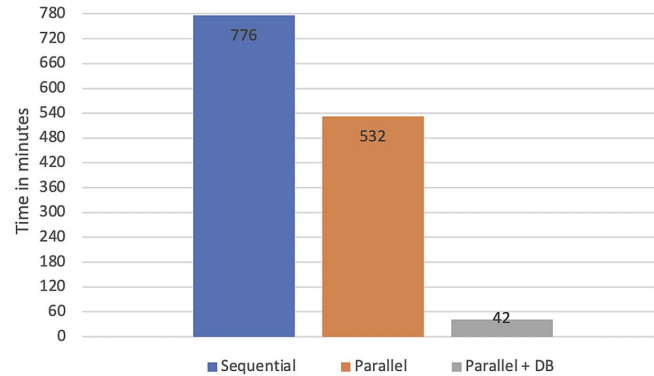
Precálculo

- 2855 posibles configuraciones de acordes válidos ...
- 8155025 pares de acordes...
- 22 segundos para corregir un par de acordes ...
- 5,8 años en las máquinas que disponemos (secuencial).

Nuevas ideas y resultados

Paralelización + Precálculo de valores de fitness: Tiempos de cálculo para pares de acordes.

Secuencial	Paralelo	DB	DB optimizado
22,5	11,25	3,127	0,001





Mutación dirigida

Aplicar mutación
dónde más convenga.

13. Melamed, D., et al.: De novo mutation rates at the single-mutation resolution in a human HBB gene-region associated with adaptation and genetic disease. *Genome Res.* (2022). <https://doi.org/10.1101/gr.276103.121>
14. Bhandari, D., Pal, N.R., Pal, S.K.: Directed mutation in genetic algorithms. *Inf. Sci.* **79**(3–4), 251–270 (1994). [https://doi.org/10.1016/0020-0255\(94\)90123-6](https://doi.org/10.1016/0020-0255(94)90123-6)
15. Tang, P.-H., Tseng, M.-H.: Adaptive directed mutation for real-coded genetic algorithms. *Appl. Soft Comput.* **13**(1), 600–614 (2013). <https://doi.org/10.1016/j.asoc.2012.08.035>
16. Puerta, B.R., Barrancas, F.D., Chavez, F., de Vega, F.F.: Un análisis preliminar de nuevos modelos de mutación dirigida en algoritmos genéticos. In: Conferencia de la Asociación Española para la Inteligencia Artificial (CAEPIA 2018), Granada, España
17. Carvalho, P., Magane, J., Lourenco, N., Machado, P.: Context matters: adaptive mutation for grammars. In: Pappa, G., Giacobini, M., Vasicek, Z. (eds.) *Genetic Programming. EuroGP 2023*. LNCS, vol. 13986, pp. 117–132. Springer, Cham (2023). https://doi.org/10.1007/978-3-031-29573-7_8



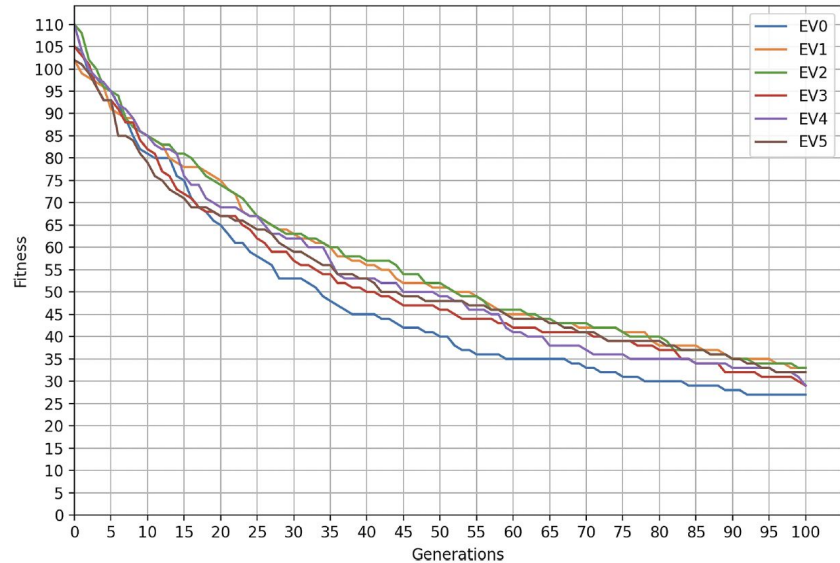
Mutación dirigida

¿Qué tal si aplicamos mutación con mayor probabilidad en lugares donde sabemos que hay errores?

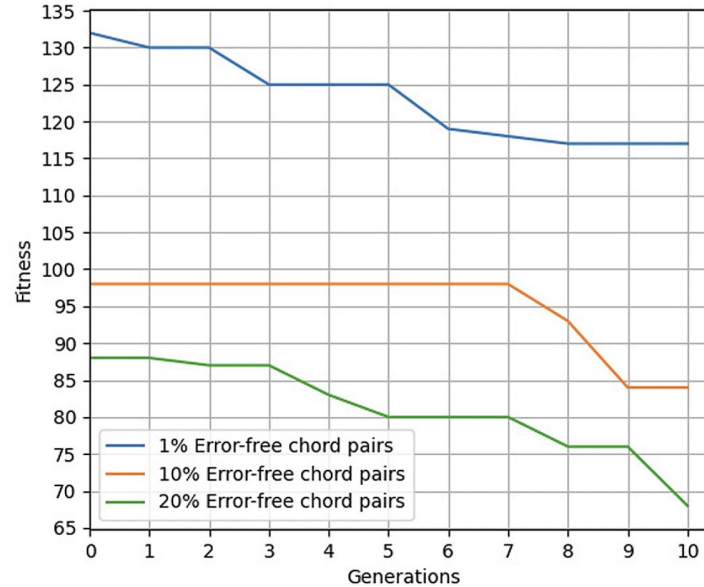
Exp	Evolving Chord Progression	Mutation
EV0	YES	100% DIRECTED
EV1	YES	100% RANDOM
EV2	YES	50% DIR. 50% RANDOM
EV3	NO	100% DIRECTED
EV4	NO	100 % RANDOM
EV5	NO	50% DIR. 50% RANDOM

Mutación dirigida

¿Qué tal si aplicamos mutación con mayor probabilidad en lugares donde sabemos que hay errores?



Modelos armónicos sintéticos





Evostar 2024

Elia Pacioni, Francisco Fernández de Vega:
**On the Impact of Directed Mutation Applied to
Evolutionary 4-Part Harmony Models.**EvoMUSART 2024:
311-325

Nominado como mejor artículo de estudiante.



Próximos pasos

Artículo enviado a PPSN 2024 con análisis sobre reducción del espacio de búsqueda:

- ¿Es necesario utilizar todo el espacio de búsqueda?
- ¿Podemos encontrar soluciones más rápidamente en un espacio limitado?



Thank you

