Workshop on AI for (Music and Games) Co-Creation (WAIC 2021)

https://webia.lip6.fr/~briot/waic2021/

22, 23 and 24 November 2021

Auditório Tércio Pacitti
CCET
UNIRIO

Jean-Pierre Briot

WAIC 2021 – UNIRIO – 22-24/11/2021
Workshop Objectives

• Share Experiences and Discuss Issues about
• Creation
• and Co-creation of Music
• in Various Contexts
• with Artificial Intelligence (AI) / Machine Learning (ML) techniques
• and notably How to Insert such Techniques into
• Human(s) Artistic Creative Process(es)
Workshop Objectives/Format

• Discussion and Problem Oriented
• Problems/Issues and *not only* Solutions
• No « sale pitch » as in usual Conferences
• Time / Slow Science
Workshop Participants Diversity

- Computer Science
- Computer Music
- Artificial Intelligence
- Machine Learning
- Synchronous/Real Time Programming
- Computer Games
- Interactive Narratology
- Digital Art
- Music Composition
- Music Performance
- …
Program – Monday 22

• Monday, 22 November Morning 09:00-12:00
  – Presentation of Workshop Objectives
    » Initiator: Jean-Pierre Briot, Successes and Challenges and Themas for Reflexion
  – Session Contexts and Prospects
    » Initiator: Geber Ramalho
    » Initiator: Carlos Eduardo Mello, Music Generation, AI and Social Good: Potentialities and Challenges

• Monday, 22 November Afternoon 14:00-17:00
  – Session Interfaces for Interaction
    » Initiator: Bertrand Petit-Hédelin, Interactive and Generative Music using Reactive Synchronous Programming
    » Initiator: Filipe Calegario

• Monday, 22 November Afternoon 17:00-19h30
  – Workshop Opening
    » Jean-Pierre Briot, Workshop Organizer
    » Olga Anokhina, Director, CNRS Rio
    » Cliff Korman, School of Music - Villa-Lobos Institute, UNIRIO
    » Markus Endler, Director, Department of Informatics, PUC-Rio
    » Sidney Lucena, Dean, CCET, UNIRIO
    – Cocktail (Offered by CNRS Rio)
Program – Tuesday 23

• **Tuesday, 23 November Morning 09:00-12:00**
  - Session Challenges and Experiences
    » Initiator: Giordano Cabral, Challenges in the adoption of music co-creation tools
    » Initiator: Philippe Pasquier, Music AI at the Metacreation Lab
    » Initiator: Bruno Feijó & Augusto Baffa, A Discussion on Interactive Narratives and Musical Elements in Games
    » Initiator: Gustavo Amaral

• **Tuesday, 23 November Afternoon 14:00-17:00**
  - Session From Music to Representation and Models
    » Initiator: Liduino Pitombeira
    » Initiator: Nathan Fradet, MidiTok, a Convenient Tool to Tokenize Symbolic Music for Deep Neural Networks
Program – Wednesday 24

• Wednesday, 24 November Morning 09:00-12:00
  – Session Emerging Theme

• Wednesday, 24 November Afternoon 14:00-17:00
  – Session Emerging Theme and Towards Convergence
  – Closing
Lunch (400m on foot) 
Resto-Buffet (ao Kilo) Terra Brasilis (Circulo Militar)
Acknowledgments

• Program PAEP (Programa de Apoio a Eventos) of CAPES, for funding the venue of some of the participants,

• CCET (Centro de Ciências Exatas e Tecnologia) of UNIRIO, for its Auditório Tércio Pacitti and associated facilities,

• CNRS Rio, the permanent representation of CNRS in Southern America, for offering the opening evening coquetel on the first day,

• DI (Departamento de Informática) of PUC-Rio, for organizing the online transmission.
Special Acknowledgments

• Sidney Lucena, Dean, CCET, UNIRIO
• Pedro Moura, Professor, CCET, UNIRIO
• Olga Anokhina, Director, CNRS Rio
• Augusto Baffa, Professor, DI, PUC-Rio
• Mauricio Lana, Post-Graduation, DI, PUC-Rio
• Bruno Feijó, Professor, DI, PUC-Rio
Context
Why Using Computer for Music?

- Vast Associative Memory
  - More systematic than Human memory
- Representation of Musical pieces, **Style**, Patterns…
- Associations and **Correlations**
- **Knowledge** (Theory, Rules, Heuristics…)

- Can Help Human musicians

- Human musicians rarely compose from scratch – They steal from others
  - Consciously
    » Plagiat, Citation…
  - Unconsciously
    » Influence
  - Recombinations
  - Historical Evolution
    » Modal monophonic -> Polyphonic (Counterpoint) -> Tonal Music (Harmony) -> Extended Harmony (Debussy, Jazz…)
  - Ruptures (Dodecaphonism, Free Jazz)
    » Rare and often transient
Music Composition Models

• Pre-Defined Elements
  – Combination (ex: Mozart Dice Music)

• Rules
  – Application
  – Filtering (ILIAC Suite), Generation, Harmonic Analysis…

• Generative Grammars
  – Valid Sentences generated by the Grammar
  – Harmonic Cadences Construction, Substitutions…

• Constraints
  – Constraint Solving Problem
  – Generation (ILIAC Suite)
  – Accompaniment: Harmonization, Counterpoint…

• Markov Chains
  – Generation (Random Walk, Constrained)
  – Style Imitation

• Neural Models (Deep Learning)
  – Prediction/Classification
  – Style Imitation
Models

- Cellular Automata
  - Evolution
- Genetic Algorithms
  - Selection
- Case-based Reasoning
  - Similarity and Adaptation
- Planning
  - Path (Melody, Chord Sequence…) Construction
- …
Handcrafted vs Learnt Models

- Handcrafted
  - Tedious
  - Error-Prone
Handcrafted vs Learnt Models

- Handcrafted
  - Tedious
  - Error-Prone

- Automatically Learnt (Induction)
  - Markov models
  - Neural models

- Style Automatic Learned from a Corpus (Composer, Form, Genre…)

- Machine Learning Techniques
  - Neural Networks, Deep Learning, Reinforcement Learning
  - (and other models/techniques)
Artificial Neural Networks & Deep Learning
Number of Scientific Papers about Neural Networks and Music (Generation, Classification…) [Pons, 2018]
Deep Learning

- **Boom Since 2012**
  - Imagenet Competition Breakthrough: 10% gain
- **Image Recognition**
- **Weather Prediction**
- **Translation**
- **Games**
- **Speech Recognition**
- **Speech Synthesis**
- **Source Separation**
- **Music Creation**
- **Image Creation**
Artificial Neural Networks in One Slide

Principle: Successive Layers of Weighted Sums
Successive Layers of Logistic Regression

Training Examples

Prediction or Classification

Jean-Pierre Briot

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Artificial Neural Networks in One Two Slides

Principle: Error Prediction/Classification Feedback

If Error Adjust Connexion Weights
Prediction or Classification

Optimization
Gradient descent

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Artificial Neural Networks -> Deep Learning

- Brute Force

- Hypervitaminized Brute Force

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GPUs

TensorFlow

PyTorch

Loss Minimization
Why Deep?

- More Complex Models
  - Universal Aproximator Theorem
- Learns better Complex Functions
- Hierarchical Features/Abstractions
- No Need for Handcrafted Features
  - (Automatically Extracted)

Distributed Representations
A Few Recent Examples
RNN Celtic Melody Generation [Sturm et al., 2016]

- Celtic Folk Music Corpus (Melodies)
- Text Encoding (ABC Notation)
- Ex. of Melody Generated

Played by a human accordeonist (Bob himself !)
Reorchestration of God Save the Queen into Bach Chorales Style by DeepBach [Hadjeres, 2017]
Doodle Bach Chorales [Google, 2019]

https://www.google.com/doodles/celebrating-johann-sebastian-bach
Painting

- 26 October 2018, Christie’s Auction, New York, US$ 432 500
- Edmond de Belamy, Obvious (Collective)
- Created with Deep Learning (GAN/CAN)
- Trained with 15 000 paintings (XIV – XX centuries)
Toonify [Open AI, 2020]

https://deepai.org/machine-learning-model/toonify
Autonomous Generation vs Creation Support
Autonomous vs Assisted Music Creation

- Autonomous Generation
  - Turing Test
  - Symbolic or/and Audio Music Generation
  - Parametrization/User Preferences (Style, Mood, etc.)
  - For Commercials, Documentaries, Video Clips
  - Create Royalty-free or Copyright-buyable Music
  - Ex: Jukedeck, Aiva Technologies, AMPER MUSIC

Ex: Business model
-- Musical model

Bought by TikTok
Bach Chorales Turing Test

- Autonomous Artificial Musicians

- Music Composition Turing test
  - Imitation Game Scenario [Turing, 1950]
  - Designed by A. Turing to explore the question "Can Machines think?"

(A) J. S. Bach

(B) DeepBach [Hadjeres et al., 2017]

(C) Listener

- To evaluate artificial composers techniques
- To explore music cognition
Bach Chorales Turing Test

- February 2017, Dutch TV Channel
- Bach vs DeepBach [Hadjeres et al., 2016] Turing Test
Autonomous vs Assisted Music Creation

- Assistance to Human Composers and Musicians
  - Propose
  - Refine
  - Analyze
  - Harmonize
  - Produce
  - Ex: FlowComposer [Pachet et al., 2014], OpenMusic [Agon et al., 1998]
Co-Creativity

- Co-Creation by Human(s)+Machine(s)
  - Ex: FlowComposer [Pachet et al., 2014], OpenMusic [Agon et al., 1998]
  - Continuator [Pachet, 2002]
  - Omax/DYCI2 [Assayag et al., 2003]
FlowComposer [Pachet et al., 2014] – Demo (B. Carré)
Hello World

- January 2018, Hello World
- Created by Musicians (Musical Direction: Skygge – aka Benoît Carré)
- with FlowComposer [Pachet et al., 2014]
- ERC Project Flow Machines [Pachet et al., 2012-2017]
- Various Techniques (Markov Constraints, Rules, …)

https://www.youtube.com/watch?v=iuWYQe3aGlg
## Objective and Evaluation [Pachet, 2019]

<table>
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<td><strong>Risk</strong></td>
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- **Current Systems**:
  - Autonomous Generalization-based

- **Future Systems**:
  - Augmentation/Assistance Creative-incentived
Appropriation
Appropriation – IKEA Effect

• The Important Issue of Appropriation
  – By the Human Musician (Composer, Arranger, Producer…)
Objective and Evaluation [Pachet, 2019]

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Current Systems: Autonomous Generalization-based

Future Systems: Augmentation/Assistance Creative-incentived
Assumption/Model: Who *May* be an Author (Creator)?

Human Only
**Assumption/Model:** Who *May* be an **Author (Creator)**?

**Human Only**

*Paris (Montmartre) Artists and Lolo Donkey, 1910*

"Et le soleil s’endormit sur l’Adriatique"

[Lolo, 2010]

**Animal**
**Assumption/Model:** Who *May* be an **Author (Creator)**?

Paris (Montmartre) Artists and *Lolo Donkey*, 1910

"Et le soleil s’endormit sur l’Adriatique"

[Jean-Pierre Briot, 2010]

Music is the most advanced form of mathematics

[GT3P, 2020]
Who is the Author?

- **Curator**
  - Identify and Select the Set of Training/Inspiration Artworks

- **Implementor**
  - Implements the Generation Platform

- **Configurator**
  - Configurates the Platform

- **"Selector"**
  - Select Final Artwork among the Various Generated

- **Program/Al/Machine**
Is Deep Learning Adapted?
Is Deep Learning Adapted to Interactive/Incremental Creation?

- Musicians May Use Music Building Blocks (e.g., Loops) Generated
Electro Dance-Pop Music

- YΔCHT (Young Americans Challenging High Technology)
- Chain Tripping Album, 30 August 2019
- Composed with Magenta MusicVAE [Roberts et al., 2018]

I'm so in love
I can feel it in my car
I can feel it in my heart,
I can feel it so hard
I want your phone to my brain
I want you to call my name
I want you to do it too
Oh, won't you come, won't you come
Won't you work on my head
Be my number nine

(Downtown) Dancing

Loud Light

Jean-Pierre Briot
YΔCHT + Magenta – Chain Tripping Album

- Melody/Chords/Rhythm Loops
  - MusicVAE (VRAE)
  - Training Corpus: Previous music by YΔCHT
- Lyrics
  - LSTM
  - Training Corpus: YΔCHT + Liked Lyrics
- Sounds
  - Nsynth (Signal VAE)
- Images and Videos
  - GAN

YΔCHT + Magenta – Chain Tripping Album

• Rules:
  – Every new song interpolated from existing YΔCHT melodies
  – 4 measures-long loops
  – Cannot add any note, harmony
  – Only subtractive or transpositional changes
  – Structure and collage allowed
  – Assignment (to vocal, bass line…)

• Human Production and Arrangements

https://www.youtube.com/watch?time_continue=1378&v=pM9u9xcM_cs&feature=emb_logo
Is Deep Learning Adapted to Interactive/Incremental Creation?

- **Musicians May Use Music Building Blocks (e.g., Loops) Generated**

- **Current Progress to Incentive**
  - Modular and Incremental Generation
    » Ex: Inpainting
  - Interactivity
Deep Learning
Co-Creation/Assistance & Interactivity

• YΔCHT/MusicVAE [Roberts et al., 2018]
  – Non interactive Generation
  – Interactive Manual Editing

• DeepBach [Hadjeres et al., 2017]
  – (Incremental Sampling)
  – Interactive/Selective Regeneration

• MeasureVAE+LatentRNN+MeasureVAE [Pati et al., 2019]
  – Inpainting
  – Previous Measure + Next measure
  – -> Latent Embeddings -> Missing Embedding
  – -> Missing Measure
Interactivity
DeepBach [Hadjeres et al., 2017]

https://www.youtube.com/watch?time_continue=28&v=OkkKjy3WRNo
Interactive Creation Environment

• A Deep Learning-Based Flow Composer Analog?
• Slower Learning than for Markov Models
  – But GPUs, etc.
  – And Corpus Pre-Training
• No (or not yet) Exact Control Method (Markov Constraints)
• Various Architectures/Strategies
• Inspiration, RNN-based
• Complementation, Feedforward-based
• Control, VAE-based
• Inpaiting, (V)AE+RNN-based
Is Deep Learning Too Conformant?
Conformance vs Surprise

- Deep Learning
- Better Conformance
- Better Quality
- More Difficult to Distinguish Artificial from Human Production
  (See Musical Turing test)
- But Less Interesting?
Style vs/and Originality

[Image of cartoon characters with captions: Say Something Original, I Love You, Originality is Overrated.]

[Mimi & Eunice]

It is better to fail in originality than to succeed in imitation.

— Perrier-Meudie

Originality

Style (learnt)

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Is Deep Learning Too Conformant?

- More Conformant !!
  - Generative Adversarial Networks (GAN)
  - Deep Fakes
Generative Adversarial Networks (GAN) [Goodfellow et al., 2014]

A differentiable function, here having parameters \( \theta \), mapping from the data space, \( \mathbb{R}^d \), to the latent space, \( \mathbb{R}^d \).

**Generator:**

\[ \text{Generator: } \theta \mapsto \mathbb{R}^d \]

**Discriminator:**

\[ \text{Discriminator: } \theta \mapsto [0, 1] \]

Goodfellow et al., 2014
Generative Adversarial Networks (GAN) [Goodfellow et al., 2014]

- Training Simultaneously 2 Neural Networks
  - Generator
    - Transforms Random noise Vectors into Faked Samples
  - Discriminator
    - Estimates probability that the Sample came from training data rather than from G
  - Minimax 2-player game
    \[
    \min_G \max_D V(G, D) = \mathbb{E}_{x \sim p_{\text{Data}}} \left[ \log D(x) \right] + \mathbb{E}_{z \sim p_z(z)} \left[ \log (1 - D(G(z))) \right]
    \]

Prediction by D

\[
\begin{align*}
D(x): & \quad P_D(x \text{ from real data}) \quad \text{(Correct)} \\
D(G(z)): & \quad P_D(G(z) \text{ from real data}) \quad \text{(Incorrect)} \\
1 - D(G(z)): & \quad P_D(G(z) \text{ from Generator}) \quad \text{(Correct)}
\end{align*}
\]

Figure by [Nam Hyuk Ahn, 2017]
 Examples of GAN Generated Images

CelebFaces Attributes Dataset (CelebA) > 200K celebrity images

[Brundage et al., 2018]

Synthetic (Generated) Celebrity images

[Brundage et al., 2018]

[Karras et al., 2018]
Is Deep Learning Too Conformant?

- **More Conformant !!**
  - Generative Adversarial Networks (GAN)
  - Deep Fakes

- **Creative**
  - Creative Adversarial Networks (CAN)
Creative Adversarial Networks (CAN) [Elgammal et al., 2017]

- Extension of GAN
- Combining 2 (Contradictory) Objectives:
  - How Discriminator believes that the sample comes from the training dataset (GAN)
  - How Easily the Discriminator can classify the sample into established styles (classes)
    - If there is strong ambiguity (i.e., various classes are equiprobable), this means that the sample is difficult to fit within the existing art styles
    - Maybe a new style has been created…
Creative Adversarial Networks (CAN) – Ex. of Paintings Generated
Is Deep Learning Too Conformant?

- **More Conformant !!**
  - Generative Adversarial Networks (GAN)
  - Deep Fakes

- Creative
  - Creative Adversarial Networks (CAN)
    - Smart, but somehow some Ad-Hoc Trick
    - But the First Move was Smart! $$
Is Deep Learning Too Conformant?

• **More Conformant !!**  
  – Generative Adversarial Networks (GAN)  
  – Deep Fakes

• **Creative**  
  – Creative Adversarial Networks (CAN)

• Not so much of a Limitation in a Co-Creation/Assistance Setting
Is Deep Learning Too Complex/Heavy?
Is Deep Learning Too Complex/Heavy?

- Vs Markov Chains
  - More Complex
  - More Conformant
  - Less Prone to Plagiat
Constrained Higher-Order Markov [Roy and Pachet, 2017]

Control of the min & max length of copied sequences from the corpus

[Roy and Pachet, 2017]
Is Deep Learning Too Complex/Heavy?

• Vs Markov Chains
  – More Complex
  – More Conformant
  – Less Prone to Plagiat

• Principles still Simple
  – Although Recent Models/Architectures Turn Out Complex and Huge
  – E.g., Perceiver, StyleGAN, GTP3…
  – And Needs Fine Tuning (Hyper-Parameters)

• Not a Problem as Long as its Usage (and User Interfaces) are Appropriate and Simple
  – Still an Open Issue/Field
Example of Accompaniment (Improvisation) System

- Jazz Bass Accompaniment (Walking Bass)
IMPACT [Ramalho, 1996]

Environment

- chord grid
- pianist
- drummer
- soloist
- audience

pre-composed parts + Scenario

Agent (bass player)

- listener
- reasoner
  - knowledge
  - goals
  - actions
- executor

events, chords, ...
synthesizer

Resoning Gap

Scenario
Executor
Reaonser

seg1
seg2

\[ \text{Em7(b5)} \quad \text{A7(b9)} \quad \text{Cm7} \quad \text{F7} \quad \text{Fm7} \ldots \]
IMPACT [Ramar, 1996]

- Autumn Leaves
- Giant Steps
- Ornithology
BassNet [Grachten et al., 2020]

https://youtu.be/Xr_cwNrEFNw
BassNet [Grachten et al., 2020]
Usage / Insertion -> Interfaces
Interface Design & Usage

- Interfaces for Physical Systems (E-Instruments)

- Interfaces for Software Systems
Collaborative Interfaces, Ex: Skini [Petit-Hédelin, 2021]

- **Interfaces for Audience**

Orchestration par le compositeur

- Groupe de Patterns X
  - Pattern 1
  - Pattern 1
  - Pattern N

- Groupe de Patterns Y
  - Pattern 1
  - Pattern 1
  - Pattern N

Audience

GrandLoup2
Self-References for More Information


https://www.springer.com/gp/book/9783319701622

http://www.briot.info/dlt4mg/


UNIRIO Course (with Implementation and Examples):

(Some) References

- Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2018
- Andrew Ng, Machine Learning Yearning, Deplearning.ai
- Judea Pearl and Dana Mackenzie, The Book of Why, Penguin Books, 2018
- Roger T. Dean and Alex McLean, The Oxford Handbook of Algorithmic Music, Oxford Handbooks, Oxford University Press, 2018
Thank You – Questions