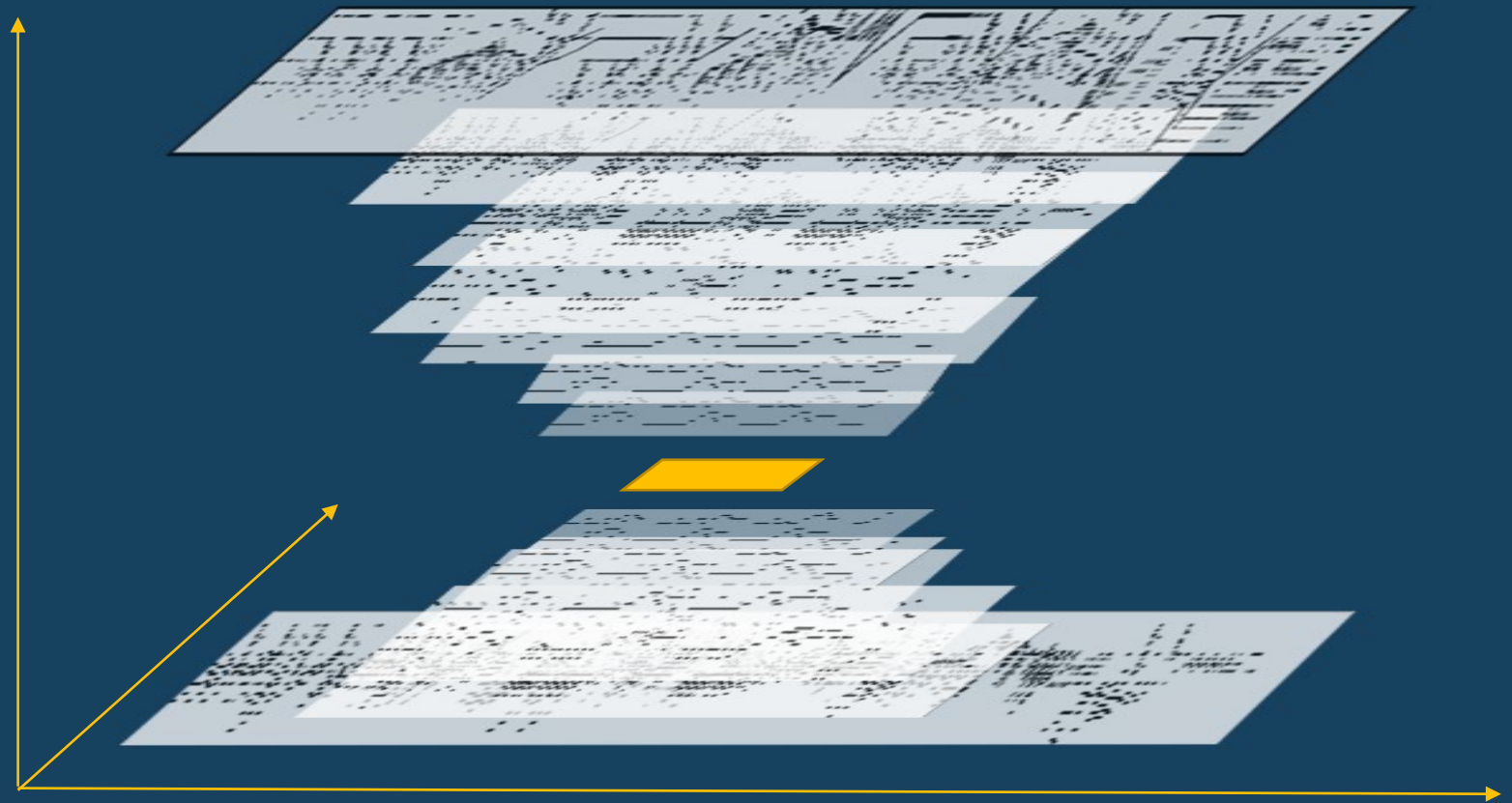

Sandglass Method: An Integrated Theory for Music Analysis and Music Composition: La Campanella as an Example

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

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MUS408: 19th century Music Analysis
FALL 2021

Overview

- Motivation
- Objectives
- Methodology
  - La Campanella
- Detail
  - Engineering
  - Mathematical

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Motivation

1. The process of doing music analysis is primarily for music composition purpose. We want to see how the composer select the raw material and transform it into a complex form that serve for any aspect in humanity, such as entertainment, sociopolitical function, religious purpose, etude etc.

2. Therefore, we need a tool to do such music analysis!
   - Existed model such as:
     - Laitz's theory: music theory in MUS 101 & 102
     - Schenker Analysis
     - Agawu Generation Analysis
     - …

Objectives

However, each analysis method has advantages and disadvantages:

Roman Numeral, Form analysis:
Pros: Precise capture of vertical music syntactical structure
Cons: Lossy compression that loses texture, melody, and etc
Schenkerian Analysis:
Pros: A useful tool to reduce texture to see how motif develop
Cons: 1. Ursatz as Racism 2. Overexplanatory nature
Agawu Analysis:
Pros: An improved version of SA based on 'Unit' with more normalized generative approach
Cons: Needs to be computational to prove universality

So…

Why not develop a better analysis paradigm for tonal music?

This paradigm should have these property:

1. **Computational-friendly** → scalable proof
2. **Integrated for both analytical aspects**
   → explain analytical & compositional process simultaneously
3. **Modular** → straightforward for pedagogical purpose

Sandglass Method

Sandglass method is a computational system of analyzing tonal music. The goal of the model is to abstract a single piece of tonal music as a hierarchy of different abstraction layers. Then a group of functors will establish the transformation relationship between each level. In the end, we can use combination of layers and functors from any musical piece to create a music generation system that can freely compose music based on selected layers and functors' style.

The abstraction of layers and functors is analogous to Gestalt principle in cognitive psychology which is more reasonable in terms of how human brain works.

$$F_A = \sum_{i \to \infty} \mathrm{f}_{0,\,\infty,\,i}(\mathrm{L}_{0,i}) \qquad F_C = \sum_{i \to \infty} \mathrm{f}_{\infty,\,0,\,i}(F_A(L_i))$$

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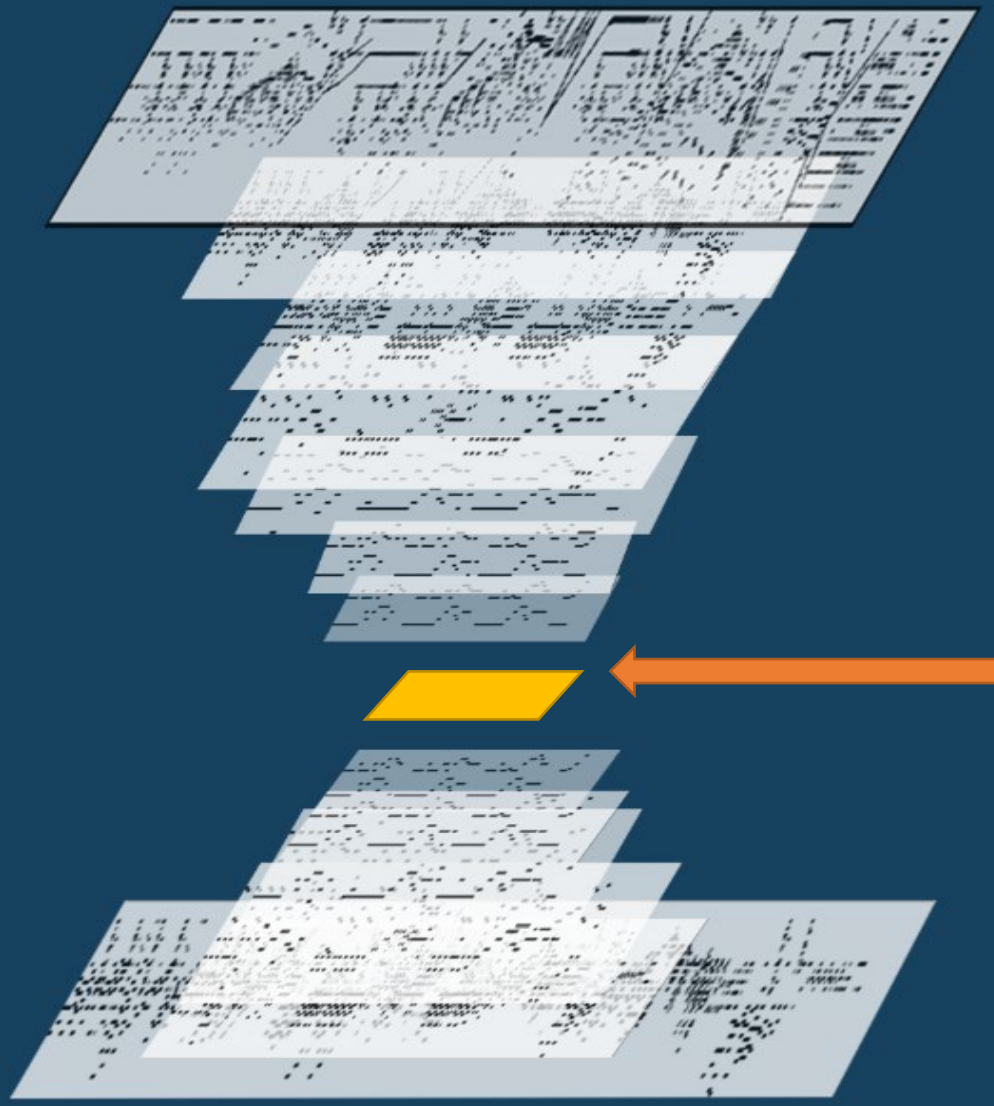

Analysis Theory –
Form Reduction

Fundamental Layer

Composition Theory –
Articulation Generation

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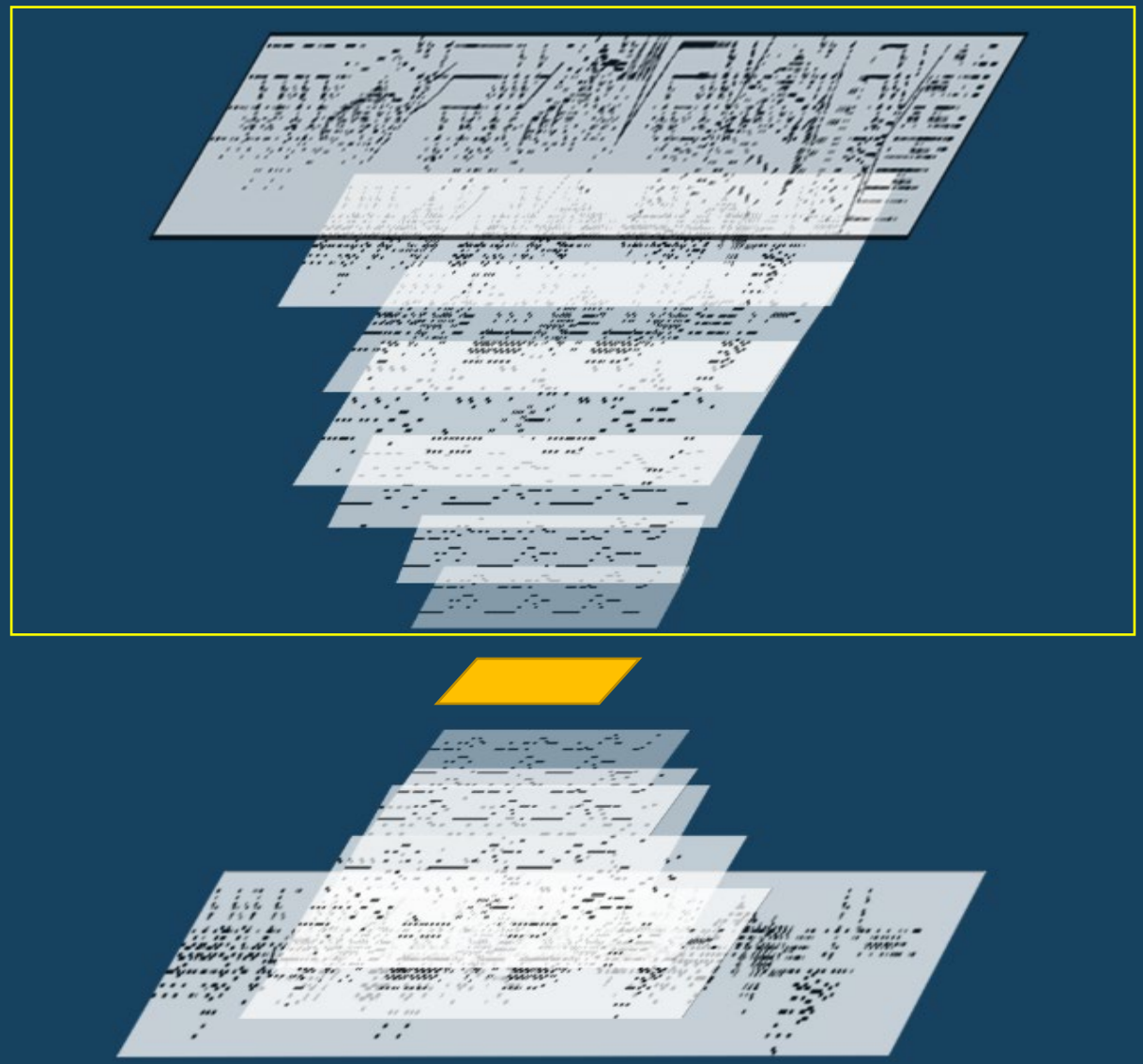

Music Analysis: Liszt's La Campanella as an example

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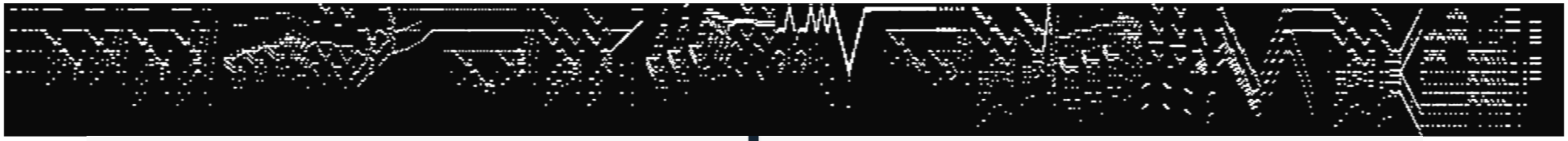


Étude in G♯ Minor, "La Campanella"

Franz Liszt
(1811 - 1886)

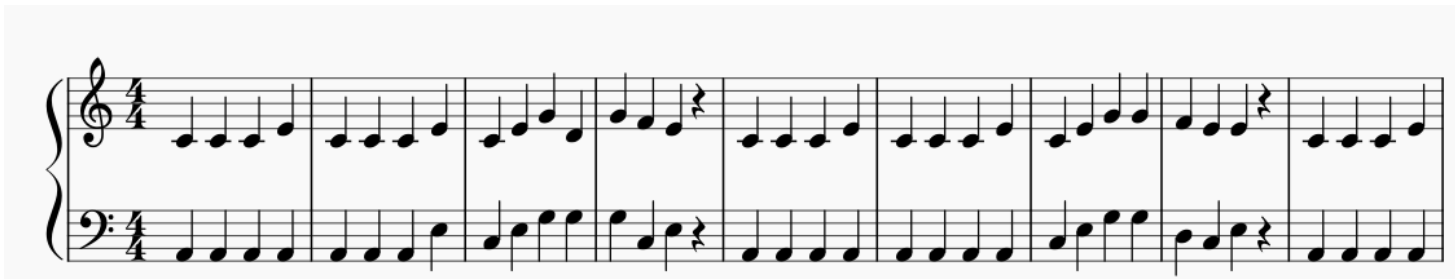
S. 141/3

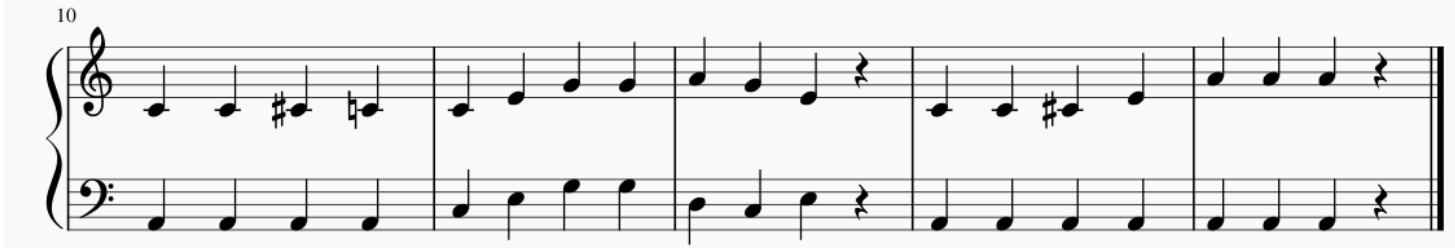
Allegretto

Piano

8va

(8va)

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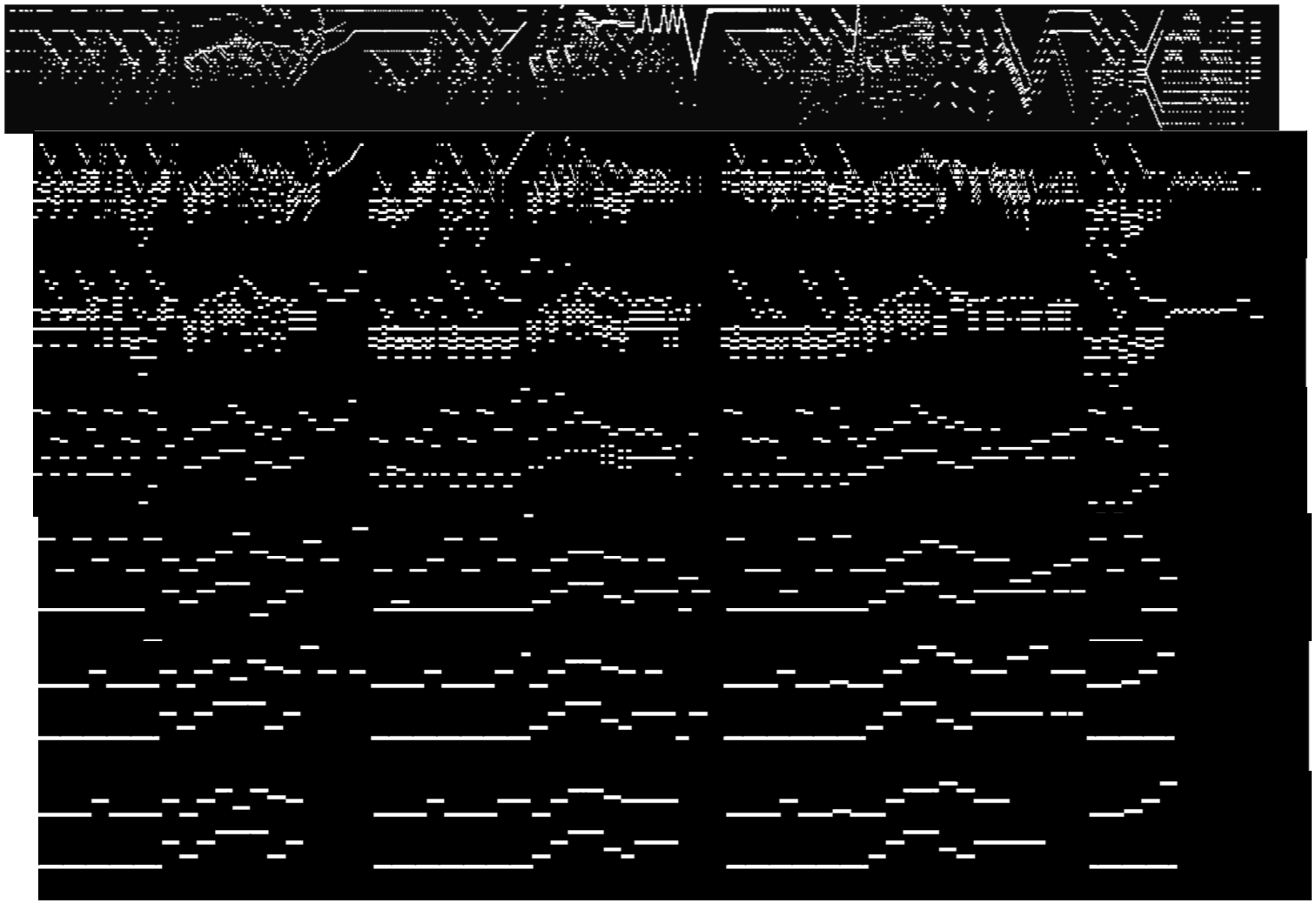
Form Analysis



Level 1

Level 2

Melody Extraction
Roman Numeral Analysis

Level 3

Melody: 1st order PT&NT Reduction
Harmony: 1st order PC&EPM Reduction

Level 4

Melody: 2nd order PT&NT Reduction
Harmony: 2nd order PC&EPM Reduction

Level 5

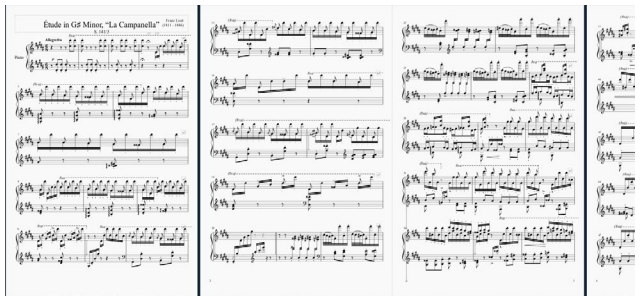
Melody: 3rd order PT&NT Reduction
Harmony: 3rd order PC&EPM Reduction

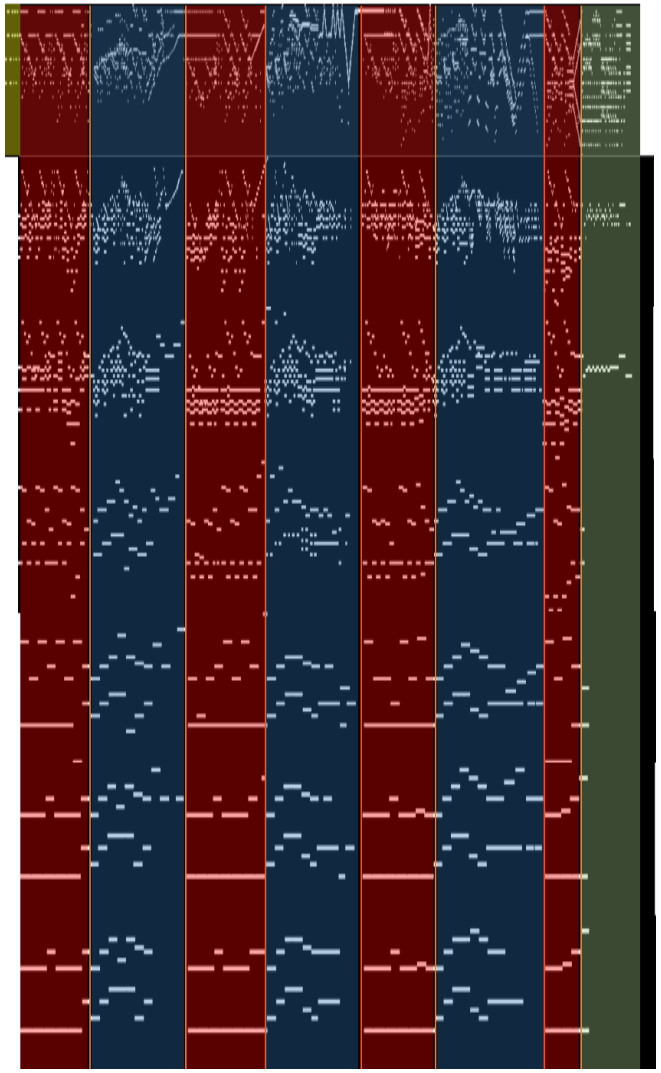
Level 6

Melody: Octave Normalization
Harmony: Octave normalization

Level 7

Melody: Structural Standardization
Harmony: Structural Standardization





Level 0

Level 1

Level 2

Level 3

Level 4

Level 5

Level 6

Level 7

Music Audio

Symbolic Transduction

ME&RNA

Musicianship (Melody Transcription, Chord Transcription)

Reduction

Normalization

Autocorrelation (Form Analysis)

Soundwave Signal Transduction

Music Perception (Peripheral Nervous System, Midbrain, TL)

Selective Attention Mechanism

Gestalt Theory (Structural Hearing) (CNS)

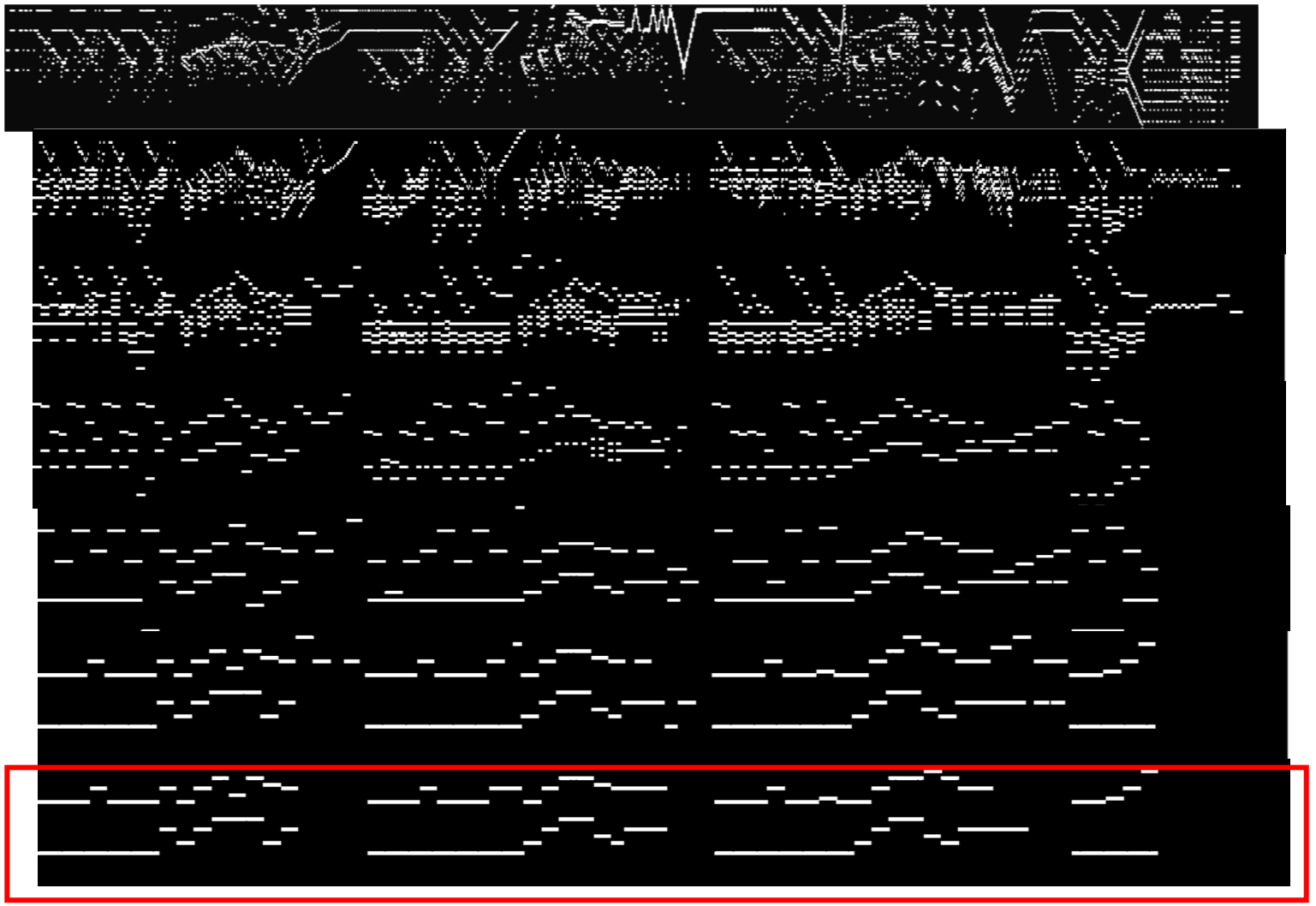
Logical Reasoning: Induction, Deduction

Emotional Reasoning: Stereotype, Bias

Music Cognition (CNS)

Memory Encoding

Form Analysis (High Abstraction level)



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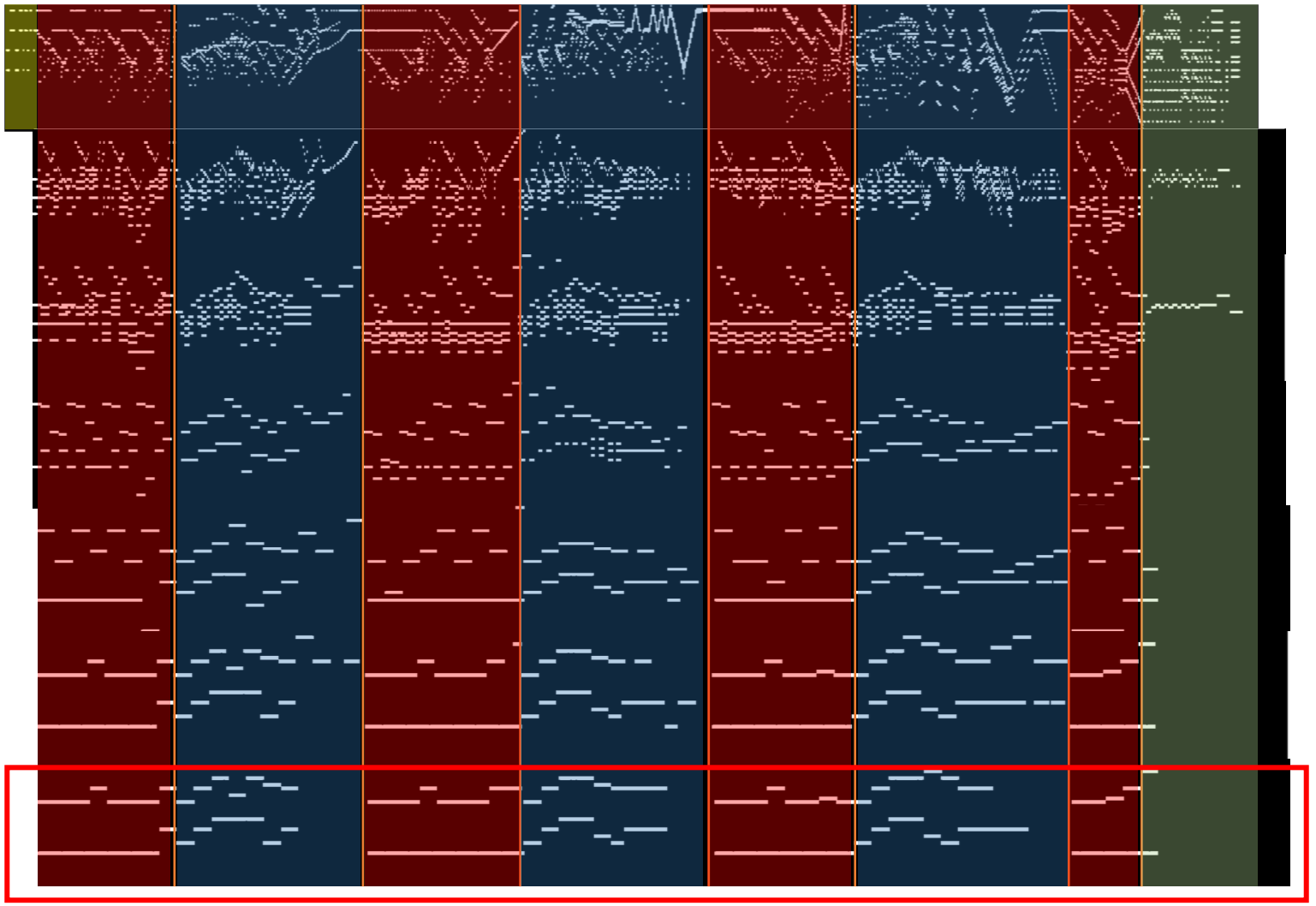
Melody: Octave Normalization
Harmony: Octave normalization

Level 6
Melody: Structural Standardization
Harmony: Structural Standardization

Level 7

Form Analysis (High Abstraction level)

A B A’ B’ A’’ B’’ A’’’ Coda



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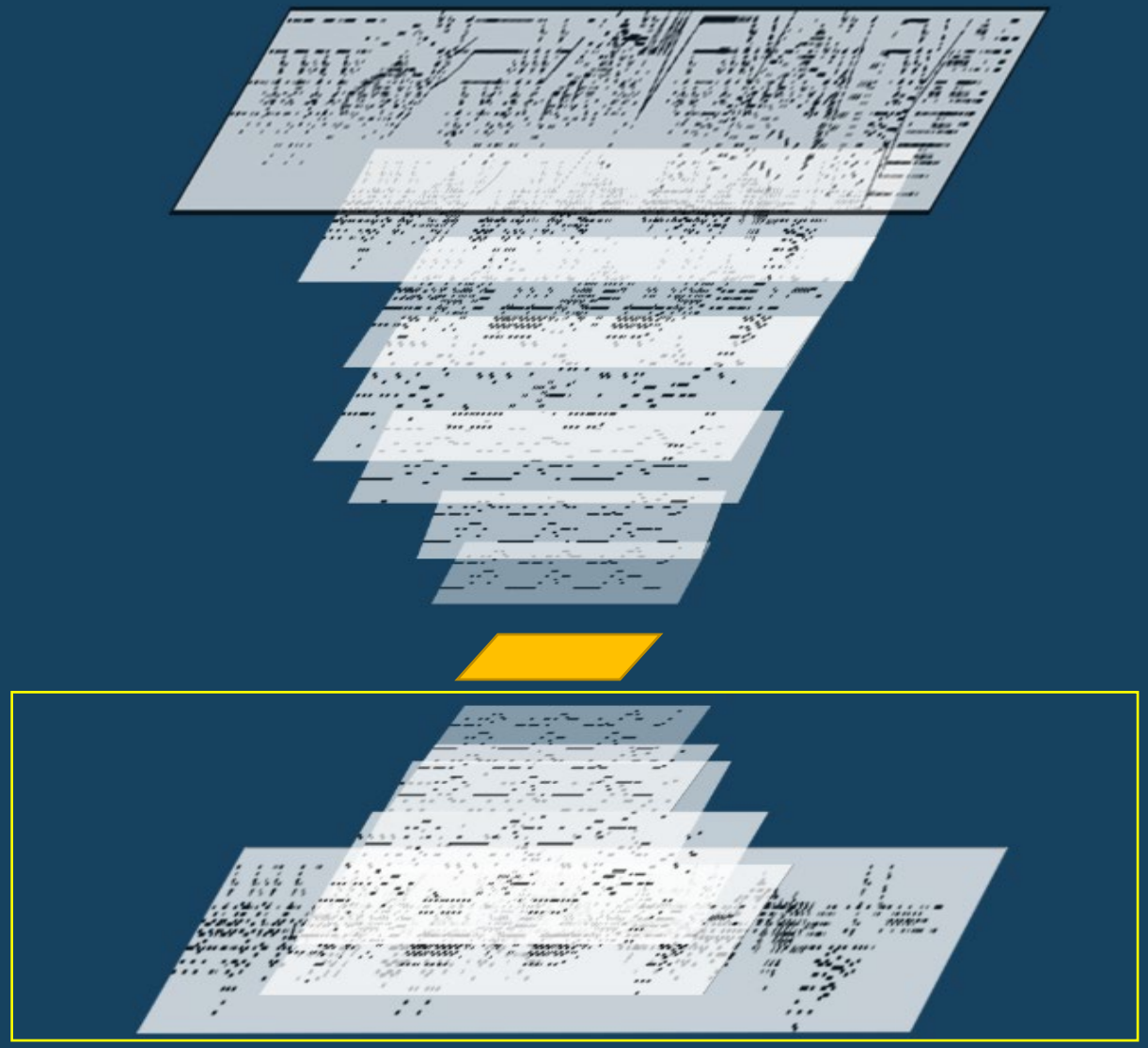
Level 7



Music Synthesis: Liszt's La Campanella as an example

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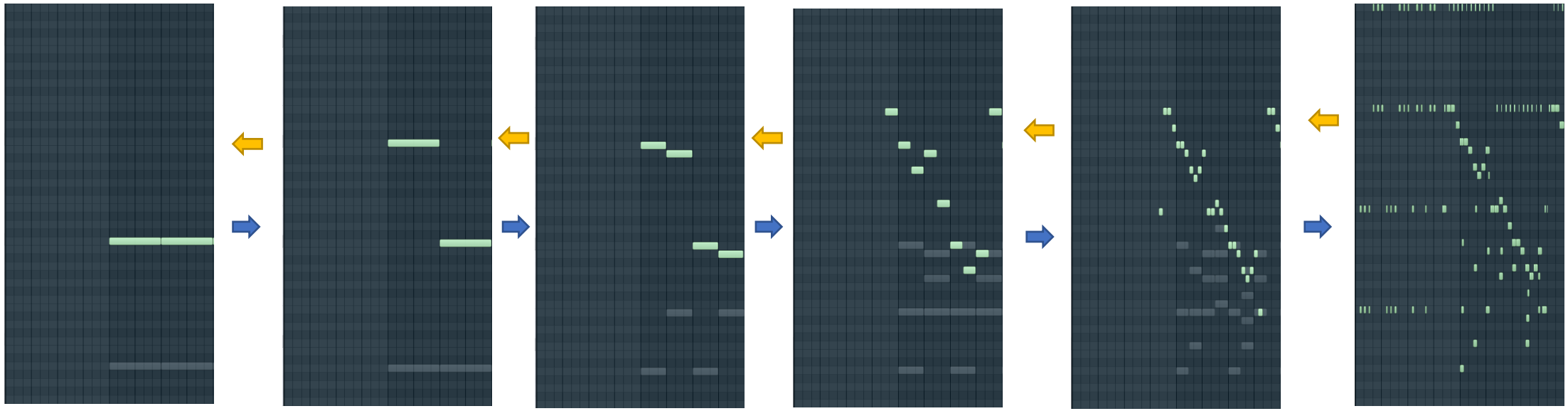
Inverse Problem: From Fundamental layer to Surface layer



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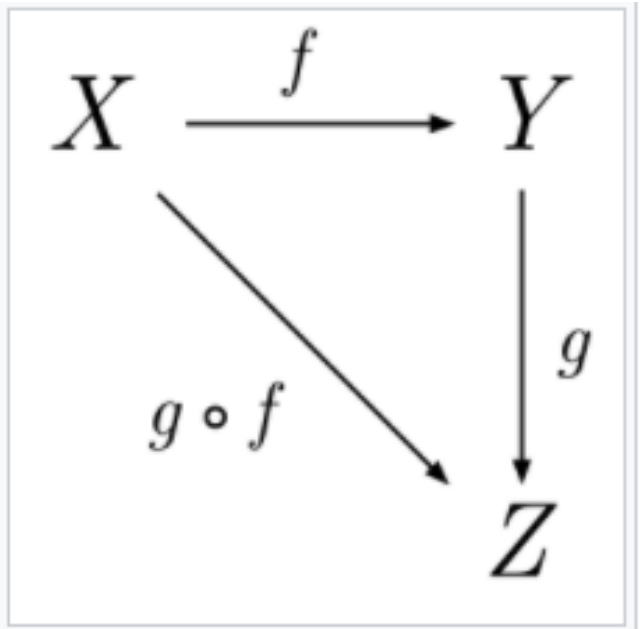
Mathematical Concept: Category Theory

Category theory formalizes mathematical structure and its concepts in terms of a labeled directed graph called a *category*, whose nodes are called *objects*, and whose labelled directed edges are called *arrows* (or morphisms). A category has two basic properties: the ability to compose the arrows associatively, and the existence of an identity arrow for each object. The language of category theory has been used to formalize concepts of other high-level abstractions such as sets, rings, and groups. Informally, category theory is a general theory of functions.



Schematic representation of a category with objects X, Y, Z and morphisms f, g, $g \circ f$. (The category's three identity morphisms 1_X, 1_Y and 1_Z, if explicitly represented, would appear as three arrows, from the letters X, Y, and Z to themselves, respectively.)

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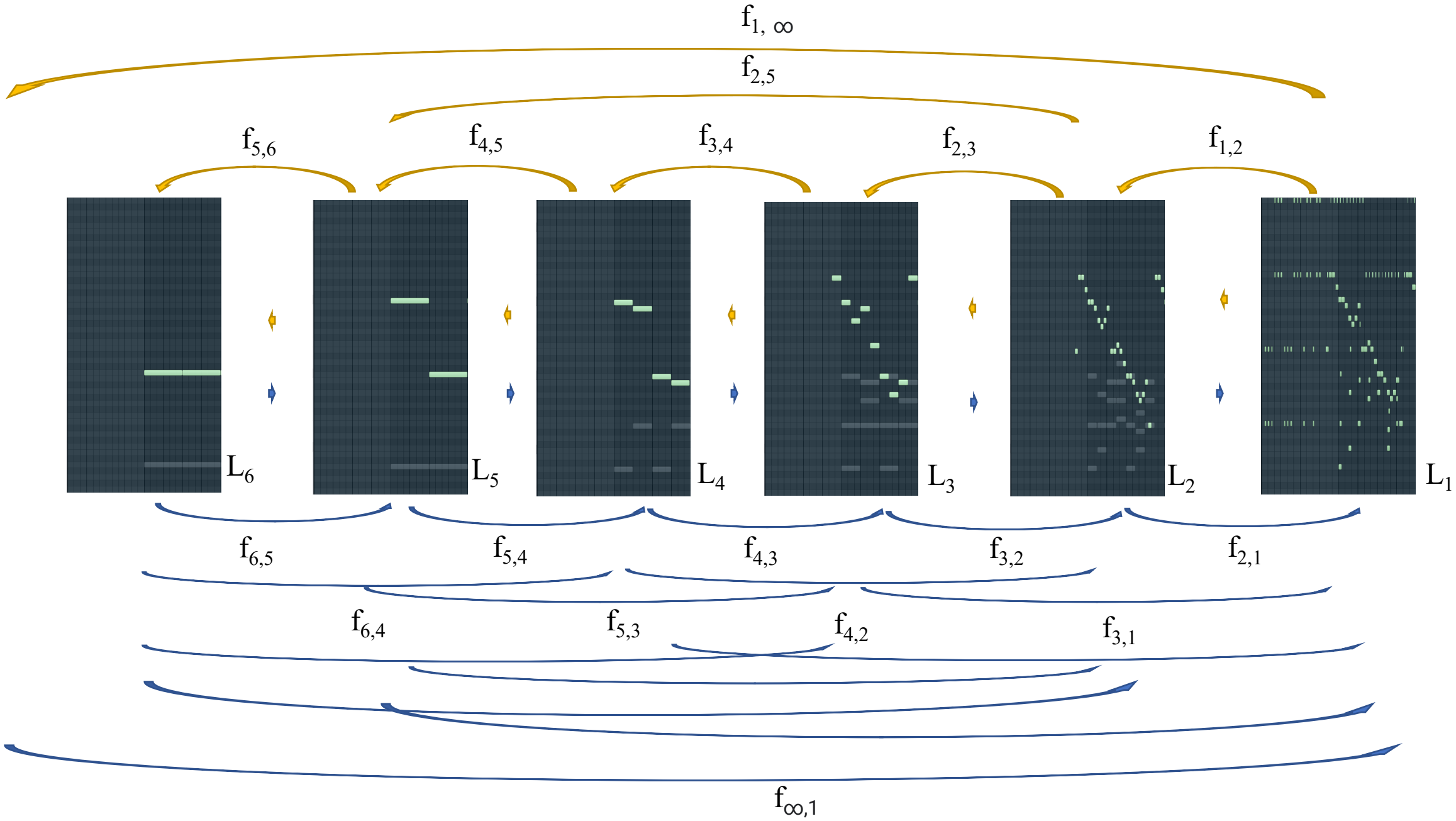
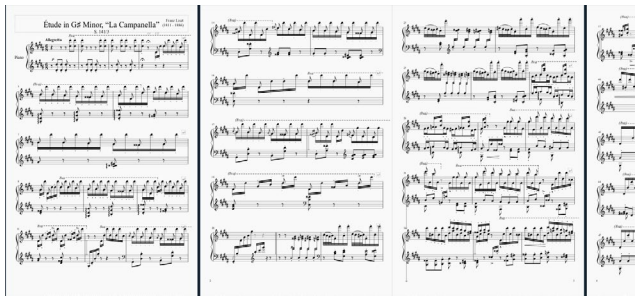
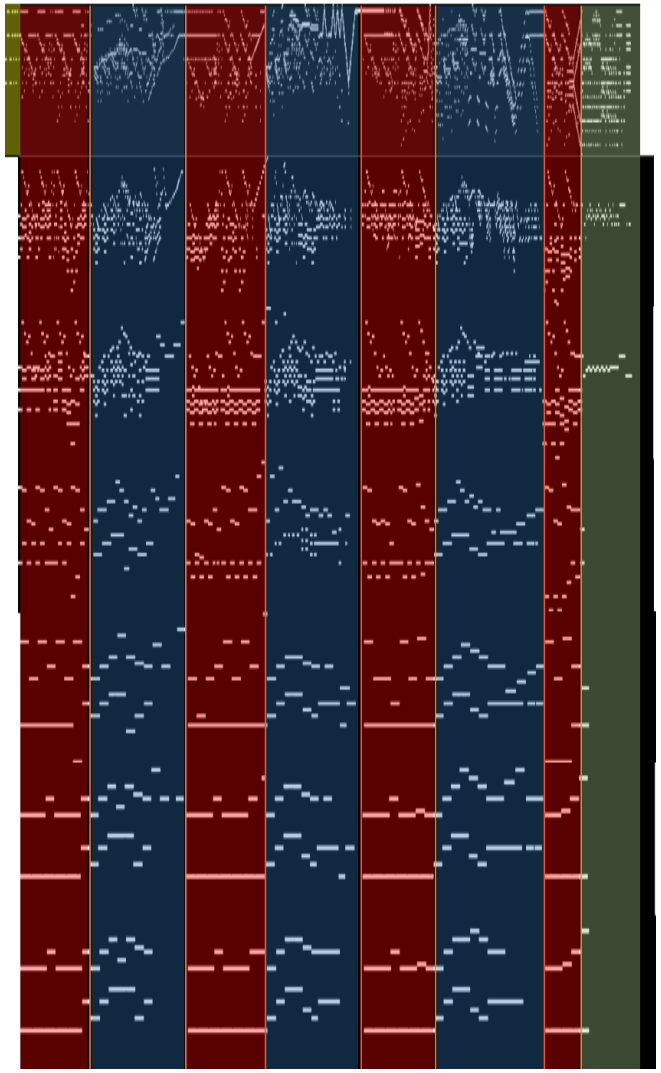
Morphism with functors and Musical Symbolic Objects







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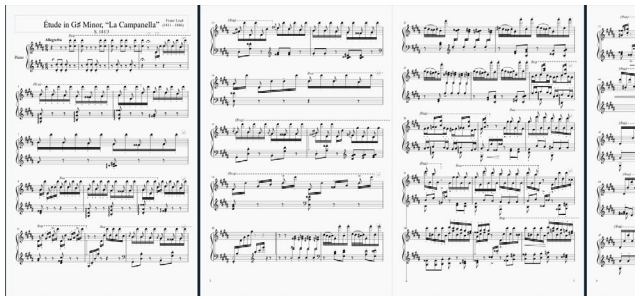

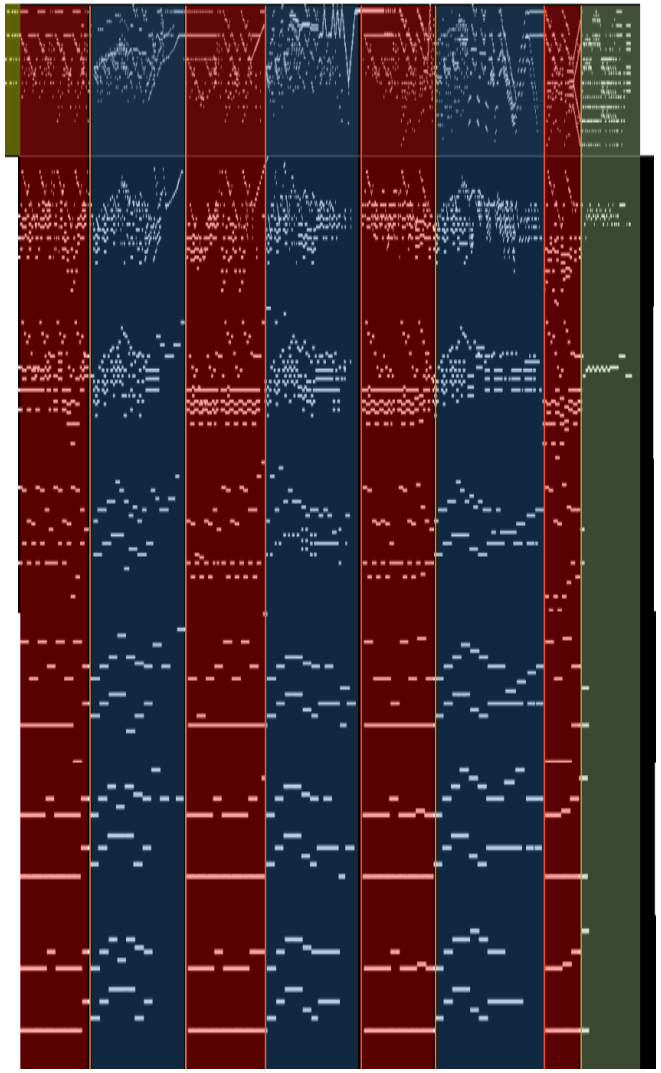

L_0

$f_{1,2}(L_1)$

$f_{2,3}(L_2)$

$f_{3,4}(L_3)$

$f_{4,5}(L_4)$

$f_{5,6}(L_5)$

$f_{6,7}(L_6)$

$f_{7,8}(L_7)$

Music Audio

$f_{0,1}(L_0)$

Symbolic Transduction

$f_{1,7}(L_1)$

ME&RNA

Musicianship (Melody Transcription, Chord Transcription)

Reduction

$f_{1,4}(L_1)$

$f_{5,7}(L_5)$

Normalization

Autocorrelation (Form Analysis)

$f_{7,\infty}(L_7)$

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Memory Encoding

Musical Composition Concept as Category theory

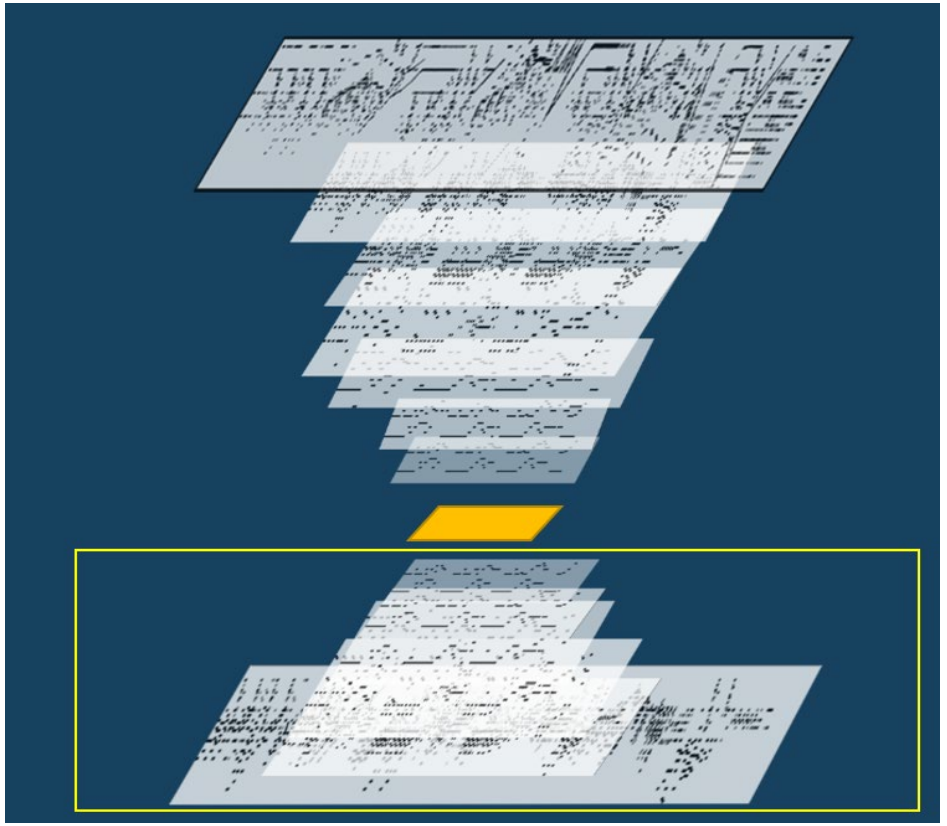
f = Given any Groups of f extracted from various musical corpus

L = Given any Groups of L extracted from various musical corpus

The following two functions illustrates music learning and composition process:

$$F_A = \sum_{i \to \infty} \mathrm{f}_{0,\,\infty,\,i}(\mathrm{L}_{0,i})$$

$$F_C = \sum_{i \to \infty} \mathrm{f}_{\infty,\,0,\,i}(F_A, \mathrm{r})$$



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