MCM 2017

Mathematics and Computation in Music 2017
Faculty of Sciences, UNAM, Mexico City
26-29 June, 2017

smcm

Contents

Welcome to Mexico City

The Sixth International Conference on Mathematics and Computation in Music will be held June 26-29, 2017 at Universidad Nacional Autónoma de México (UNAM), Mexico City, México.

MCM is the flagship conference of the Society for Mathematics and Computation in Music (SMCM), whose official publication is the Journal of Mathematics and Music (JMM).

MCM 2017 continues the tradition of biennial international conferences of the Society for Mathematics and Computation in Music held on alternating sides of the Atlantic. In this occasion it is hosted by the Facultad de Ciencias at UNAM.

The conference brings together researchers from around the world who combine mathematics or computation with music theory, music analysis, composition and performance. MCM provides a dedicated platform for the communication and exchange of ideas amongst researchers in mathematics, computer science, music theory, composition and performance, musicology and related disciplines.

The disciplines of Mathematics and Music share an intertwined history stretching back more than two and a half millennia. More recently, computer science has made possible new approaches to these disciplines, often with transformative effect.

In addition to the scientific program, there will be concerts open to both congress participants and the general public.

Organization

General Organizing Committee

- Guerino Mazzola, School of Music, University of Minnesota, USA.

- Emilio Lluis-Puebla, Faculty of Sciences, UNAM, Mexico.

- Octavio Alberto Agustín Aquino, Universidad de la Cañada and Universidad Tecnológica de la Mixteca, Oaxaca, Mexico.

- Mariana Montiel, Georgia State University, USA.

- Gabriel Pareyón, National Center for Music Research, Documentation and Information, CENIDIM-INBA.

- Roberto Morales-Manzanares, Laboratorio de Informática Musical, Universidad de Guanajuato, Mexico.

- Emil Awad, CECDA, Universidad Veracruzana, Mexico.

- Juan Sebastián Lach, Conservatorio de las Rosas, Michoacán, Mexico.

Scientific Programme Committee

The Scientific Programme Committee was responsible for the scientific content of MCM 2017. It prepared the final list of oral and poster presentations and invited speakers and selected contributed papers based on peer review amongst those submitted for consideration. It consists of:

- Emilio Lluis-Puebla, Faculty of Sciences, UNAM, Mexico.

- Mariana Montiel, Georgia State University, Georgia, USA.

- Octavio Alberto Agustín Aquino, Universidad de la Cañada and Universidad Tecnológica de la Mixteca, Mexico.

Scientific Committee

- Octavio Alberto Agustín Aquino.

- Emmanuel Amiot.

- Gilles Baroin.

- Chantal Buteau.

- Clifton Callender.

- Clément Cannone.

- Johanna Devaney.

- Andrée Ehresmann.

- Alice Eldridge.

- Francisco Gómez.

- Yupeng Gu.

- Julian Hook.

- Timothy Hsu.

- Franck Jedrzejewski.

- Maximos Kaliakatsos-Papakostas.

- Maria Mannone.

- Alan Marsden.

- Andrew Milne.

- Mariana Montiel.

- Thomas Noll.

- Pablo Padilla.

- Robert Peck.

- Richard Plotkin.

- Alexandre Popoff.

- David Rappaport.

- David Temperley.

- Florian Thalmann.

- Jason Yust.

- Marek Žabka.

Local Organizing Committee

The Local Organizing Committee was responsible for functional organization of MCM 2017, including the selection of the most suitable locations, preparation of the internet site and conference software, arrangement of the musical and social programme, production and publication of the proceedings volume, organization of book exhibitions and coordinating the contact between invited speakers, discussants, contributing authors, participants, publishers and exhibitors. The LOC consists of

- Emilio Lluis-Puebla, Faculty of Sciences, UNAM, Mexico,

- Octavio Alberto Agustín Aquino, Universidad de la Cañada and Universidad Tecnológica de la Mixteca, Mexico,

with the valuable assistance of the following graduate and undergraduate students, all from the Faculty of Sciences, UNAM:

- Alison Barbosa Guzmán.

- Ruby Almazán Calzada.

- Yemile Chávez Martínez.

- Kuauhtemok González Cortés.

- Gabriela Jacinto.

- Bruno Martínez Warnholtz.

- Julisa Rodríguez Torres.

Collaborating Institutions

We thank the following institutions for providing their infrastructure and human resources for the organization of the MCM 2017:

- Facultad de Ciencias de la Universidad Nacional Autónoma de México.

- Society for Mathematics and Computation in Music.

- Escuela Superior de Música.

- Georgia State University.

- Museo Nacional de Historia.

- Sociedad Matemática Mexicana.

- Universidad de la Cañada.

Useful Information

Conference Address

Conjunto Amoxcalli,
Facultad de Ciencias (UNAM),
Ciudad Universitaria,
Circuito Exterior s/n,
Coyoacán, C. P. 04510,
Ciudad de México,
México.

Other Venues' Addresses

Museo Nacional de Historia (Chapultepec Castle)

Segunda Sección del Bosque de Chapultepec,
Circuito "Correr es Salud" s/n,
Miguel Hidalgo, C.P. 11800,
Ciudad de México,
México.

The usual entrance to the museum is by Gandhi and Reforma Avenues unless otherwise announced. Conference attendees will be carried by our shuttle transportation.

Escuela Superior de Música

Manuel Fernández Leal 31,
Barrio de la Concepción,
La Concepción, C. P. 04020,
Ciudad de México,
México.

Registration Desk

The registration desk will be open in the lobby of Conjunto Amoxcalli from 9:00 to 12:00 during the whole conference.

Mazzola's MaMuTh (nanocourse by O. A. Agustín Aquino)

Guerino Mazzola, in a series of books beginning with *Gruppen und Kategorien in der Musik* (1985), following with his monumental *Topos of Music* (2002) and unfolding with a flurry of recent additions in the *Computational Music Science* series, established a powerful and all-encompassing framework for Mathematical Music Theory (MaMuTh). In this three day nanocourse, with perhaps extremely but necessarily broad strokes, Octavio Alberto Agustín Aquino sets out on the ambitious journey of presenting an accessible panorama of Mazzola's theory with an emphasis on counterpoint, along the following route:

1. Affine symmetries in music.

2. Modules and presheaves.

3. The Yoneda philosophy.

4. The first-species counterpoint model as a paradigmatic example.

5. The "gesture shock" and Escher's theorem.

6. Are music and mathematics adjoint activities? The diamond conjecture.

Participation Identification

Conference badges are essential to ensure admission to the conference venues and to the academic sessions and social events. Therefore we ask you to wear your badge at all times.

Accompanying Persons

Accompanying persons are welcome to attend to all the recitals of the conference and the visit to the National Museum of History. No ticket is required, but there is limited availability at some venues. For the farewell dinner, please confirm the attendance of accompanying persons.

Liability

Neither the Universidad Nacional Autónoma de México (UNAM) nor the Scientific Committe nor Local Organizing Committee of the MCM 2017 will assume any responsibility for accident, desease, loss or damage, or for delays or modifications in the programme, caused by unforeseen circumstances. We will not assume indemnities requested by contractors or participants in the case of cancellation of the conference due to unforeseen circumstances. It is strongly advisable to purchase travel insurance in preparation for any incident.

Electricity

Electric sockets in Mexico carry 110V/60Hz and conform to the American type. Adaptors can be bought at shops in Perisur.

Food and Drinking Water

In Mexico three meals are customary, usually separated by six hours intervals, beginning around 7:00-9:00. Thus it is recommendable to have a generous breakfast to go comfortably through the sequence of talks during the morning. Please, be wary about consuming any raw foods and avoid street food entirely.

Generally speaking it is not safe to drink water from the tap, hence it is advisable to drink bottled water and make sure the cap is securely sealed before you imbibe.

Transportation

Subway and *Metrobús* systems are inexpensive and fast ways of moving throughout Mexico City, but they are usually crowded.

Do not take street cabs if you are unfamiliar with Mexico City or have a poor command of Spanish. All legitimate cabs have a distinctive licence plate consisting of a capital letter and five numbers. The driver's license card should be visible: it is a laminated document with official stamps, a hologram and a photograph of the taxi driver on it, that should be presented as a full-color original. The number on the license card should match the license plates. If you are carrying any valuable equipment (e.g. laptop or expensive cameras) it is best to get a cab from a taxi rank, use an App-Cab service, or get your hotel to phone a local taxi for you.

Mexico City Subway

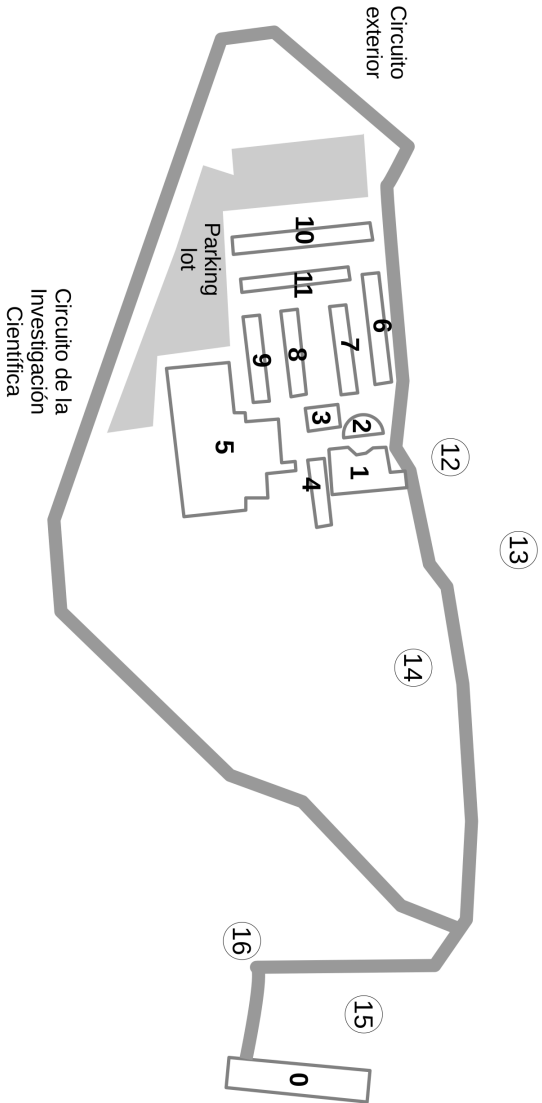| Venue	Closest station
Escuela Superior de Música	General Anaya
Faculty of Sciences, UNAM	Universidad
Museo Nacional de Historia	Chapultepec

Faculty of Sciences, UNAM

0. Universidad Subway Station.
1. Amoxcalli.
2. Prometeo-Quetzalcóatl Fountain.
3. Cafeteria.
4. Yelizcalli.

5. Tlahuizcalpan.
6. Physics.
7. Mathematics.
8. Biology A.

9. Biology B.
10. "P" Building.
11. "O" Building.
12. Mathematics Institute.

13. Astronomy Institute.
14. Physics Institute.
15. Bicipuma.
16. Pumabús.

Circuito exterior

Circuito de la Investigación Científica

Parking lot

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Book exhibitions

Publications by Springer, CENIDIM and Facultad de Ciencias (UNAM) will be on exhibit in Amoxcalli's lobby during the whole conference for sale.

Musical and Social Programme

Recitals

Latin&American Recital

Date: June 26, 2017, 18:30
Venue: Anfiteatro "Alfredo Barrera Marín", Amoxcalli

1. **Trois Miniatures**
   I. Comme une vague   II. Parfum d'avril   III. Comme une danse
   Adrian Andrei (1977-   )

2. **Trois Valses pour Guitare**
   Pierre Lerich (1937-2008)

3. **Valzer brillante**
   Simone Ianarelli (1970-   )

4. **Homenaje a Tárrega**
   I. Garrotín   II. Soleares
   Joaquín Turina (1882-1949)

5. **Chôros No. 1**
   Heitor Villa-Lobos (1887-1959)

6. **Cuatro valses venezolanos**
   I. Tatiana   II. Natalia   III. Andreína   IV. Yacambú
   Antonio Lauro (1917-1986)

7. **Un día de noviembre**
   Leovigildo Brouwer (1939-   )

8. **Preludio, Balletto y Courante**
   Manuel María Ponce (1882-1948)

Octavio Alberto Agustín Aquino, *guitar*

Imaginary Time for Real Music

For the pleasure of living and creating mathematics and music:
Guerino Mazzola's 70th anniversary

Date: June 27, 2017, 18:00
Venue: Escuela Superior de Música

Guerino Mazzola, *piano*
Heinz Geisser, *percussions*

The free jazz collaboration of drummer Heinz Geisser and pianist Guerino Mazzola has lasted twenty years now. They have, together with several other musicians, published 17 CDs on important labels, such as Cadence Jazz, Silkheart, or Black Saint, a documentary movie *Teak Leaves at the Temples* in Indonesia, and a VIMEO-published video *Imaginary Time.* In April 2017 they had a series of six highly acclaimed concerts in Tokyo and Yokohama with Japanese free jazz musicians, resulting in three CD productions.

Geisser and Mazzola strongly adhere to the idea that music should transform with virtuosity gestures and thoughts in the imaginary time of our consciousness into real sound structures that shape the body of time instead of following any external baton.

Lluis-Puebla's Beethoven Cycle

For the pleasure of living and creating mathematics and music:
Emilio Lluis-Puebla's 65th anniversary

Date: June 28, 2017, 19:45
Venue: National Museum of History (Chapultepec Castle)

1. Sonata in C, TVW 41:C2

    I. Cantabile
    II. Allegro
    III. Grave
    IV. Vivace

Georg Philipp Telemann (1681-1767)

2. Sonata Op. 17

    I. Allegro moderato
    II. poco Adagio, quasi Andante
    III. Rondo Allegro, moderato

Ludwig van Beethoven (1770-1827)

3. Sonata für Arpeggione und Pianoforte, D. 821

    I. Allegro moderato
    II. Adagio
    III. Allegretto

Franz Schubert (1797-1828)

4. Rhapsody
Andrew Gant (fl. 1998-   )

5. In pace
John Marsh (fl. 1998-   )

6. Just a moment
Quentin Thomas (fl. 1998-   )

Harald Fripertinger, *flute*
Emilio Lluis-Puebla, *piano*

Visit to Museo Nacional de Historia (Chapultepec Castle)

June 28, 2017, 17:45.

The toponomy of Chapultepec comes from nahuatl: *chapul(in)*, grasshopper and *tepe(tl)*, hill or mountain, meaning *In the Hill of the Grasshopper*. This landmark provides an excellent vantage point of the history of Mexico.

During the rulership of Moctezuma Ilhuicamina (1440-1469 AD) an aqueduct was built to bring water from this location to Mexico-Tenochtitlan, and was thus considered as a sacred place of the water gods Tlaloc and Chalchihuitlicue.

In 1785, Viceroy Bernardo de Gálvez ordered the construction of a stately home for himself at the top of the hill, but the project faced several drawbacks, and it would never be truly completed. In 1833 the building was decreed to become the location of the Colegio Militar (Military Academy) and a sequence of several structural modifications were done, including the addition of the watchtower.

On September 13, 1847, five Mexican military cadets plus one of their instructors died defending the castle while it was taken by United States forces during the Battle of Chapultepec of the Mexican-American War. They

are honored with a large mural on the ceiling above the main entrance to the castle.

The building acquired most of its current configuration during the Second Mexican Empire, when Emperor Maximilian I of Mexico and his wife Empress Carlota chose it as their residence and the seat of their court in 1864. At the time, the castle was still located on the outskirts of Mexico City, hence Maximilian ordered the construction of a straight boulevard (modeled after the great boulevards of Europe, such as Vienna's Ringstraße and the Champs-Élysées in Paris), to connect the Imperial residence with the city centre, and named it *Paseo de la Emperatriz* ("Promenade of the Empress"). Following the reestablishment of the Republic in 1867 by President Benito Juárez and the end of the Reform War (Guerra de Reforma), the boulevard was renamed *Paseo de la Reforma*.

The castle fell into disuse after the fall of the Second Mexican Empire in 1867. In 1876, a decree established it as an Astronomical, Meteorological and Magnetic Observatory, which was opened in 1878 and remained functional for only five years.

The palace underwent several structural changes beginning on 1882 and during the long tenure of President Porfirio Díaz. Other presidents who made the palace their official residence were Francisco I. Madero, Venustiano Carranza, Álvaro Obregón, Plutarco Elías Calles, Emilio Portes Gil, Pascual Ortiz Rubio and Abelardo Rodríguez. It was used for a time as an official guest house or residence for foreign dignitaries.

On February 3th, 1939, President Lázaro Cárdenas issued the law that created the National Institute of Anthropology and History. This law, in particular, declared the Chapultepec Castle as a national heritage site and ordered to install in it the National Museum of History to house the collection of its predecessor, the National Museum of Archeology, History and Ethnography.

The National Museum of History divides the castle proper from the *Alcázar*, where the residential character of the building is preserved and the daily lifestyle of the heads of state who had inhabited it is recreated. It hosts many concerts and recitals during the year, like in the case of the Fripertinger and Lluis-Puebla' special recital prepared for the MCM 2017 attendees at the end of the tour.

Conference Schedule

Monday, June 26th, 2017

9:00-12:00 Registration

9:15-9:45 Opening Session
Auditorio "Carlos Graef Fernández", Amoxcalli

Opening Address

Prof. Dr. Guerino Mazzola
President of the Society for Mathematics and Computation in Music

Prof. Dr. Emilio Lluis-Puebla
Head of the Scientific and Local Organizing Committees

Prof. Dr. Octavio Alberto Agustín Aquino
Member of the Scientific and Local Organizing Committees

9:45-10:45 Plenary Talk
Auditorio "Carlos Graef Fernández", Amoxcalli

Mathematical Music Theory and the Musical Math Game
Guerino Mazzola

10:45-11:00 Coffee break

11:00-12:00 Contributed Talks
Auditorio "Carlos Graef Fernández", Amoxcalli
Chair: Emilio Lluis-Puebla

11:00 Using Inharmonic Strings in Musical Instruments
Kevin Hobby, William A. Sethares and Zhenyu Zhang

11:30 A Symmetric Quantum Theory of Modulation in $\mathbb{Z}_{20}$
Jesús David Gómez-Téllez, Emilio Lluis-Puebla and Mariana Montiel

11:00-12:15 Mazzola's MaMuTh (nanocourse by O. A. Agustín Aquino)
Aula Magna "Leonila Vázquez", Amoxcalli

12:00-12:30 Poster Session
Amoxcalli's Lobby

12:30-14:00 Panel
Auditorio "Carlos Graef Fernández", Amoxcalli

Contemporary Music Composition in Relation to Mathematics and Computing. Current Perspectives and Approaches

Juan Sebastián Lach, Roberto Morales-Manzanares, Gabriel Pareyón and Edmar Soria

The topic of the panel is to discuss different perspectives from contemporary musical composition towards mathematics and computation, evidenced by the divergent approaches, mathematical concepts and computational tools used by the participants.

17:00-18:15 Editorial Board Meeting of the Journal of Mathematics and Music
Aula Magna "Leonila Vázquez", Amoxcalli

18:30-19:30 "Latin&American" Recital
Anfiteatro "Alfredo Barrera Marín", Amoxcalli

Tuesday, June 27th, 2017

9:00-10:00 Plenary Talk
Auditorio "Carlos Graef Fernández", Amoxcalli

    On All-Distances-Twice Tone Rows
    Harald Fripertinger

10:00-13:45 Contributed Talks
Auditorio "Carlos Graef Fernández", Amoxcalli
Chair: Mariana Montiel

10:00 Almost Difference Sets in Transformational Music Theory
    Robert W. Peck

10:30 Strange Symmetries
    Emmanuel Amiot

11:00 Coffee break

11:15 The Evolution of Tango Harmony, 1910-1960
    Bruno Mesz, Augusto Paladino, Juan Pérgola and Pablo Amster

11:45 Cross Entropy as a Measure of Coherence and Uniqueness
    Christopher Wm. White

12:15 Using Probabilistic Parsers to Support Composition in Salsa Music
    Brayan Rodríguez, Raúl Gutiérrez de Piñérez and Gerardo M. Sarria M.

12:45 Dynamic Time Warping for Automatic Musical Form Identification in
    Symbolical Musical Files
    Cristian Bañuelos and Felipe Orduña

13:15 Pairwise Well-Formed Modes and Transformations
    David Clampitt and Thomas Noll

11:00-12:15 Mazzola's MaMuTh (nanocourse by O. A. Agustín Aquino)
Aula Magna "Leonila Vázquez", Amoxcalli

18:00-19:30 "Imaginary Time for Real Music" Recital
Escuela Superior de Música

Wednesday, June 28th, 2017

10:00-13:45 Contributed Talks
Auditorio "Carlos Graef Fernández", Amoxcalli
Chair: TBD

9:00 On the Group of Transformations of Classical Types of Seventh Chords
Sonia Cannas, Samuele Antonini and Ludovico Pernazza

9:30 A Cluster Analysis for Mode Identification in Early Music Genres
Daniel Tompkins

10:00 Interval Content vs DFT
Emmanuel Amiot

10:30 Abstract Gestures
Juan Sebastián Arias Valero

11:00 Coffee break

11:15 Determination of Compositional Systems through Systemic Modeling
Liduino Pitombeira

11:45 Probing Questions About Keys
Jason Yust

12:15 Homometry in Dihedral Groups
Grégoire Genuys and Alexandre Popoff

12:45 A Fuzzy-Clustering Based Approach for Measuring Similarity Between
Melodies
Brian Martínez and Vicente Liern

13:15 Hamiltonian Graphs as Harmonic Tools
Giovanni Albini and Marco Paolo Bernardi

11:00-12:15 Mazzola's MaMuTh (nanocourse by O. A. Agustín Aquino)
Aula Magna "Leonila Vázquez", Amoxcalli

17:45-19:45 Visit to Museo Nacional de Historia (Chapultepec Castle)
National Museum of History (Chapultepec Castle)

19:45-21:00 "Lluis-Puebla's Beethoven Cycle" Recital
National Museum of History (Chapultepec Castle)

Thursday, June 29th, 2017

9:00-12:45 Contributed Talks
Auditorio "Carlos Graef Fernández", Amoxcalli
Chair: Octavio Alberto Agustín Aquino

9:00 Developing Software for Dancing Tango in *Compás*
Emmanuel Amiot, Jean-Philippe Lerat, Bérenger Recoules and Válerie Szabo

9:30 New Investigations in Rhytmic Oddity
Franck Jedrzejewski

10:00 Complementary Collections and Ligeti's Combinatorial Tonality
Clifton Callender

10:30 Identification and Evolution of Musical Style
Francis Knights, Pablo Padilla and Dan Tidhar

11:00 Coffee break

11:15 Algebra of Harmony
Marek Žabka

11:45 Real-Time Compositional Procedures For Mediated Soloist-Ensemble Interaction
Pedro Louzeiro

12:15 Polytopic Graph of Latent Relations
Corentin Louboutin and Frédéric Bimbot

12:45-13:45 Plenary Talk
Auditorio "Carlos Graef Fernández", Amoxcalli

The Physical Musical Space, Fix or Mobile, Bi- and Tridimensional
Julio Estrada

20:00-   Farewell dinner at Radisson

List of Abstracts

Hamiltonian Graphs as Harmonic Tools

Giovanni Albini and Marco Paolo Bernardi

This article introduces a method for building and studying various harmonic structures in the actual conceptual framework of graph theory. Tone-networks and chord-networks are therefore introduced in a generalized form, focusing on Hamiltonian graphs, iterated line graphs and triangles graphs and on their musical meaning. Reference examples as well as notable music-related Hamiltonian graphs are then presented underlining their relevance for composers.

Interval Content vs. DFT

Emmanuel Amiot

Several ways to appreciate the diatonicity of a pc-set can be proposed: Anatol Vierù enumerates connected fifths (or semitones, as an indicator of chromaticity), Aline Honingh similarly measures 'interval categories' against prototype pc-sets; numerous generalizations of the diatonic scales have been advanced, for instance John Clough and Jack Douthett 'hyperdiatonic' which supersedes Ethan Agmon's model and the tetrachordal structure of the usual diatonic, and many others. The present paper purports to show that magnitudes of Fourier coefficients, or 'saliency' as introduced by Ian Quinn, provide better measurements of diatonicity, chromaticity, octatonicity... The latter case may help solve the controversies about the octatonic character of slavic music in the beginning of the XXth century, and generally disambiguate appreciation of hitherto mostly subjective musical characteristics.

Strange Symmetries

Emmanuel Amiot

It would seem that the notion of musical inversion is one of the simplest and least mysterious: they are just run-of-the-mill symmetries around axes. However, much depends on the context and even more on the model wherein inversions are used. For instance in neo-Riemannian theory, one talks of the **local** inversion R – turning a triad into its relative –, though its actual effect on pitch-classes depends on which triad R is applied to: the connection with inversions in the circle of pcs is tenuous at best. Other models may turn R into a global operation, but lose the essential relation $R^2 = \mathrm{Id}$, while still other contexts enable to embed operations on points into the more general operations on (most) pc-sets, in a natural and visual way. This paper purports to synthesize most of the different situations and help understand and/or picture wht an inversion really is, in its full complexity.

Developing software for dancing Tango in Compás

Emmanuel Amiot, Jean-Philippe Lerat, Bérenger Recoules and Válerie Szabo

Argentine Tango faces dancers with specific challenges. As it is an improvised dance, the leader is expected to follow patterns and trends in the music. While musicians have an advantage, many beginners prove unequal to the task, and are often driven to abandon. *Compass Trainer* is a piece of smartphone software intended to help dancers feel and integrate in their movements the 'Compás', the rhythmic pulse of the dance. Its development blended theoretical and down-to-earth, practical considerations. Our team had to take into account the mixed rhythmical structure – binary with a ternary component; explore signal processing techniques such as beat tracking; interview tango maestros and musicians, and build a mobile application to help our users discover the rhythmical layers of a tango track. Experimentation in Tango classes was rewardingly successful. Presentation on stage of this conference should of course involve some dance demonstration.

Abstract Gestures: A Unifying Concept in Mathematical Music Theory

Juan Sebastián Arias

We present the notion of abstract gestures and show how it encompasses Mazzola's notions of gestures on topological spaces and topological categories, the notion of diagrams in categories, and our notion of gestures on locales. A relation to formulas is also discussed.

Dynamic Time Warping for Automatic Musical Form Identification in Symbolical Music Files

Cristian Bañuelos and Felipe Orduña

Music information retrieval techniques are used to automatically extract structural data of a piece, however there have been few attempts to study ways to automatically identify the musical form of digital files. In this work we present an implementation of the dynamic time warping algorithm for the automatic identification of musical form structure by means of a segmentation matrix in which we group elements according to maximal similarity. The system was implemented in symbolic files parsed with the music21 library. We tested it in two pieces: Bagatelle No. 25 in A minor by L.V. Beethoven, and Piano Sonata No. 11 in A major, K331, movement 3 by W.A. Mozart. The system obtained a correct identification of the similar sections, both with a rondo form. We foresee that this algorithm can be extended to measure harmonic similarity and with this be able to analyze more complex forms, like a sonata.

Some Transformational Representations on Elliot Carter's Tempi Counterpoint

Erik Baqueiro Victorín

The aim of this paper is to formally analyze some passages from Elliott Carter's repertoire of the end of the twentieth century, with special focus on

time domain through a transformational approach. About the first movement of *Tempo e Tempi* (1999) for soprano, violin, English horn and bass clarinet, is presented a graphical representation of the tempi counterpoint on the beginning of the piece. Second, we built a tempi modulation network of the first of the *Two Diversions* (1999) for piano solo, which evinces some temporal relationships at general level. Finally, we present an analysis of the final passage of *Shard* (1997) for guitar solo, a fragment that constantly displaces our perception of the hypothetical time-point of reference.

Primal-Circular Substitutions

Marcus Booth

There are two ongoing tensions in the pursuit of understanding music that traditional and interdisciplinary approaches have acknowledged yet left under-explored and unresolved. Intra-culturally imposed and preserved terminological constraints have brought about a need for: 1. an analytical protocol uniformly applicable to both the local and the global form, with underlying logic portable across analysis of different musical elements. 2. the reversibility of these compositional and analytical approaches in effort to epistemologically unhinge creative progress. Trends toward the mathematical treatment of other musical elements point to these needs, but the trajectory is especially transparent in regard to harmony, given its foundational status in the west. The following paper will proceed by example from theory toward a compositional end, employing techniques from group theory and algebra to create a system of chord substitution that resolves the tensions indicated above while maintaining both past historical relevancy and future creative potential.

Elastic Lapsus

Patricio Calatayud

We are witnessing how the interest of composers in digital technologies is being renovated. Instead of using the computer capabilities only to generate sound, a large number of creators and researchers around the world are focusing their efforts on producing new methods of musical interaction between creative thinking and interpretive actions, that result as performativity

representations of musical works. This trend of computational work tries to remove the virtual aspect of sound creation –produced and executed within and from a computer. The goal seems to be the focus on the complexity of mediated and embodied production of sound. Although this shift is not exclusive, the people interested in using computer for music have a powerful music creation tool, which isn't limited to the transcription of a manuscript but has the potential to operate at the same level of linguistic structure and semiotic construction. This article starts with a brief immersion in the field of the score production and its writing, to continue establishing the relevance of including new digital technology for the construction of scores, to finish with a musical work, where these developments became present.

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Complementary Collections and Ligeti's Combinatorial Tonality

Clifton Callender

This paper examines one aspect of Ligeti's approach to writing music that is nei- ther tonal nor atonal: the use of complementary collections to achieve what Richard Steinitz has termed combinatorial tonality.

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On the Group of Transformations of Classical Types of Seventh Chords

Sonia Cannas, Samuele Antonini and Ludovico Pernazza

This paper presents a generalization of the well-nown neo-Riemannian group PLR for the classical five types of seventh chord (dominant, minor, half-diminished, major, diminished) considered as tetrachords with a marked root and proving that it is isomorphic to the abstract group $S_5 \ltimes \mathbb{Z}_{12}^4$. This group includes as subgroups the PLR group and several other groups that already appear in the literature.

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Pairwise Well-Formed Modes and Transformations

David Clampitt and Thomas Noll

One of the most significant attitudinal shifts in the history of music occurred in the Renaissance, when an emerging triadic consciousness moved musicians towards a new scalar formation that placed major thirds on a par with perfect fifths. In this paper we revisit the confrontation between the two idealized scalar and modal conceptions, that of the ancient and medieval world and that of the early modern world, associated especially with Zarlino. We do this at an abstract level, in the language of algebraic combinatorics on words. In scale theory the juxtaposition is between well-formed and pairwise well-formed scales and modes, expressed in terms of Christoffel words or standard words and their conjugates, and the special Sturmian morphisms that generate them. Pairwise well-formed scales are encoded by words over a three- letter alphabet, and in our generalization we introduce special positive automorphisms of $F3$, the free group over three letters.

The Physical Musical Space, Fix or Mobile, Bi- and Tridimensional

Julio Estrada

Since remote times, the space in music has been integrated to the architecture and to the movements of traditional music processions. In the present times, "spatialization" has reborn in Europe and in the USA after the Second World War through electroacoustics and computer music science, both at the avant-garde of procedures in which the technology itself demands a renewal of chrono-acoustical vocal and instrumental music writing, as well as their interaction with new technologies. In terms of musical writing, the synthesis of rhythm, sound and space belonging to the notion of macro-timbre allows to include height, deepth and length, three aspects through which to indicate with precission the global space of the audible sources, their individual position at each instant and, in terms of individual movements, to calculate trajectories' time-space of diverse real sources in a relatively free transit of the musical matter.

On All-Distances-Twice Tone Rows

Harald Fripertinger and Peter Lackner

Tone rows are sequences of twelve pitch classes so that each pitch class occurs exactly once. Usually we use pitch classes from the set $\mathbb{Z}_{12}$, the residue class ring modulo 12. The interval from pitch class a to pitch class b is the difference $b - a \in \mathbb{Z}_{12}$.

Each tone row defines a vector of 11 non-zero intervals between consecutive pitch classes in the row. If each non-zero interval occurs exactly once in this vector, then the tone row is called an all-interval-row. These rows were thoroughly studied and frequently used in compositions.

For $d \in \{1, 2, 3, 4, 5, 6\}$ both the interval d and $12 - d$ represent the same distance d in $\mathbb{Z}_{12}$. Using the notion of tone rows as it is given in H. Fripertinger's and P. Lackner's paper "Tone rows and tropes", Journal of Mathematics and Music 9, 111–172, 2015, a tone row is considered as a closed cycle of twelve pitch classes. Hence we also obtain closed cycles of 12 intervals or of 12 distances between consecutive pitch classes of a row. From these cycles we construct the interval or distance structure of (an equivalence class of) a tone row. If we consider an all-interval-row, then each distance occurs exactly twice in this cycle. Therefore, such tone rows will be called all-distances-twice rows. Moreover, there exist several tone rows, which are not all-interval-rows but all-distances-twice rows. Thus all-distances-twice rows form a richer structure than all-interval-rows. Since from the acoustical point of view all-interval-rows and all-distances-twice rows have the same quality, we suggest to use the latter more often.

Using the "Database on tone rows and tropes" by H. Fripertinger and P. Lackner it is possible to analyze all tone rows with respect to their distance-structure. Further generalizations of this concept will be presented.

Homometry in the Dihedral Groups: Lifting Sets from $\mathbb{Z}_n$ to D_n

Grégoire Genuys and Alexandre Popoff

The paper deals with the question of homometry in the dihedral groups D_n of order $2n$. These groups are non-commutative, leading to new and challenging definitions of homometry, as compared to the well-known case of homometry in the commutative group $\mathbb{Z}_n$. We give here a musical interpretation of homometry in D_{12} using the well-known neo-Riemannian groups,

some results on a complete enumeration of homometric sets for small values of n, and some properties disclosing the deep links between homometry in $\mathbb{Z}_n$ and homometry in D_n.

A Symmetric Quantum Theory of Modulation in $\mathbb{Z}_{20}$

Jesús David Gómez-Téllez, Emilio Lluis-Puebla and Mariana Montiel

Elementary concepts from number and group theory are reviewed in order to study certain aspects of microtonal scales: construction, harmonic structure and different translations of a specific scale. In particular, a scale of 20 notes is revisited, and we adapt for it a model based on the symmetry group of the scale. This model allows for modulation to a translation of the scale. A musical example based on this symmetry model is included in this presentation. On the other hand, there is a significant similarity between the usual major diatonic scale and certain 11-note scale, immersed within the 20-note scale, obtained through group and number theoretical properties. This work is based on the premise that musical expression has an underlying mathematical structure and that the coherence of this structural approach can be appreciated through the quality of the musical results.

Using Inharmonic Strings in Musical Instruments

Kevin Hobby, William A. Sethares and Zhenyu Zhang

Uniform strings have a harmonic sound; nonuniform strings have an inharmonic sound. This paper experiments with musical instruments based on nonuniform/inharmonic strings. Given a precise description of the string, its spectrum can be calculated using standard techniques. Dissonance curves are used to motivate specific choices of spectrum. A particular inharmonic string consisting of three segments (two equal unwound segments surrounding a thicker wound portion) is used in the construction of the *hyperpiano*. A second experiment designs a string with overtones that lie on steps of the 10-tone equal tempered scale. The strings are sampled, and digital (software) versions of the instruments are made available along with a call for composers interested in writing for these new instruments.

New Investigations on Rhythmic Oddity

Franck Jedrzejewski

The "rhythmic oddity property" (rop) was introduced by ethnomusicologist Simha Aron in the 1990s. The set of *rop words* is the set of words over the alphabet $\{2, 3\}$ satisfying the rhythmic oddity property. It is not a subset of the set of Lyndon words, but is very closed. We show that there is a bijection between some necklaces and rop words. This leads to a formula for counting the rop words of a given length. We also propose a generalization of rop words over a finite alphabet $\mathcal{A} \subset \{1, 2, \ldots, s\}$ for some integer $s \geq 2$. The enumeration of these generalized rop words is still open.

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Special Properties of 15 Equal Tuning and its Relationship to Others

Noah Jordan

We investigate primarily to what limits the tuning of 15 equal tones per octave (or 15-ed2) may be mapped between tunings that are not divisible by 5. The properties include but are not limited to, harmonic movements, melodic movements, symmetrical movements, and interpretations and representations of regular temperaments. This tuning will be compared to standard 12 equal tuning, meantone temperaments, high number equal divisions of the octave, and the 6n equal divisions of Julian Carrillo. The viewpoint of this paper is primarily that of comparing and contrasting the properties of 5n-ed2s (equal divisions of the octave which are multiples of 5), with other systems, especially 6n-ed2s and its subset of 12n-ed2s. The focus is very much on the multitude of perspective shifts possible depending on the sense or the concept of an interval within a piece. For example, 12-ed2 can be viewed as a mean-tone system, or as a "half-tone" version of the whole-tone scale.

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Identification and Evolution of Musical Style I: Hierarchical Transition Networks and their Modular Structure

Francis Knights, Pablo Padilla and Dan Tidhar

The problem of identifying musical styles using mathematical tools is central not only in musicology and the mathematical theory of music, but also

in applications to music pattern recognition and automated music generation in a particular idiom. In this paper we propose a methodology related to the transition network approach developed by D. Cope in his Experiments on Musical Intelligence, EMI. This extension allows for the possibility of defining stylistic cells at different scales as motifs and moduli of networks at the corresponding scale. We also outline how this methodology can be used to systematically study stylistic changes in different contexts by incorporating probabilistic and statistical tools and connections with other approaches.

Polytopic Graph of Latent Relations: A Multiscale Structure Model for Music Segments

Corentin Louboutin and Frédéric Bimbot

Musical relations and dependencies between events within a musical passage may be better explained as a graph rather than in a sequential framework. This article develops a multiscale structure model for music segments, called Polytopic Graph of Latent Relations (PGLR) as a way to describe nested systems of latent dependencies within the mu- sical flow. The approach is presented conceptually and algorithmically, together with an extensive evaluation on a large set of chord sequences from a corpus of pop songs. Our results illustrate the efficiency of the proposed model in capturing structural information within such data.

Real-Time Compositional Procedures for Mediated Soloist-Ensemble Interaction: the Comprovisador

Pedro Louzeiro

The "Comprovisador" is a real-time, networked system through which a conductor/composer mediates the interaction between a solo improviser and an ensemble of musicians who sight-read an animated score. The system uses multiple computers – one host and several clients – to perform algorithmic composi- tional procedures with the music material improvised by the soloist and to coordinate the musical response of the ensemble. The present paper focuses on the main aspects of the compositional algorithms used, overviewing the concept and structure of this system as well as describing the main

features of its notation interface. Some of the real-world opportunities for development and testing that have occurred are also reported.

A Fuzzy-Clustering Based Approach for Measuring Similarity Between Melodies

Brian Martínez and Vicente Liern

Symbolic melodic similarity aims to evaluate the degree of likeness of two or more sequences of notes. In this work, we propose the use of Fuzzy c-Means Clustering as a tool for the measurement of the similarity between two melodies with a different number of notes. Moreover, we present an algorithm, FOCM, implemented in a computer program written in C♯ able to read two melodies from files with MusicXML format and to perform the clustering to calculate the dissimilarity between any two melodies. In addition, for each iteration step in the convergence process of the algorithm, a family of intermediate states (transition melodies) are obtained that can be used as new thematic material. This last feature, could be especially useful in the near future, as a complement in computer-aided composition.

Mathematical Music Theory and the Musical Math Game—Two Creative Ontological Switches

Guerino Mazzola

Mathematical Music Theory (MaMuTh) can be understood as a creative support of the musical ontology, a toolset for composition, or a model for theoretical approaches. Several MaMuTh scholars who are also musicians have asked about the opposed possibility, a Musical Math Game (MuMaGm), namely the creative musical support of the mathematical ontology, setting up conjectures, mathematical theories and eventually helping solve mathematical problems. We discuss this idea and our related proposal of music and mathematics being adjoint functors between (the categories of) formulas and gestures. We illustrate this bidirectional ontological shift of creativity between music and mathematics through the history of counterpoint.

The Evolution of Tango Harmony, 1910-1960

Bruno Mesz, Augusto Paladino, Juan Pérgola and Pablo Amster

In this article, we look at the diachronic changes in tango harmony with the methods of network science. We are able to detect some significative tendencies of harmonic discourse in the first half of the XXth century, among them an enrichment of harmonic transitions and power law frequency distribution of triadic chords with exponents compatible with a quite small rate of accretion of the vocabulary. This work was supported by project 'Evolución musical' UNTREF.

Probabilistic Generation of Ragtime Music from Classical Melodies

Joel Michelson, Hong Xu, and Phillip B. Kirlin

We examine the computational problem of taking a classical music composition and algorithmically recomposing it in a ragtime style. Because ragtime music is distinguished from other musical genres by its distinctive syncopated rhythms, our work is based on extracting the frequencies of rhythmic patterns from a large collection of ragtime compositions. We use these frequencies in two different algorithms that alter the melodic content of classical music compositions to fit the ragtime rhythmic patterns, and then combine the modified melodies with traditional ragtime bass parts, producing new compositions which melodically and harmonically resemble the original music. We evaluate these algorithms by examining the quality of the ragtime music produced for eight excerpts of classical music alongside the output of a third algorithm run on the same excerpts; results are derived from a survey of 163 people who rated the quality of the ragtime output of the three algorithms.

Almost Difference Sets in Transformational Music Theory

Robert W. Peck

The combinatorial theory of difference sets has prior applications in the field of mathematical music theory. The theory of almost difference sets, however, has not received similar attention from music scholars. Nevertheless, these types of structures also have significant musical applications. For

instance, the well known all-interval tetrachords of pitch-class set theory are almost difference sets. To that end, we investigate the various categories of almost difference sets (cyclic, abelian, and non-abelian) in terms of their representations in Lewinian music-transformational groups.

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Determination of Compositional Systems through Systemic Modeling

Liduino Pitombeira

In this paper we propose the systemic modeling of Camargo Guarnieri's Ponteio No.1 with the aim of identifying a hypothetical compositional system that gave rise to this work. From this compositional system we will plan a new work for woodwind trio. The model, specifically related to the harmonic syntax and the melodic gestures, is encoded into two algorithms written in Python and MATLAB.

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Using Probabilistic Parsers To Support Composition of Salsa Music

Brayan Rodríguez, Raúl Gutiérrez de Piñérez and Gerardo M. Sarria M.

Salsa is a long-established music genre. It has been used as a way to define, identify and express social beliefs. Due to the limited computational study of this genre, we consider relevant to identify and analyze the musical features of this music genre. Thus, we train a corpus with Grupo Niche songs for generating the production rules for an induced probabilistic context-free grammar through a probabilistic parser. In addition, we implement a web-based tool to support musical composition and generate automatic Salsa songs. In this work, we also compare three automatic songs using cross-validation on the corpus. We show the stability of the grammar because the precision of the generated songs compared to corpus' songs is close to those that are not in the corpus.

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A Cluster Analysis for Mode Identification in Early Music Genres

Daniel Tompkins

This paper presents a corpus study that identifies the number of statistically distinct modes used in sacred and secular genres from 1400–1750. Corpora used for the study include Masses, motets, and secular songs from the Franco-Flemish School, works by Palestrina, secular Italian songs with alfabeto guitar tablature from the early seventeenth century, and works by J.S. Bach. A k-means cluster analysis of key profiles determine the number of distinguishable modes in each corpus. The results of this study show that the number of modes present in a corpus depend not only on date of publication but also on the genre of a composition.

Cross Entropy as a Measure of Coherence and Uniqueness

Christopher Wm. White

Cross entropy, a measurement of the complexity/predictability of a series of observations given a probabilistic model, has been used in a variety of domains in music scholarship for decades. This paper presents a novel application of this metric to musical corpus analysis. Given a series of divisions to a larger corpus, a sub-corpus is relatively "unique" if a probabilistic model derived from its pieces better predicts its constituent pieces than do models derived from other sub-corpora. A sub-corpus is relatively "coherent" if its own model describes its pieces better than a model derived from the entire corpus. The Yale-Classical-Archives corpus was used to illustrate several strategies for sub-corpus division, each of which are tested for uniqueness and coherence. Some broader interpretive applications are also described.

Probing Questions about Keys: Tonal Distributions through the DFT

Jason Yust

Pitch-class distributions are central to much of the computational and psychological research on musical keys. This paper looks at pitch-class distributions through the DFT on pitch-class sets, drawing upon recent theory that has exploited this technique. Corpus-derived distributions consistently exhibit a prominence of three DFT components, f_5, f_3, and f_2, so that we might simplify tonal relationships by viewing them within two- or three-dimensional phase space utilizing just these components. More generally, this simplification, or filtering, of distributional information may be an essential feature of tonal hearing. The DFTs of probe-tone distributions reveal a subdominant bias imposed by the temporal aspect of the behavioral paradigm (as compared to corpus data). The phases of f_5, f_3, and f_2 also exhibit a special linear dependency in tonal music giving rise to the idea of a tonal index.

Algebra of Harmony: Transformations of Just Consonances

Marek Žabka

The paper focuses on mathematical aspects of harmonies in extended just intonation and their relations. The first part lays down a theoretical framework for the investigation of structural features of such harmonies. Among other aspects, it addresses symmetry, inversion, and multiplication of harmonies. The second part explores transformational relations among harmonies of the same type, while the approach is intrinsically dualistic. Riemann-Klumpenhouwer's concepts of *Schritts* and *Wechsels* are generalized for 'harmony spaces' in extended just intonation. This enables a deeper analysis of harmonic 'neighborhoods.' Finally, a graphical representation of the complete neighborhood of a harmony, called 'neighborhood network,' is presented along with several simpler and more complex examples.

List of Poster Submissions

- Some Transformational Representations on Elliot Carter's Tempi Counterpoint
  Erik Baqueiro Victorín

- Primal-Circular Substitutions
  Marcus Booth

- Elastic Lapsus
  Patricio Calatayud

- Special Properties of 15 Equal Tuning and its Relationship to Others
  Noah Jordan

- Probabilistic Generation of Ragtime Music from Classical Melodies
  Joel Michelson, Hong Xu, and Phillip B. Kirlin

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- Juan Sebastián Arias Valero, Universidad Nacional de Colombia, Colombia.
- Cristian Bañuelos, Universidad Nacional Autónoma de México, Mexico.
- Erik Baqueiro Victorín, Escuela Superior de Artes de Yucatán, Mexico.
- Frédéric Bimbot, IRISA, France.
- Marcus Booth, San Diego State University, USA.
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- Sonia Cannas, Università di Pavia, Italy.
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- Harald Fripertinger, Karl-Franzens-Universität Graz, Austria.
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- Kevin Hobby, Synchratron, USA.
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