ICSEA 2021 Keynote Talk
Barcelona
October 4 -7, 2021

Tchaikovsky Riddles, or How Software Technology Can Contribute to Musicology

Evgeny PYSHKIN
University of Aizu

THE UNIVERSITY OF AIZU 1993
会津大学

Abstract

In this talk, I'm introducing the aspects of using computer and software technology for better understanding of how humans perceive the art works. I will go through a number of our projects where we studied the models, which are helpful for the areas that seem to be very distant, but very connected in fact. In particular, these areas include speech prosody processing, modeling, visualization, and estimation for the benefits of computer-assisted language learning, algorithms of music similarity evaluation and their links to speech processing algorithms, as well as our recent approach to study the phenomenon of Tchaikovsky's "Children Album" as an excellent example of transdisciplinary research.

Though exploring rich metaphors hidden in the musical compositions lay usually in scope of musicology, there is still large space for formal methods based on mathematical models and software technology that can be helpful in discovering complementary insights to how the composition is structured, what are its relationships to the precursors' works, and how it affects the later works of the same or other authors. Interestingly, signal processing algorithms used in speech intonation analysis and evaluation along with the functional music representation models, can be promising for finding the new ways to improve our understanding of the hidden language of music. Thus, I will try to make a somewhat visionary journey connecting the studies of the melody of voice to the investigation on how computational models can enhance traditional musicology research.

** Presentation contains the links to mp3 audio samples of the music compositions by Beethoven, Wagner, Tchaikovsky, Scriabin, and Schumann recorded by the author on Yamaha Arius YDP-144 and Yamaha Clavinova CLP-735 digital pianos and processed using Logic Pro 10.6.3 software*

The Speaker (1): Position and University

Senior Associate Professor, Ph.D., Doctoral Maru-Go ***University of Aizu***

Career: Software Engineer; Assistant Professor; Associate Professor;
Senior Associate Professor ***Peter the Great St. Petersburg Polytechnic University***

- ***Aizu-Wakamatsu – city in Tohoku Region, North-East Japan***
  - Population around 120000
  - Rice, buckwheat, persimmon growing
  - Several sake breweries
  - Samurai city
- ***University of Aizu***
  - “To Advanced Knowledge for Humanity”
  - 40% of staff are foreigners
  - Focused on computer technology and its applications
  - The only university in Japan offering bilingual programs in the undergraduate school
  - In the graduate school instruction is completely in English

Charming Aizu

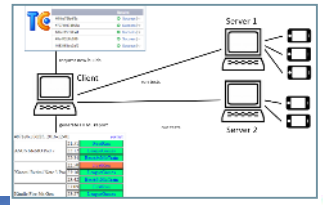
The Speaker (2): Academia and Society Links

- Undergraduate Courses
  - Introduction to Programming; Programming in C
  - Introduction to Data Management
- Graduate Courses
  - Software and Cultures

- Areas of Interest
  - Human-centric applications
    - Information systems for travelers
    - Speech processing applications
    - Educational software
  - Software engineering and education
  - Art and Humanities
    - Classical music and fine arts
    - Architecture and history
    - Opera and ballet

*"We are in era where we are reimagining nearly everything… powered by new devices, plus connectivity, plus new user interfaces, plus **beauty**…"*

Mary Meeker



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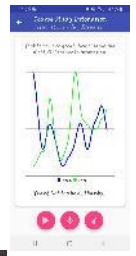
Official web page

https://u-aizu.ac.jp/~pyshe

I AM A FRIEND OF
ROYAL OPERA HOUSE

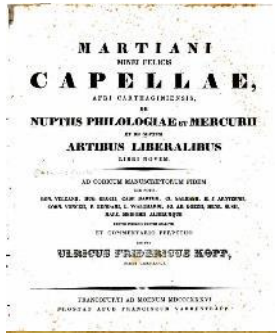


**

** K. Pain, "The most popular coding languages of 2015", https://www.linkedin.com/pulse/most-popular-coding-languages-2015-kerry-pain

Journey to the Past (1): From Engineering to Liberal Arts

- From Engineering to Liberal Arts: Revisiting a Case of Software Engineering Education *
- Considering software disciplines within the context of liberal arts is connected to significant changes in the learning models
- We anticipate more than only professional developers' skills from our students
- It is extremely important to find ways to create a collaboration environment where students can actively participate in the **co-learning** process together with their more experiences colleagues


MARTIANI
MINNI FELICIS
CAPELLAE,
AFRI CARTHAGINIENSIS,
DE
NUPTIIS PHILOLOGIAE ET MERCURII
ET DE SEPTEM
ARTIBUS LIBERALIBUS
LIBRI NOVEM.
AD CODICUM MANUSCRIPTORUM FIDEM
ULRICUS FRIDERICUS KOPP,
TRANSCRIPTI AD MODUM MDCCXXVI
FRANCOFURTI APUD FRANCISCUM VARRENTRAPP.

Computer Science

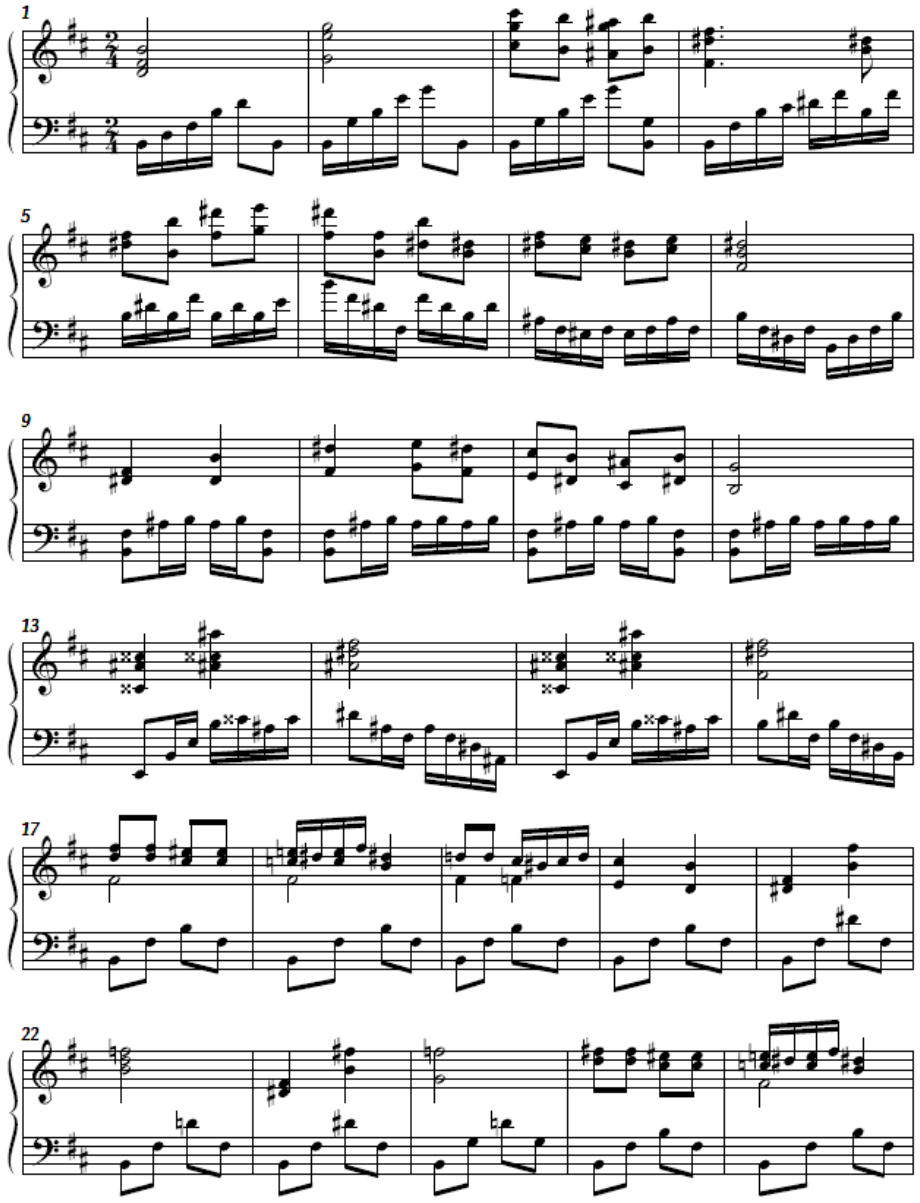
- Arithmetic
- Geometry
- Astronomy
- Logic
- Grammar
- Rhetoric
- **Music**

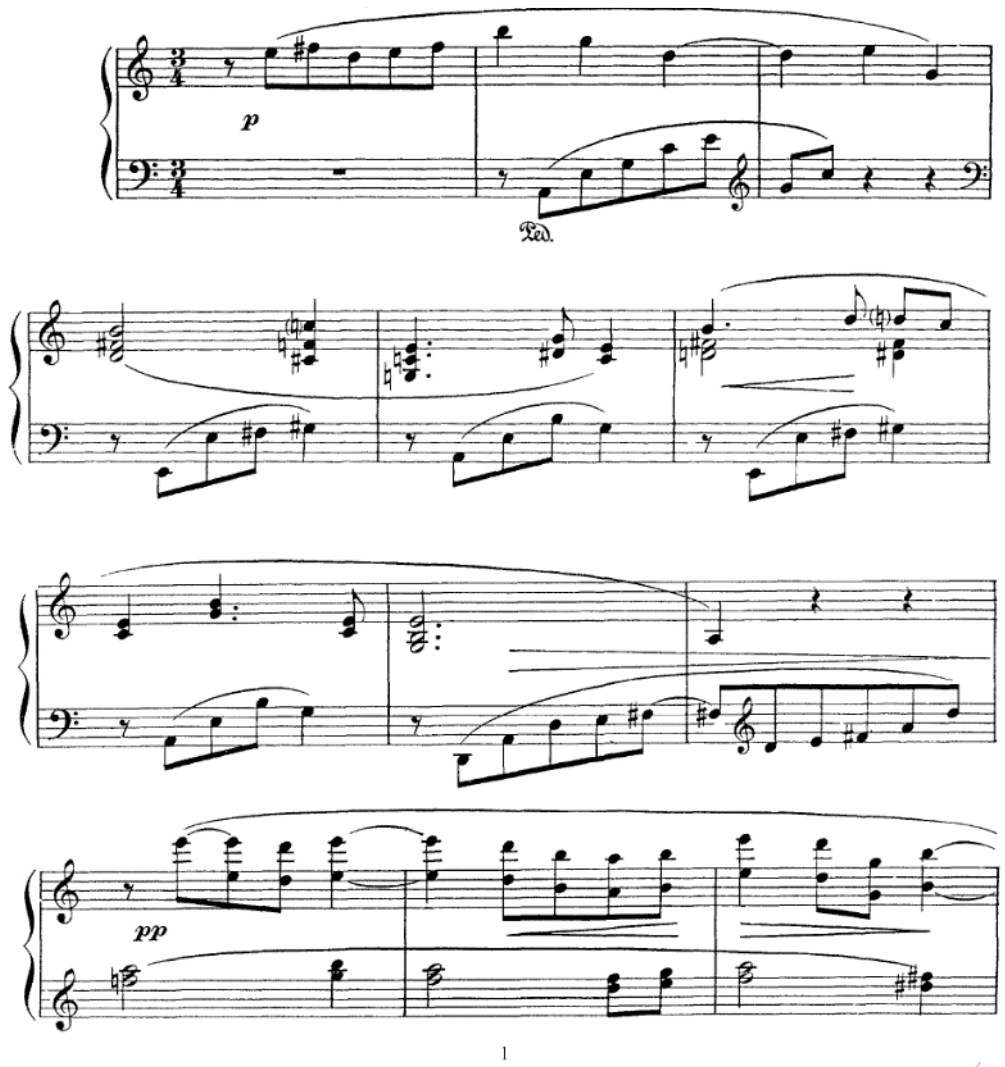
*"Computer science draws upon perspectives from many disciplines and has a symbiotic relationship with the liberal arts disciplines, so it might be considered the ultimate of them" ***

* E. Pyshkin, "Liberal arts in a digitally transformed world: A case of software development education," CEE-SECR '17, https://doi.org/10.1145/3166094.3166117.
** H.M. Walker and C. Kelemen, "Computer science and the liberal arts: a philosophical examination," ACM Transactions on Computing Education (TOCE), Mar 1, 2010, vol. 10, no. 1, pp.2:1–2:10.

Journey to the Past (2): Music from the Office

Let’s start with two pieces of music…





Computational Models and Music: Research Question

TO BE OR NOT TO BE – THAT IS THE QUESTION

(ABLE TO UNDERSTAND HOW HUMANS PERCIEVE MUSIC)

- ***How computer science and AI may enhance musicology research on music style identification, music generation, music composition, and music analysis?***
- Possible interesting areas
  - Improving search algorithms and similarity evaluation
  - Advancing tools for music creators
  - Links between speech and music processing *
  - AI approaches for music generation
  - Understanding how human beings perceive music

* N. Bogach et al., “Speech Processing for Language Learning (…),” Electronics, 10 (3), 2021.

Important Notes on the Related Work

- Music is a symbolic fact characterized by the complex configuration of interpretants *
- Great variety of models used for music representation (e.g., different notations and views) is one of reasons why music provides an interesting and complex use case for experimenting with information retrieval, object recognition and classification algorithms
- Music representation complexity can be explained by the presence of two arrays of elements and relationships, where the first one corresponds to the elements that can be treated mathematically (pitch, rhythm, or harmony), while the second one includes non-mathematical elements such as tension, expectancy, and emotion **
- Current approaches to music similarity evaluation mostly target the searching and retrieval systems including well-known apps, such as Shazam
- There is no perfect fit to the problems of stylistic similarity evaluation
- Among the models assumed to be more adequate to the problem of music style identification:
  - Functional representation of music along with harmony and harmonic similarity estimation ***
  - Automated extraction of music signatures ****
  - Modeling music structure using ontology and graph-based representations
  - Classification based on machine learning algorithms

* J.-J. Nattiez, Music and discourse: Toward a semiology of music. Princeton University Press, 1990.
** R. B. Dannenberg, “Music representation issues, techniques, and systems,” Computer Music Journal, vol. 17, no. 3, 1993, pp. 20–30.

*** J. P. Magalhaes and W. B. de Haas, “Functional modelling of musical harmony: an experience report,” ACM SIGPLAN Notices, vol. 46, no. 9, 2011, pp. 156–162.
**** D. Cope, Experiments in Musical Intelligence. Madison, WI: A-R Edition, 1996.

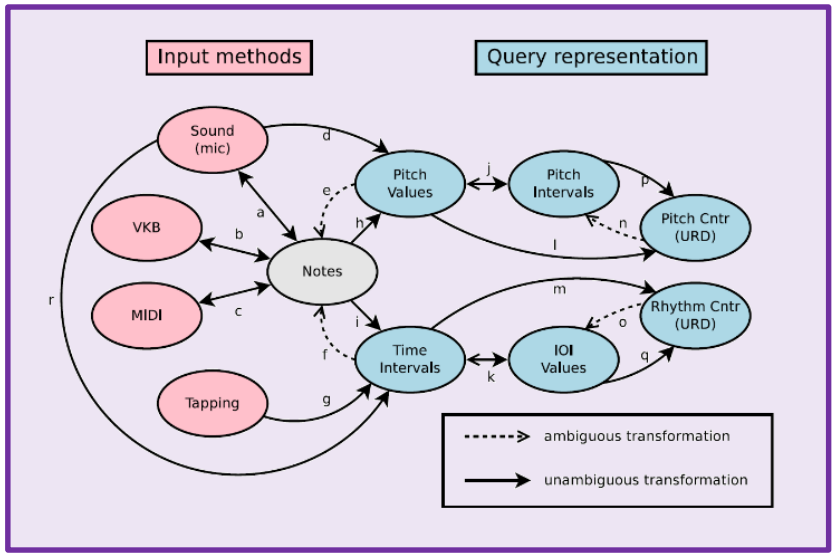
Similarity Evaluation: Why is it so Important?

- Art and musicology research
  - Genesis and development of style
  - Citations and allusions

See next slide example …

musipedia
The Open Music Encyclopedia

- Simply *"To know that tune…"*
- Commercial applications
  - Customers who want to find and purchase compositions they like
- Copyright issues
  - Plagiarism in creative works



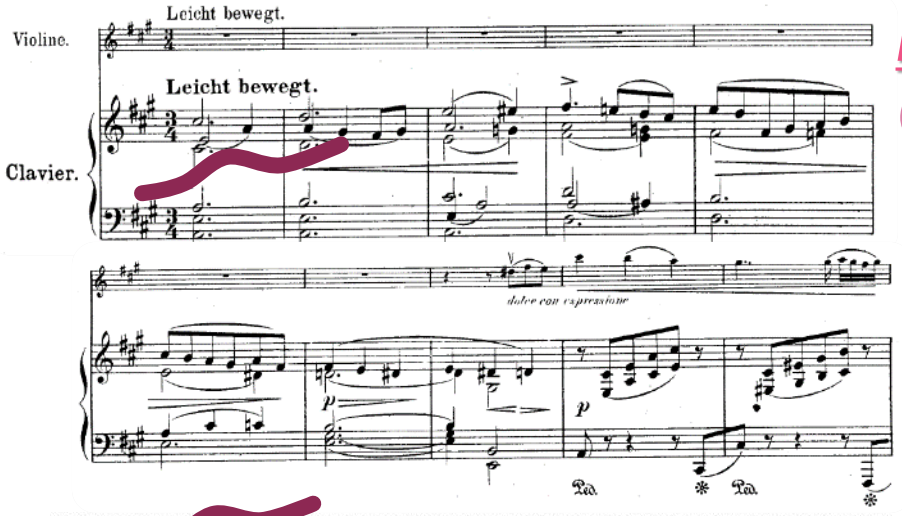
*

* M. Purgina, A. Kuznetsov, and E. Pyshkin. "Leveraging user experience through input style transformation to improve access to music search services," Informatica, 38(1), 2014

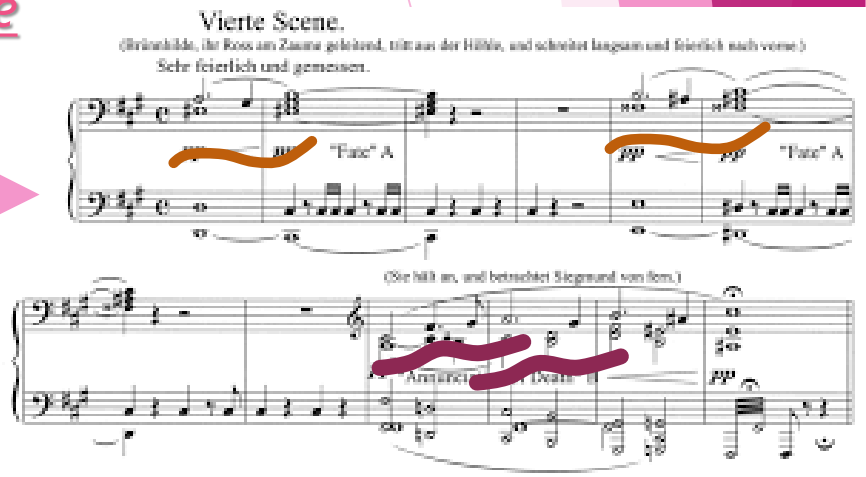
WAGNER
1813 – 1883

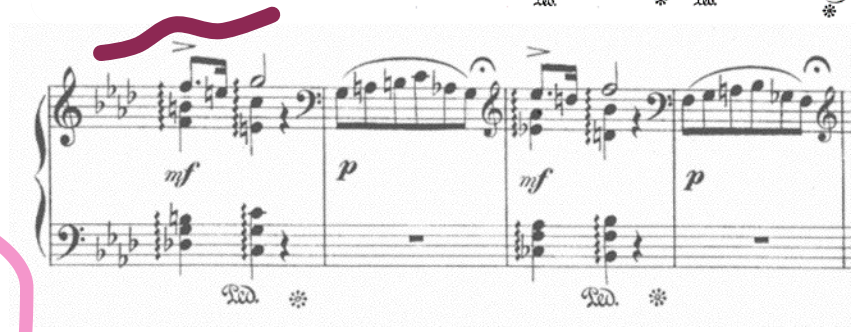
TCHAIKOVSKY
1840 – 1893

SCRIABIN
1872 – 1915



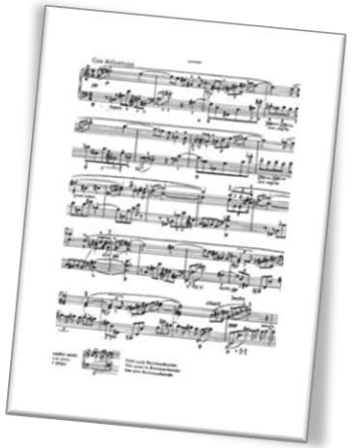
Romance
(1840)

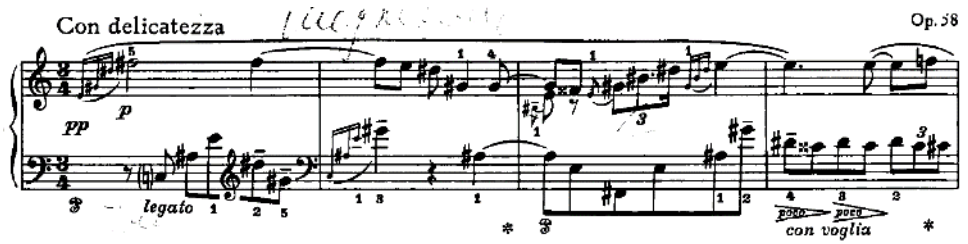




Interrupted Dreams
Op. 38 No. 12
(1878)

Intro to Scene 4 from The Valkyrie
Op. 38 No. 12
(1870)

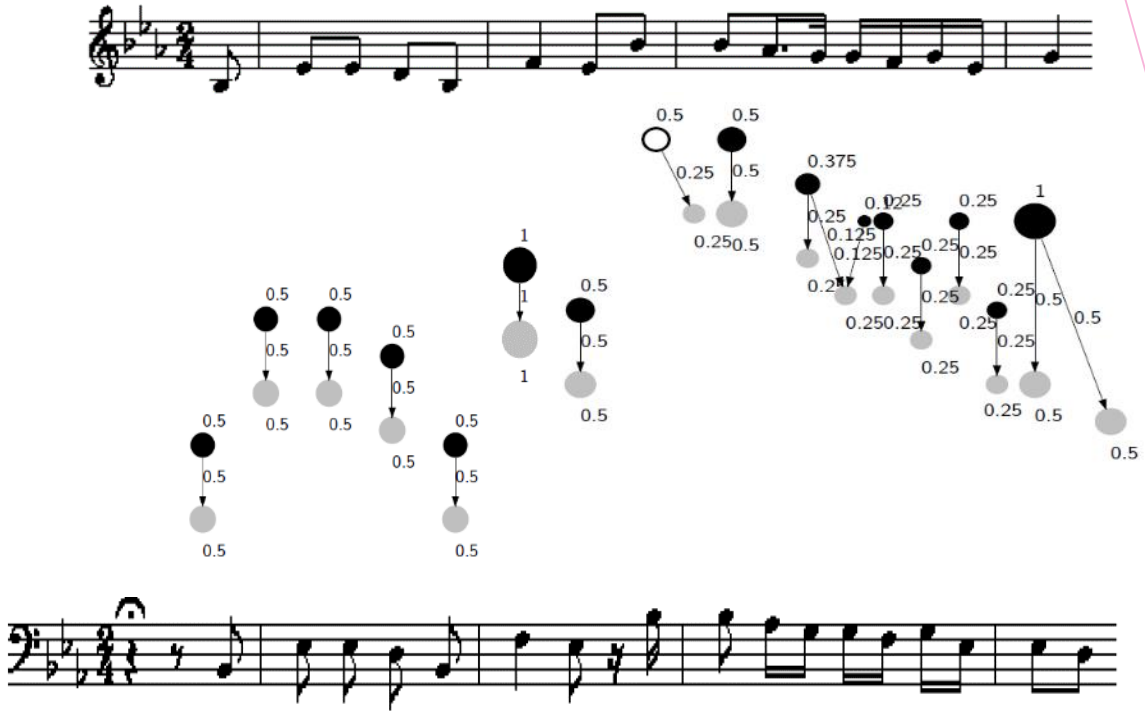




Feuillet d'album Op. 58
(1910)

Similarity Evaluation: Not simple even if we know the score

- How to measure ***distance*** between music fragments?
  - *Earth Mover's Distance* *
  - *May be fine for simple melodies…*
  - *… but doesn't work pretty well for more complex compositions with multiple voices*



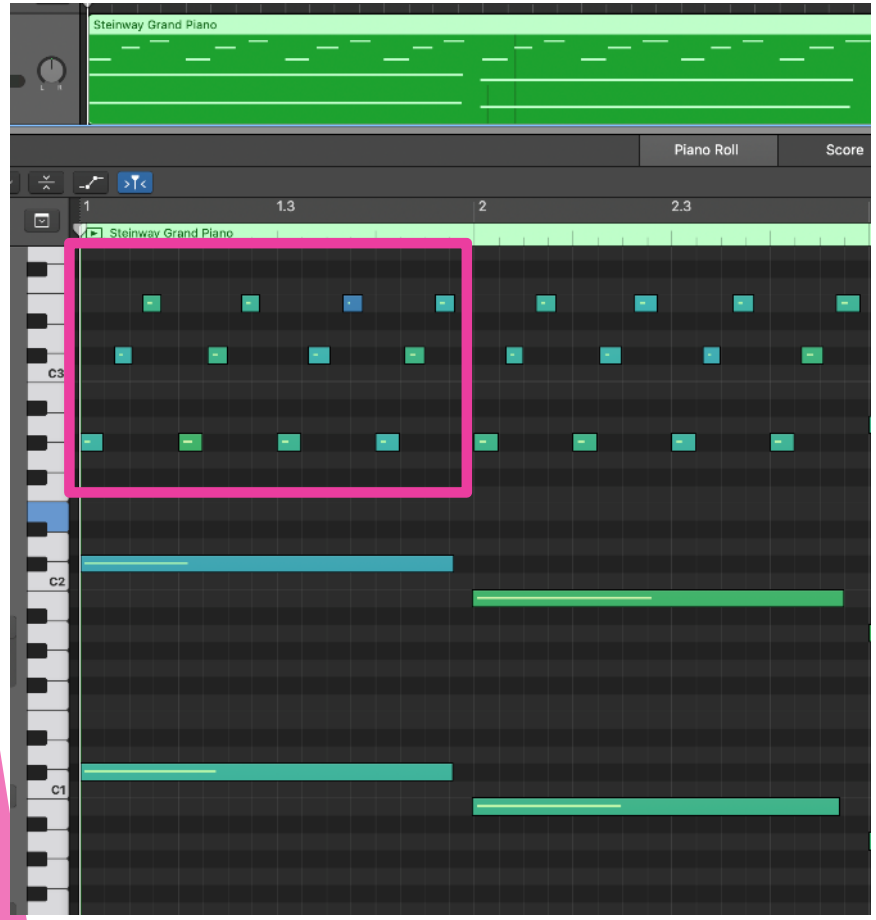
*Adopted figure from**

- Music is not simply sequences of notes (surprisingly!)

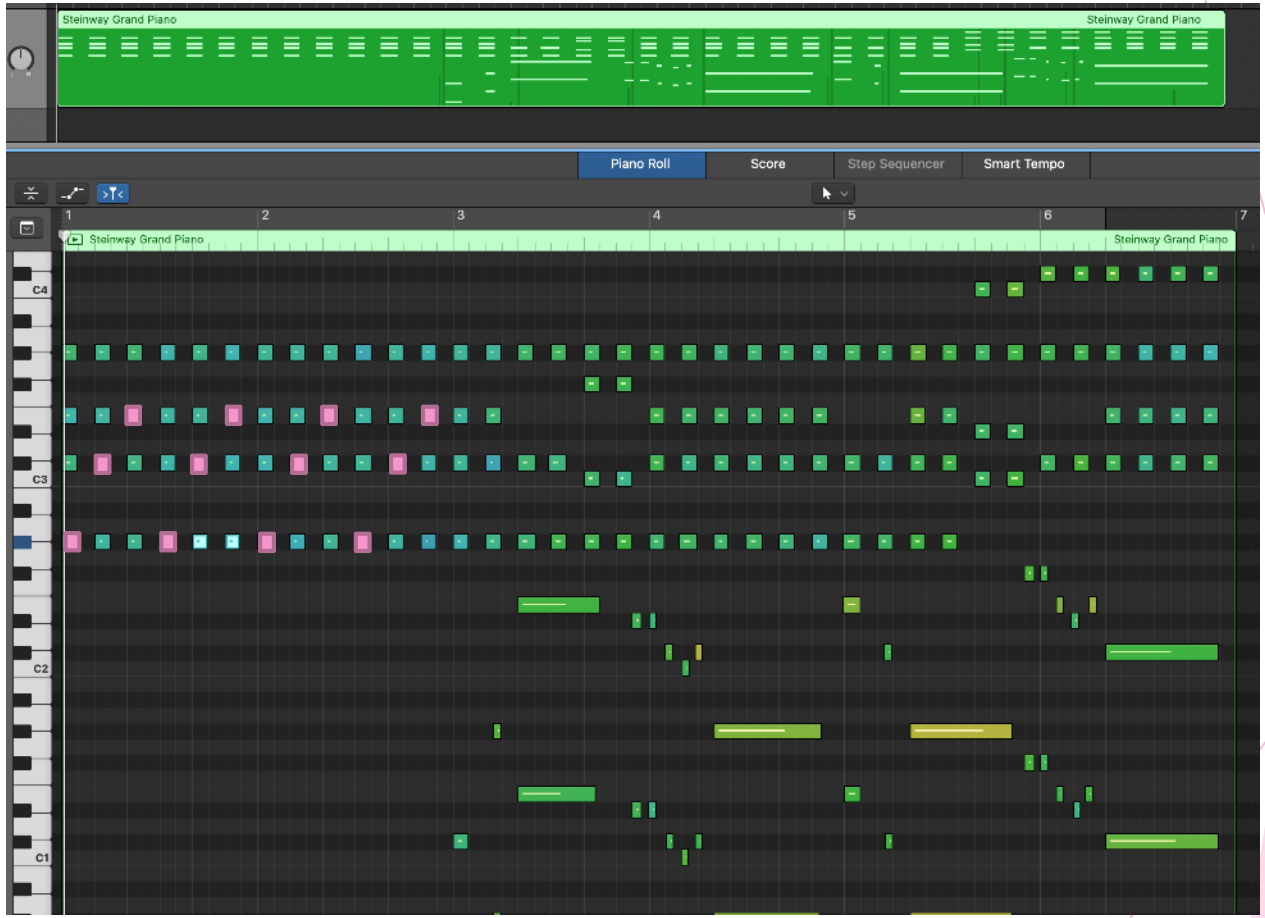
* R. Typke, P. Giannopoulos, R. C. Veltkamp, F. Wiering, and R. van Oostrum. Using transportation distances for measuring melodic similarity. In Proceedings of the International Conference on Music Information Retrieval (ISMIR), Baltimore, October 2003.

Similarity Evaluation: Case Study (1) *

- Beethoven's Sonata 14 in C sharp Minor ("Moonlight")



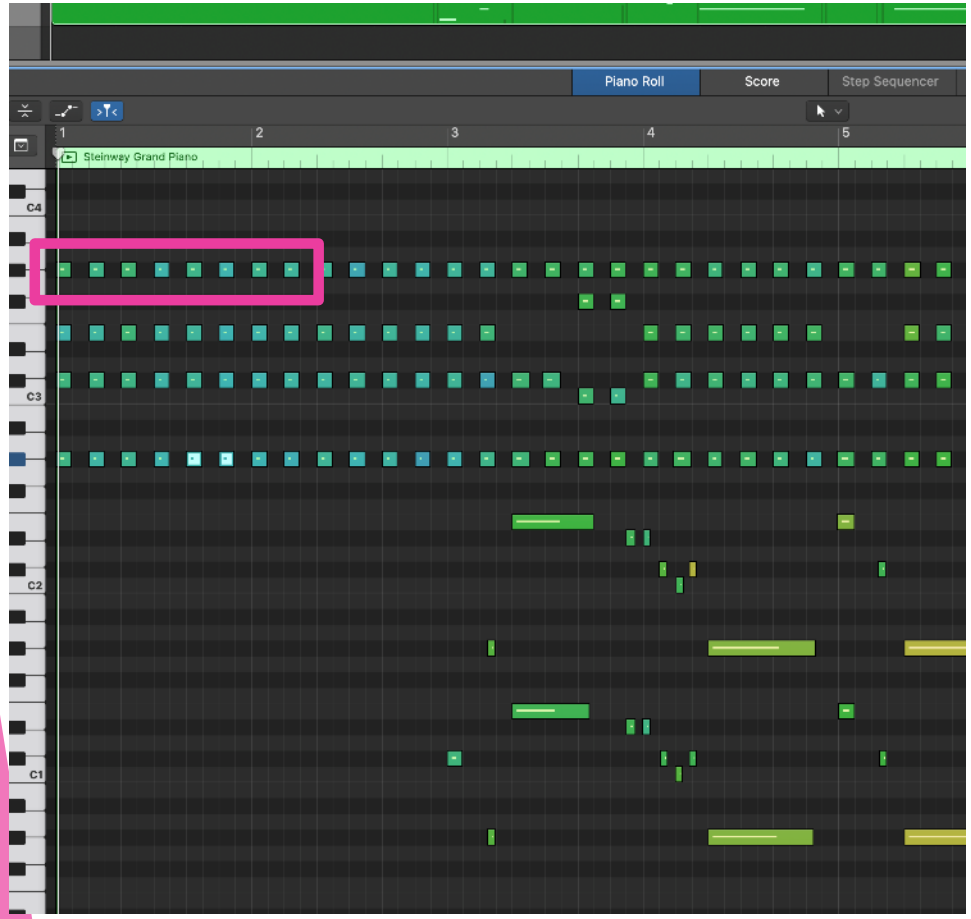
- Chopin's Polonaise in C Minor Op. 40 No. 2 (transposed to C sharp Minor)



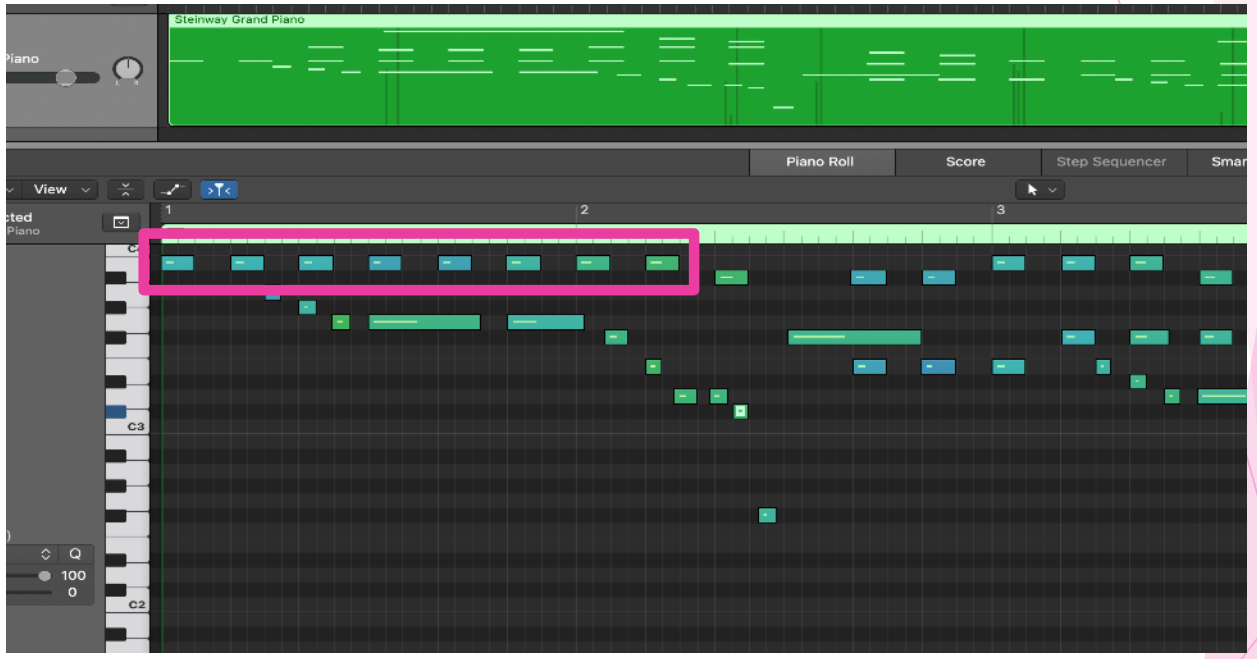
* *A*. Kuznetsov, and E. Pyshkin, "Searching for music: from melody in mind to the resources on the Web," HC2010, pp. 152-158.

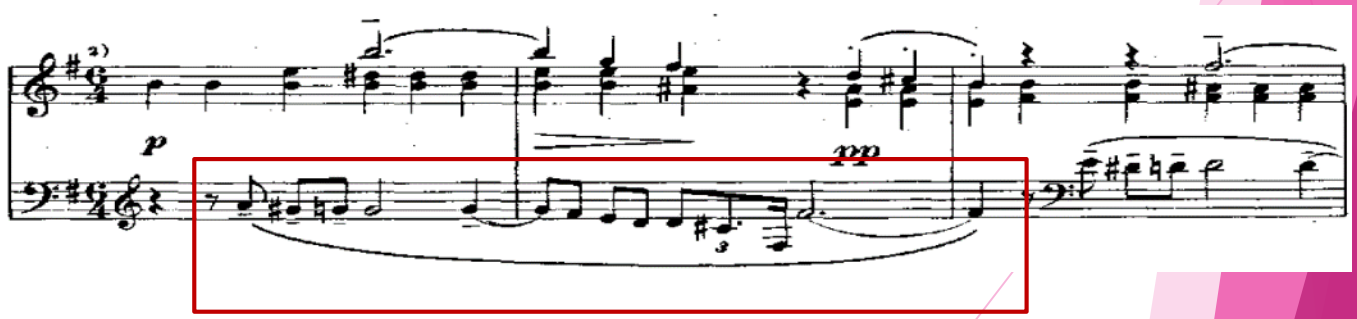
Similarity Evaluation: Case Study (2)

- Chopin's Polonaise Op. 40 No. 2



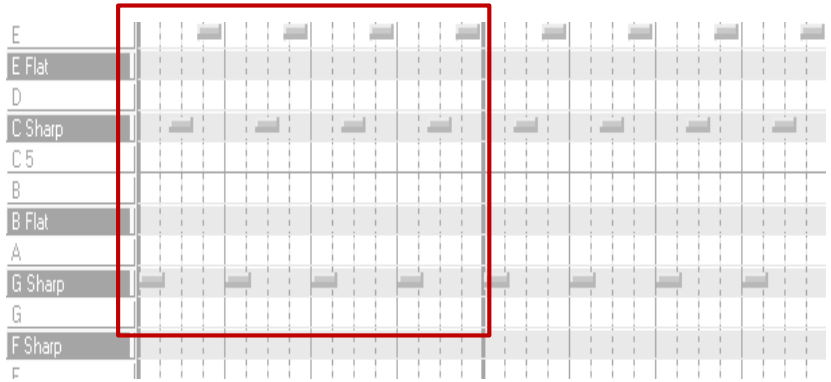
- Scriabin's Prelude in E Minor Op. 11 No. 4



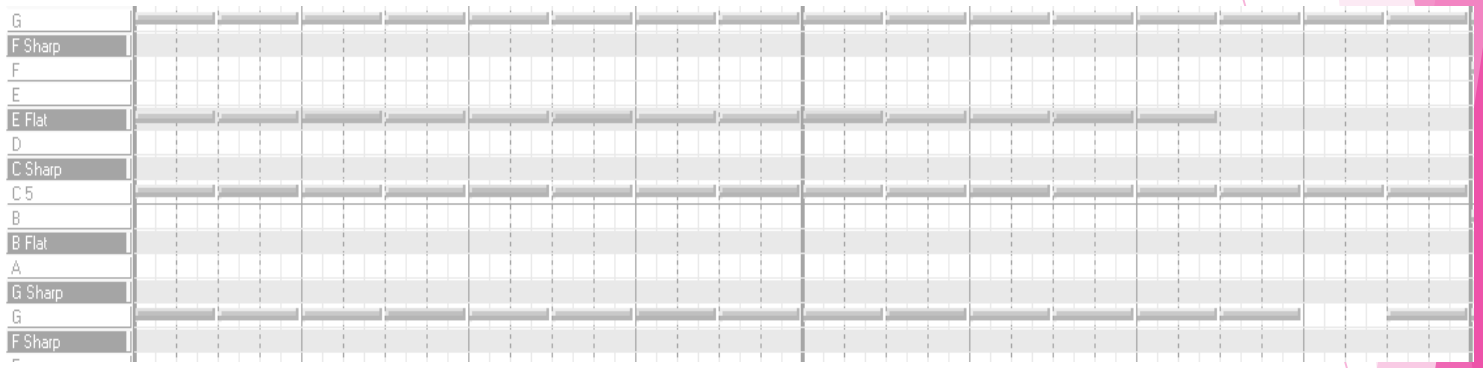


Similarity Evaluation: Case Study… Back to (1)

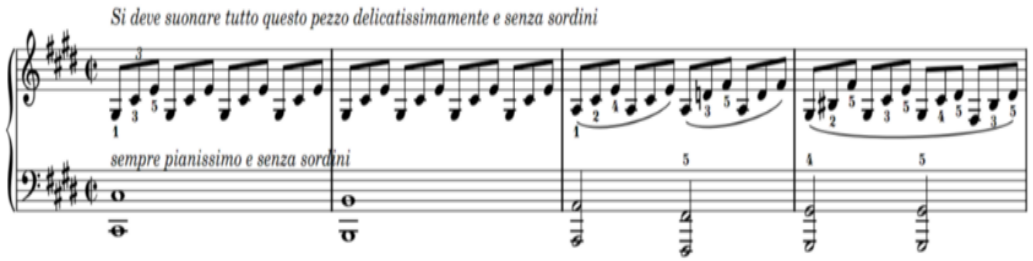
- Beethoven's Sonata 14 ("Moonlight Sonata")



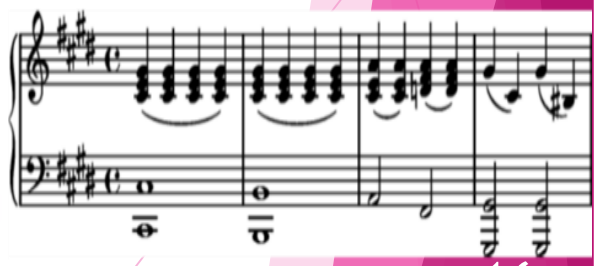
- Chopin's Polonaise in C Minor Op. 40 No. 2



- Harmony and Functional Similarity *



$$F(t) = O(u(t)) \cdot CON(v_1, v_2) +$$
$$+(A(t, CR(v(t), h(t), start(t), itlen(t)) + Inv(0, 0, -1))) \cdot v_3$$
$$u = [C\#2, H1, A1, F\#1, G\#1, G\#1] \cdot SEQ(\dots)$$
$$v = [C\#4, C\#4, A3, D4, G\#3, C\#4, G\#3, H\#3] \cdot SEQ(\dots)$$

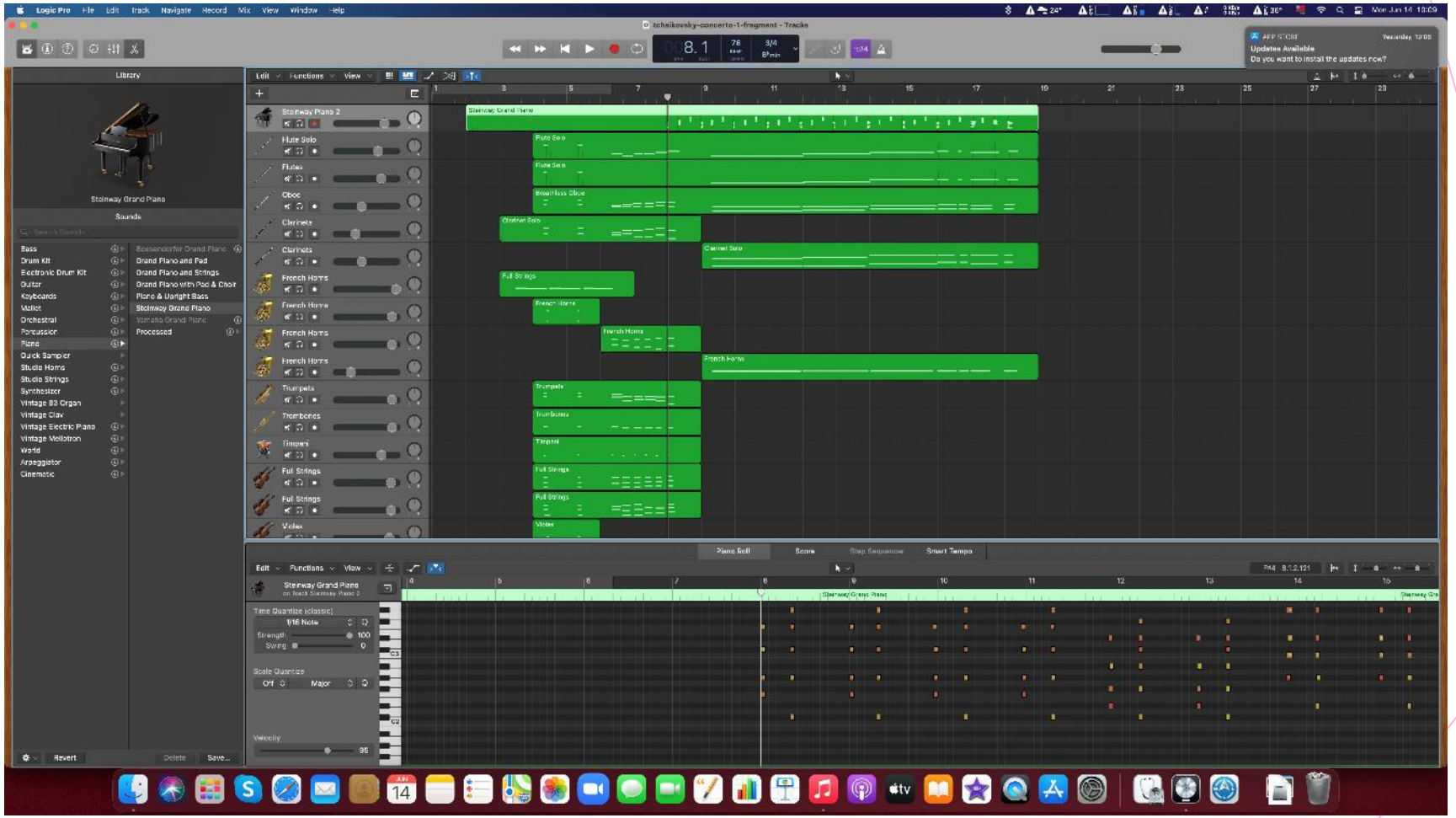


* A. Kuznetsov, and E. Pyshkin, "Function-based and circuit-based symbolic music representation, or Back to Beethoven," HCCE-2012, pp. 171-177.

Music Composition – not AI only: Computers that help composers

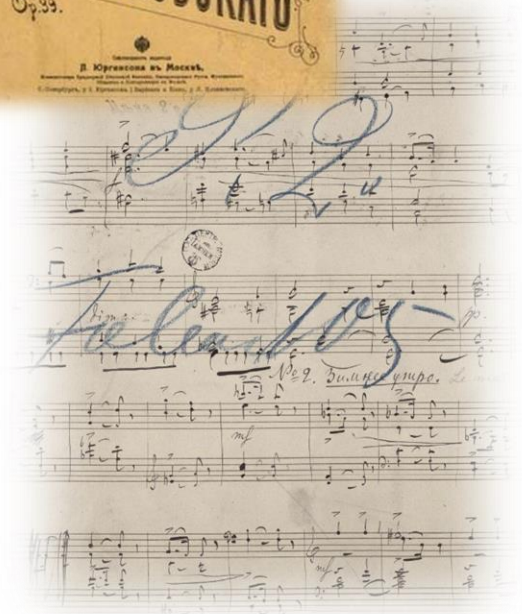
- Using Logic Pro for music composition, mastering and training

1st Piano Concerto Op. 23 (1875)



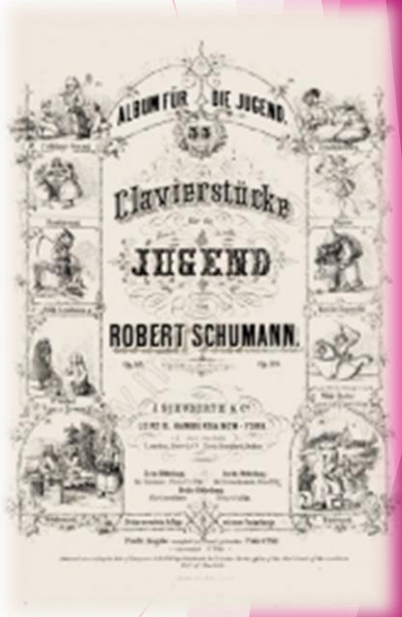
Screen from a demo project made in Logic Pro ***Piano Concerto No.1 (intro)***

Phenomenon of Piotr Tchaikovsky's "Children's Album"*



- Rich metaphors hidden in the pieces thought to be for children naturally lies in the scope of art and musicology, but there is still a large research space for formal methods based on mathematical and computational models
  - Insights into our understanding of the structure and organization of the whole work
    - Relationships to precursors (such as "43 Clavierstücke für die Jugend"** by Robert Schumann)
    - Argued reasons for significant differences between the original manuscript and the first published edition

ROBERT & KLARA SCHUMANN
1810 - 1856 1819 - 1896

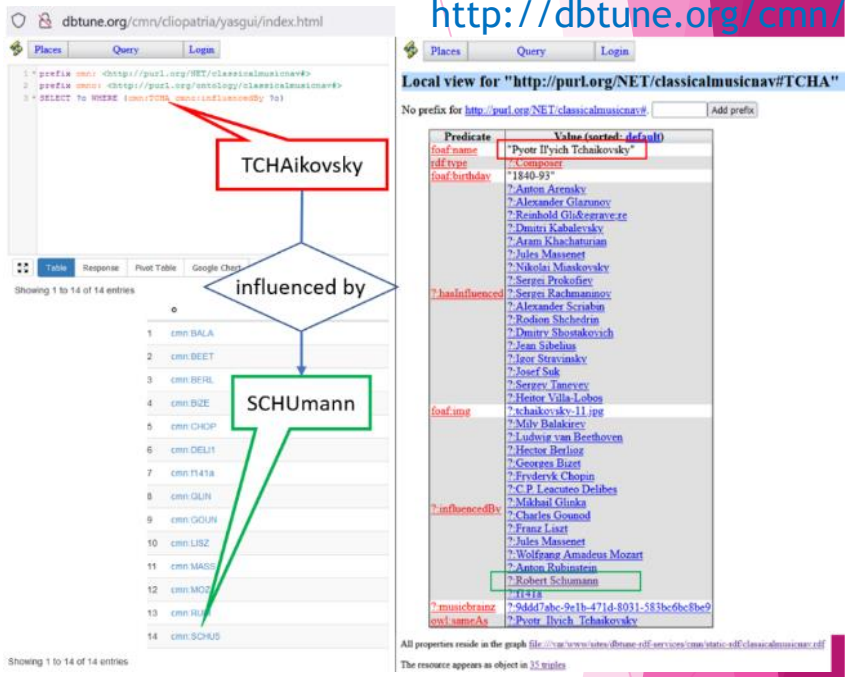


* P. Tchaikovsky, Children's Album. Op 39. Yurgenson, 1878.
** R. Schumann, 43 Piano Pieces for the Youth. Op 68 (Orig. Title in German: 43 Clavierstücke für die Jugend). Schuberth and Co., 1848.

Study on Relationships to Schumann's Works

- Admitting Schumann's influence to Tchaikovsky does not lead us to automatically judge the "Children's Album" as an imitation of Schumann's pieces for the young (also with long history of editions but rather few scholarly studies *)

Schumann Op 68	Tchaikovsky Op 39
Melody Humming Song	Mama (3)
Soldier	March of Wooden Soldiers (5)
Chorale	Morning Prayer (1) In Church (23)
The Wild Horseman	Toy Horse Play (4)
Sicilienne	Old French Song (16) The Hurdy-Gurdy Man is Singing (24)
First Loss	The Doll is Sick (7) Old French Song (16)
The Reaper's Song	Italian Song (15)
Echoes from the Theatre	Waltz (9)
Sheherazade In Memoriam	Sweet Dream (21)

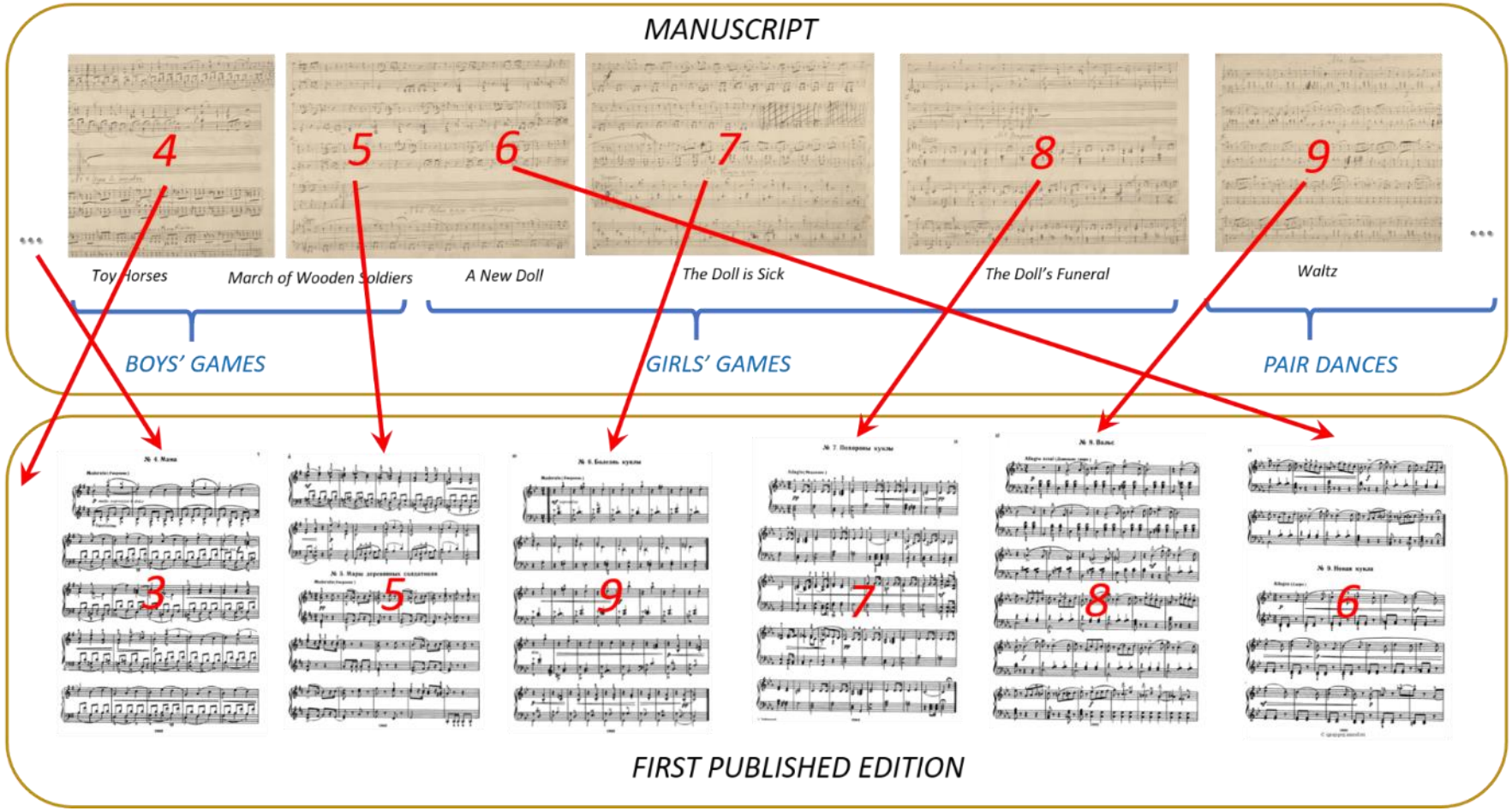


- Challenges
  - In the process of study, we need to investigate, what are the suitable computational approaches that may contribute to style identification.
  - Because of the subjectivity of style attribution and style dependency analysis, a possibility to construct and assess different computational models should be considered.
  - It may be that particular models can contribute to particular characteristics of music style recognition.

* B. R. Appel, Actually, taken directly from family life: Robert Schumann's Album fur die Jugend. Princeton University Press, 2014, pp. 171–202. [Online]. Available: https://doi.org/10.1515/9781400863860.171

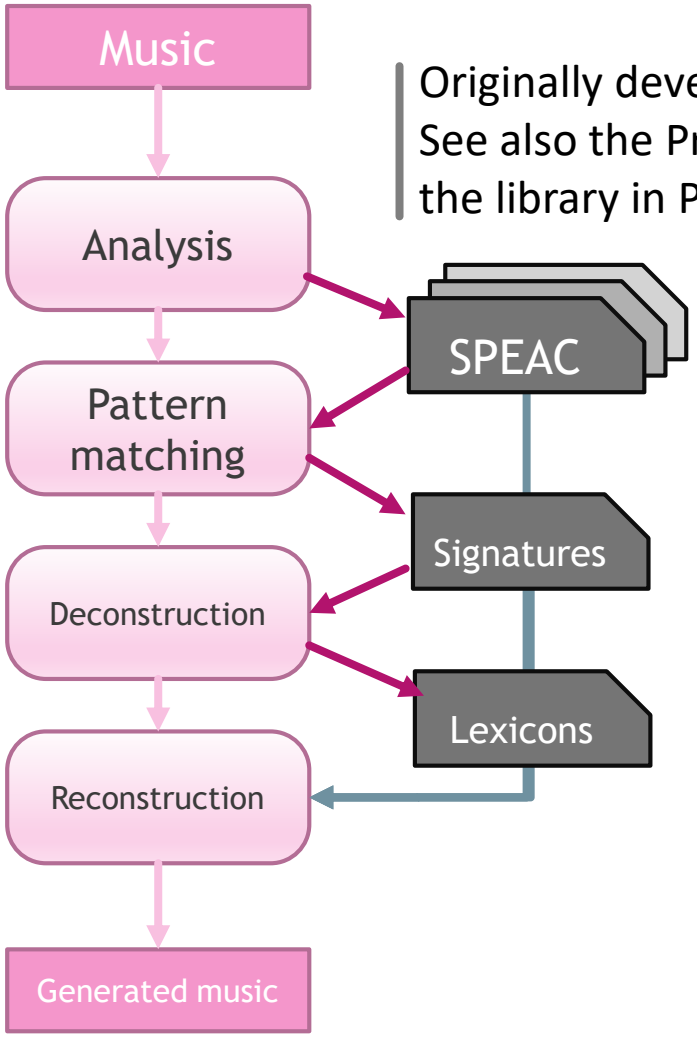
Back to Music Analysis.
Case Study: Children's Album

- How to evaluate and "decode" transformations destroying the structure of the album as an indissociable whole, and deforming the micro-cycles existing in the manuscripts?

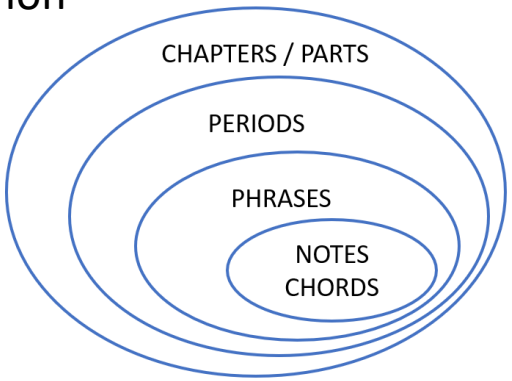


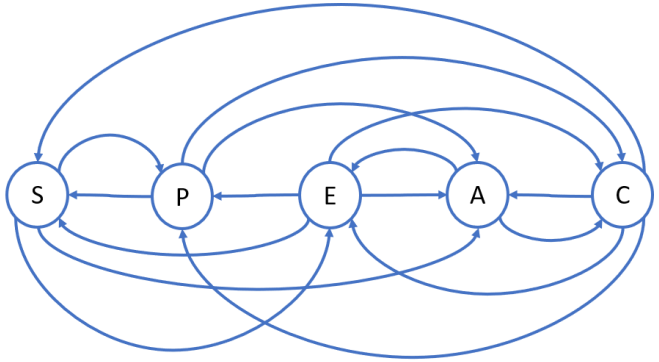
David Cope's Approaches to Musical Intelligence* and Creativity Modelling**

David Cope (born May 17, 1941 in San Francisco, California) is an American author, composer, scientist, and former professor of music at the University of California, Santa Cruz. His primary area of research involves artificial intelligence and music; he writes programs and algorithms that can analyse existing music and create new compositions in the style of the original input music. (Wikipedia Article)



Originally developed in Lisp by Cope.
See also the Project on redesigning the library in Python****

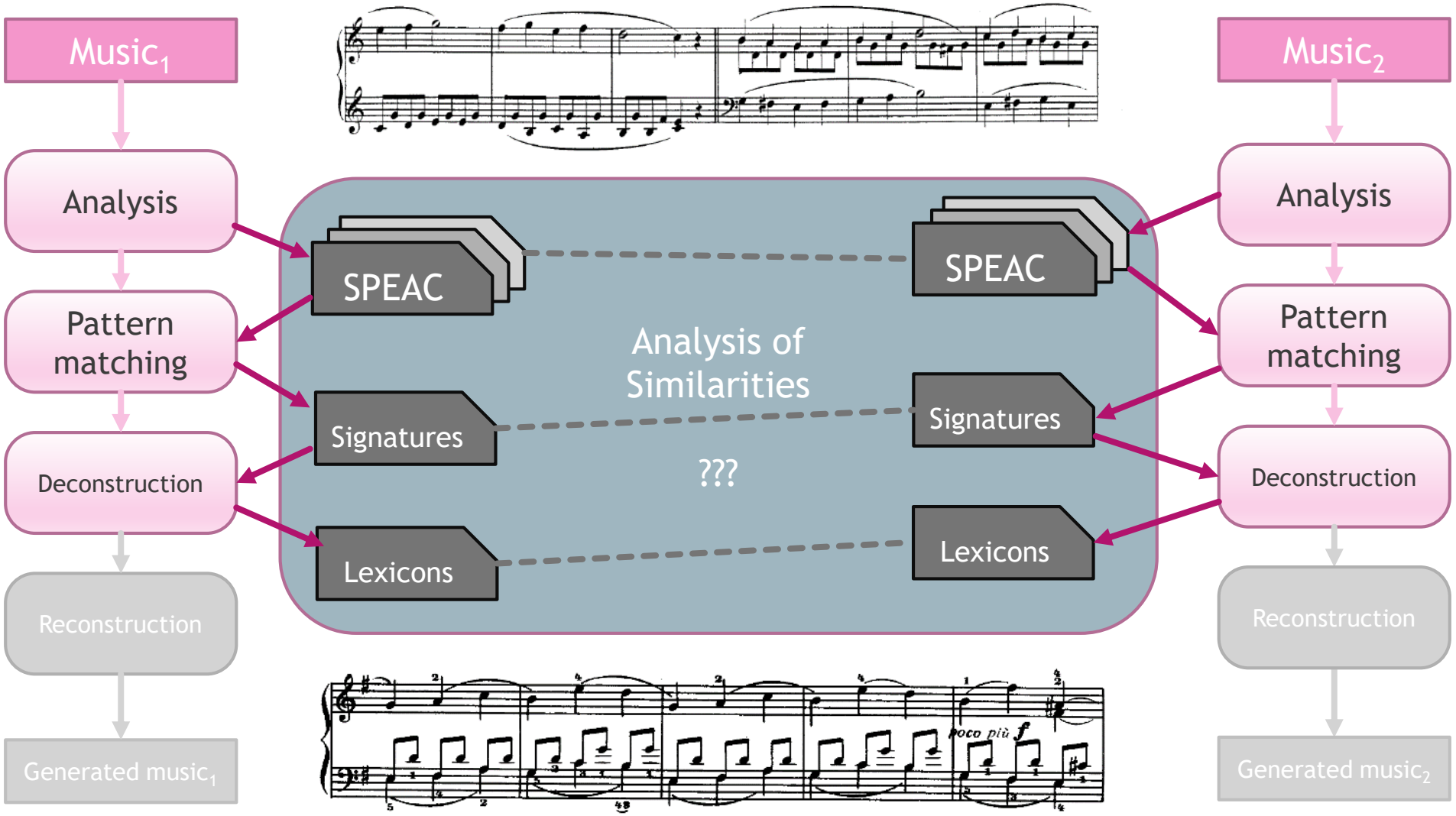




Hierarchical representation of musical structure in nested contexts.
SPEAC analysis states:
statement S, preparation P, extension E, antecedent A, and consequent C, all of which are kinds of abstractions assigned to groups of notes
*"depending on levels of tension between intervals, metrical placement, and agogic emphasis, measured both in the preceding and following groups"****

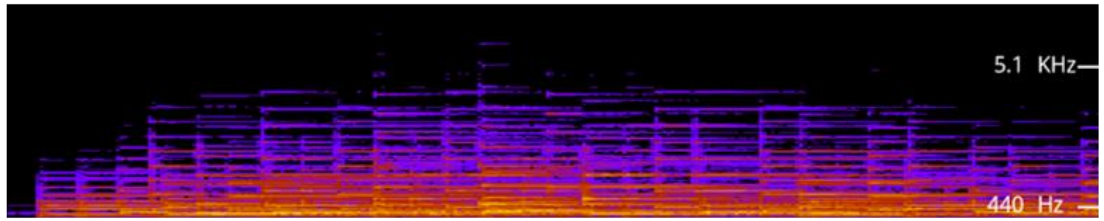
* D. Cope, "Experiments in Music Intelligence," 2nd Ed. A-R Editions, Inc. 2014
** D. Cope, "Computer models of musical creativity," Mit Press Cambridge, 2005.
*** P. da Silva, "David Cope and experiments in musical intelligence," 2003.
**** N. Golzitsky, "SPEAC-analysis Python library," 2021, https://github.com/GolzitskyNikolay/SPEAC-analysis

David Cope's Approaches to Musical Intelligence and Creativity Modelling: Similarity Analysis

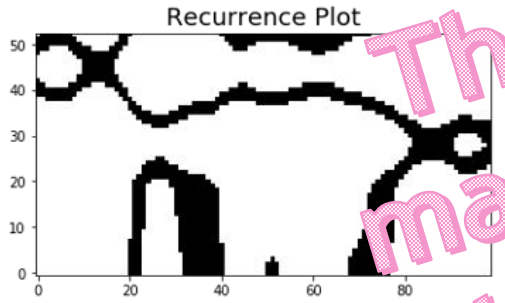


Further Promising Approaches to be Studied

- Detection similarity using signal processing algorithms
- Grouping compositions based on weaker traits of similarity in their themes and sub-themes
- Acoustic spectral fingerprints for unique identification of the music fragments
- Combining the problem of music style identification with the approaches to music generation
- Detecting recurrences and irregular cyclicities if considering music as a semi-chaotic natural process (as in automated speech analysis)



Spectrogram of "A New Doll"
(first 30 measures, Recorded at
Yamaha YDP-144 by Evgeny Pyshkin)



Recurrence plot of the
spoken pitch

There are still many questions, challenges, and open areas!

Conclusion

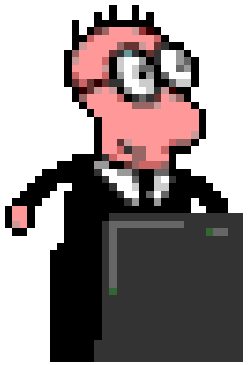
In this study, the problem of music style identification is sketched via a brief analysis of computational models and technical solutions that may be helpful to musicologists in their research on genesis and implications of musical compositions with an example of exploring the links between Tchaikovsky's "Children Album" and Schumann's "Album for the Youth". With the help of computer technology we can discover more findings to support meaningful hypotheses about the possible reasons explaining significant discrepancies between Tchaikovsky's manuscript and the following editions of "Children's Album".

Naturally, the outcomes from such compact joint musicology and computer science studies can address the broader scope of research on music style understanding, modeling, and recognition for the benefit of both computer technology and humanities so as to provide interesting use cases for AI applications as well as *"a further strand of evidence for systematic musicology to exploit"* as nicely formulated by Collins*.

* N. Collins, "Computational analysis of musical influence: A musicological case study using MIR tools." in ISMIR, 2010, pp. 177–182.

Acknowledgements to Collaborators

In memory of Vitaly Klyuev…



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