# Towards a Harmonic Complexity of Musical Pieces
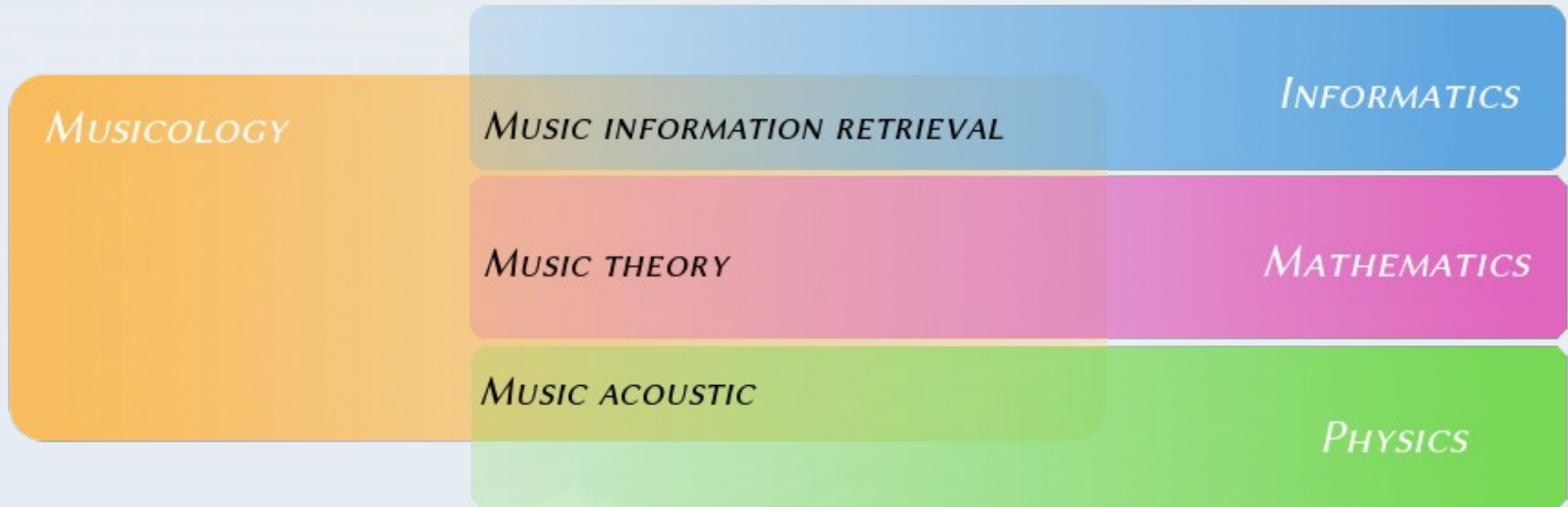
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# Categorization

# Our results

- New *mathematical model* for harmony analysis

- Distinguish *complex* and *simple* music – defining **Harmonic complexity**

- Analysis of music in **MP3 format**, interesting **results**

# Motivation

- **Music classification:** Possible new descriptor

- **Music recommendation:** New recommender systems

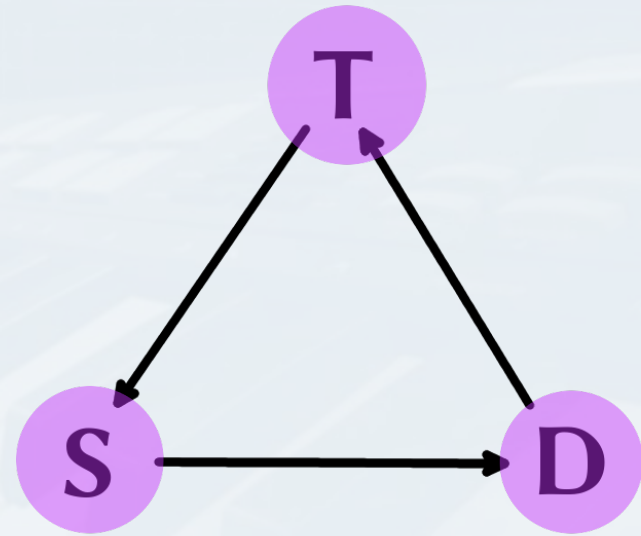- **Musicology:** Comparing artists, genres and periods

**How we did that?**

Creating a mathematical model based on **Tonal Harmony**

# Tonal harmony – basic harmonic functions

*„Most important in music is its harmony.“*

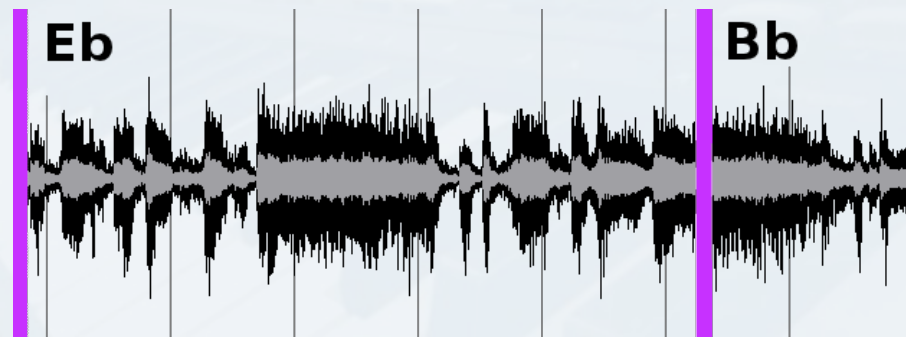Ilja Zeljenka

- Tonic

- Subdominant

- Dominant

# Simple harmony

Folk song: Slovenské mamičky



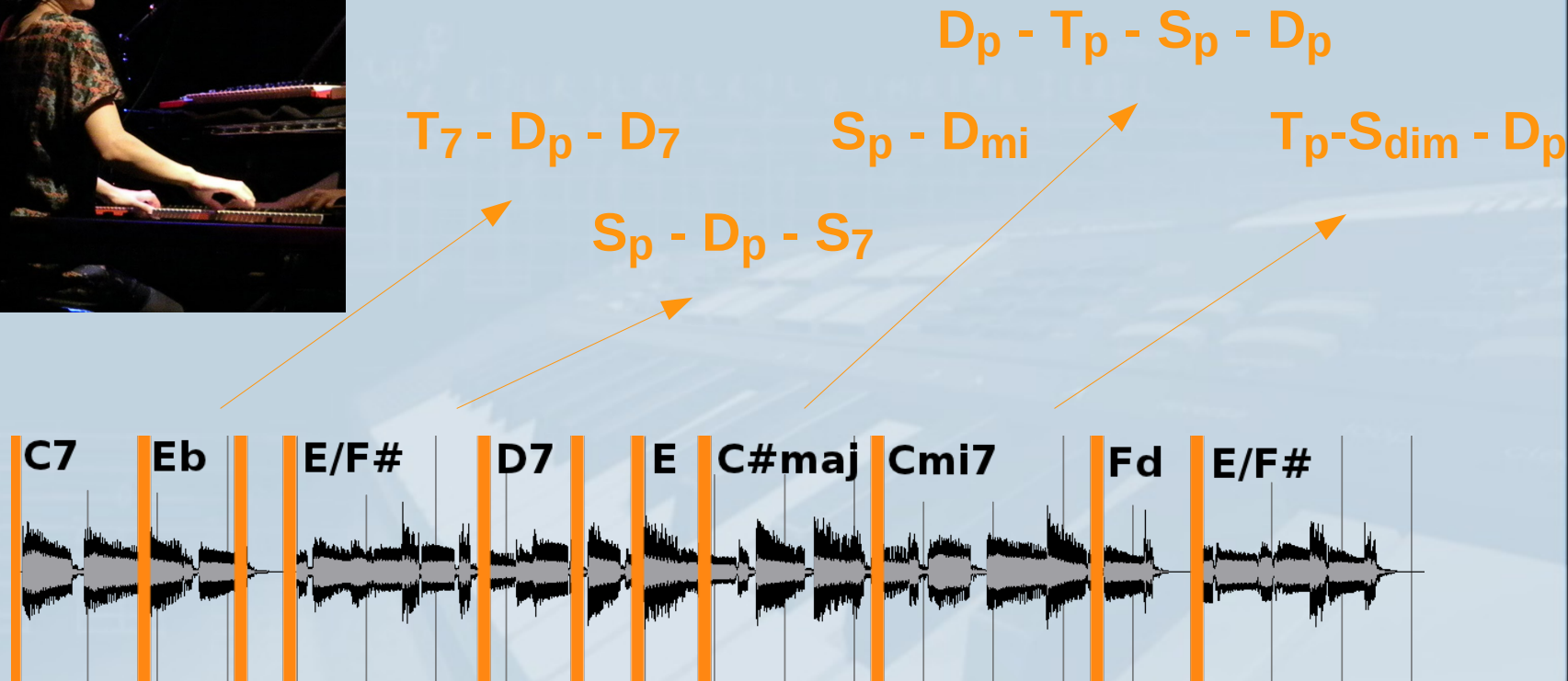Basic harmonic functions

**T – D – T – D**



Eb          Bb

# Complex harmony

Hiromi: 010101 (Binary System)

Modifications of basic harmonic functions

$D_p - T_p - S_p - D_p$

$T_7 - D_p - D_7$    $S_p - D_{mi}$    $T_p - S_{dim} - D_p$

$S_p - D_p - S_7$

C7    Eb    E/F#    D7    E    C#maj    Cmi7    Fd    E/F#

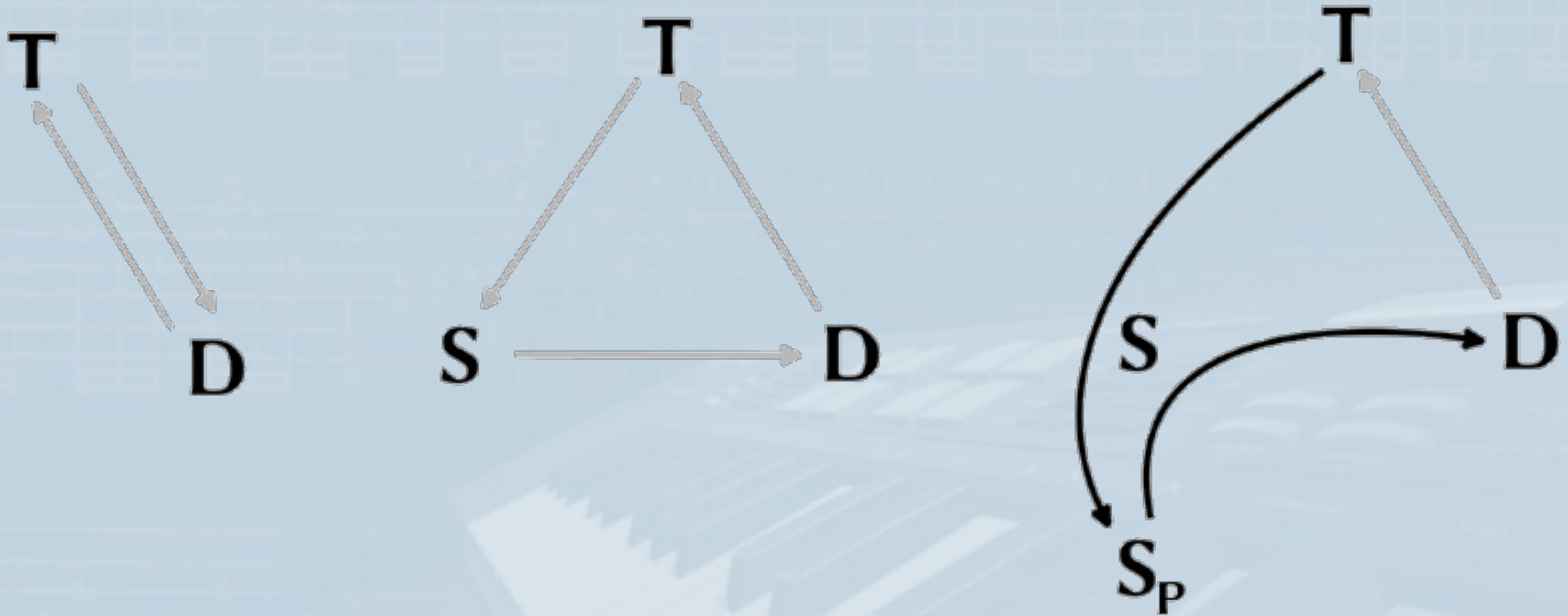# Complex harmony

Bedřich Smetana – Moldau



$(D) - (T)$

$T - S_P - T_P - S- T - D - T$
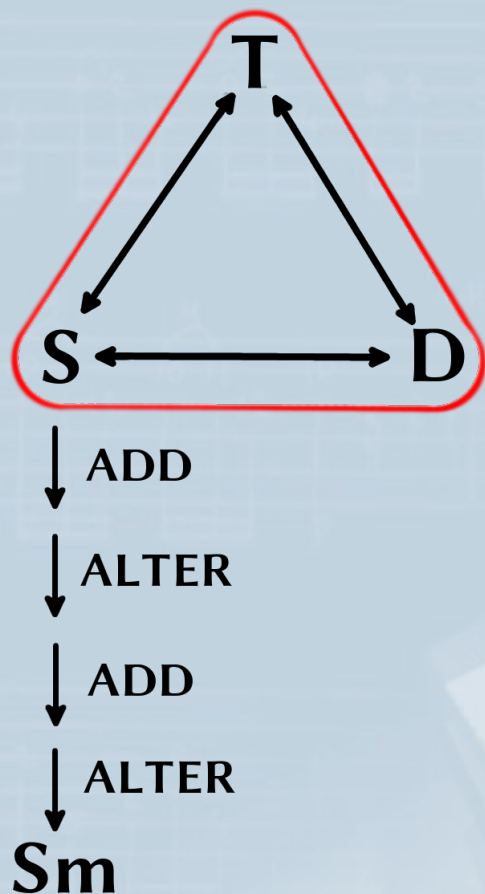
# Model of harmonic complexity

- TSD model

# Model of harmonic complexity

- Similar to formal grammars

- Basic harmonic function = start sentential form

- 2 rules applicable on sentential form:
  - ADD – adds a new tone
  - ALTER – alters the tone

- Example:

$$CEG \xrightarrow{ADD} CEFG \xrightarrow{ALTER} CEF\#G \xrightarrow{ALTER} CEF\#G\#$$

# Chord complexity
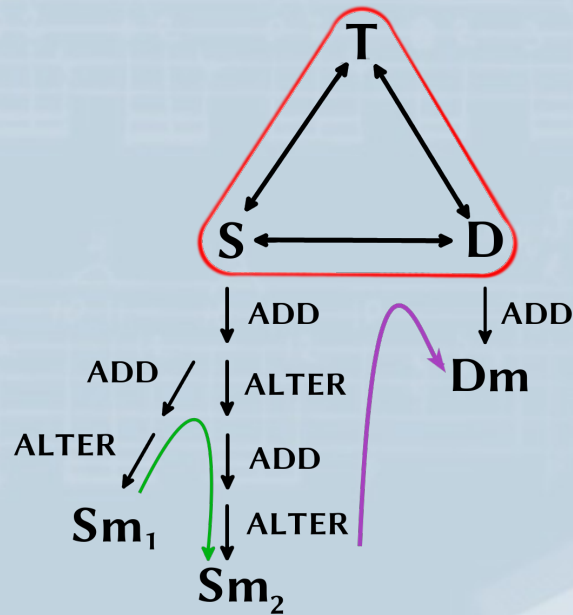
T

S ←→ D

ADD

ALTER

ADD

ALTER

Sm

- Chord complexity

  = **length of derivation**

  = **distance** from the root harmony
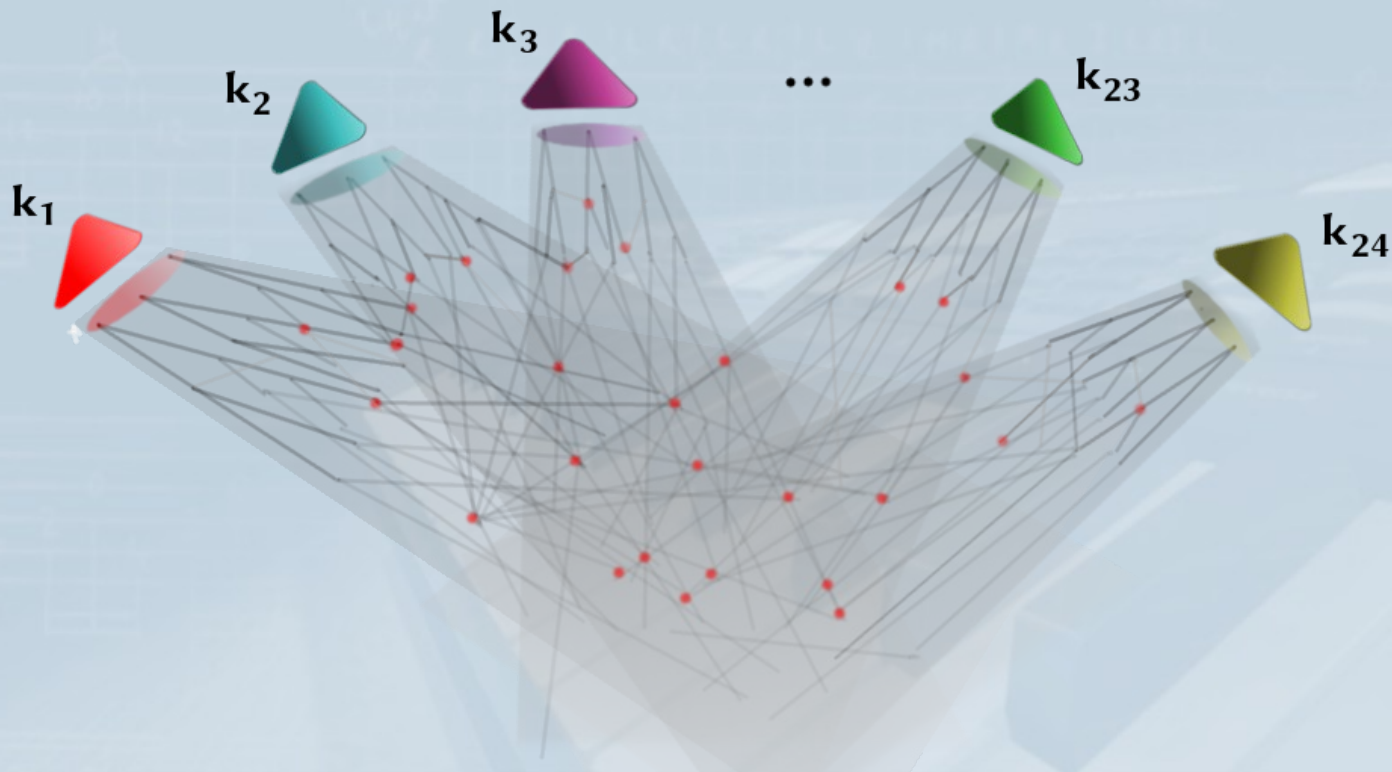
# Transition complexity



$$tc\,(Sm_1,Sm_2) = 5 \qquad tc\,(Sm_2,Dm) = 5$$

- Transition complexity (**TC**)

  = **steps needed** to create

  a harmony from previous one

# Implementation methods

- Query method (localization of the 2 harmonies)

- Graph method (preprocessing, BFS)

# Example analysis

Hiromi

010101 (Binary System)

**Complexity:**  **1   3 7     1 7 2     4   7   1   7**
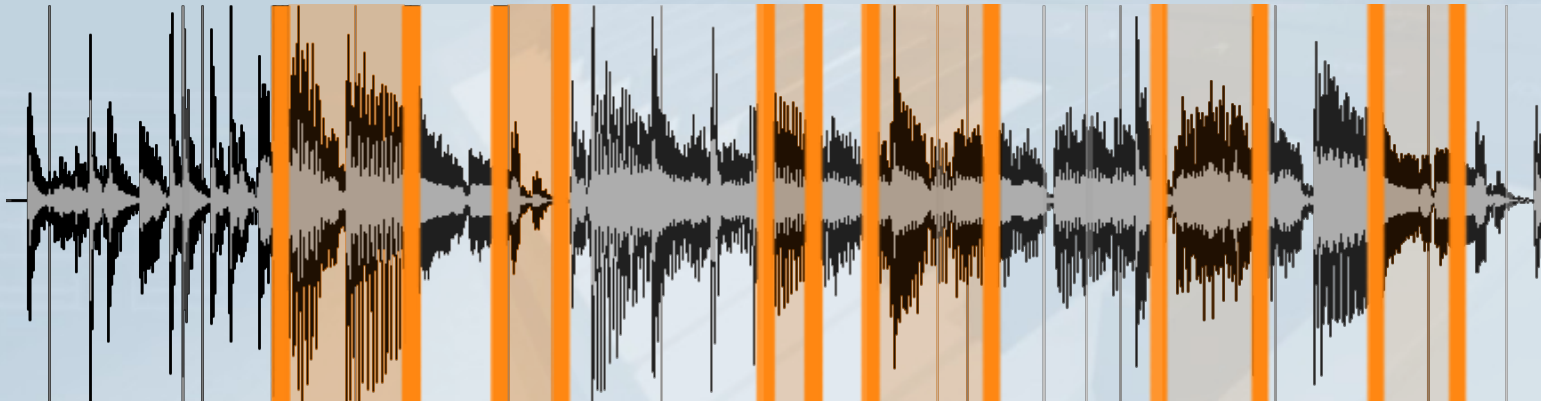
DbGb          CEFA  DGAB        D#EAb  DbGb
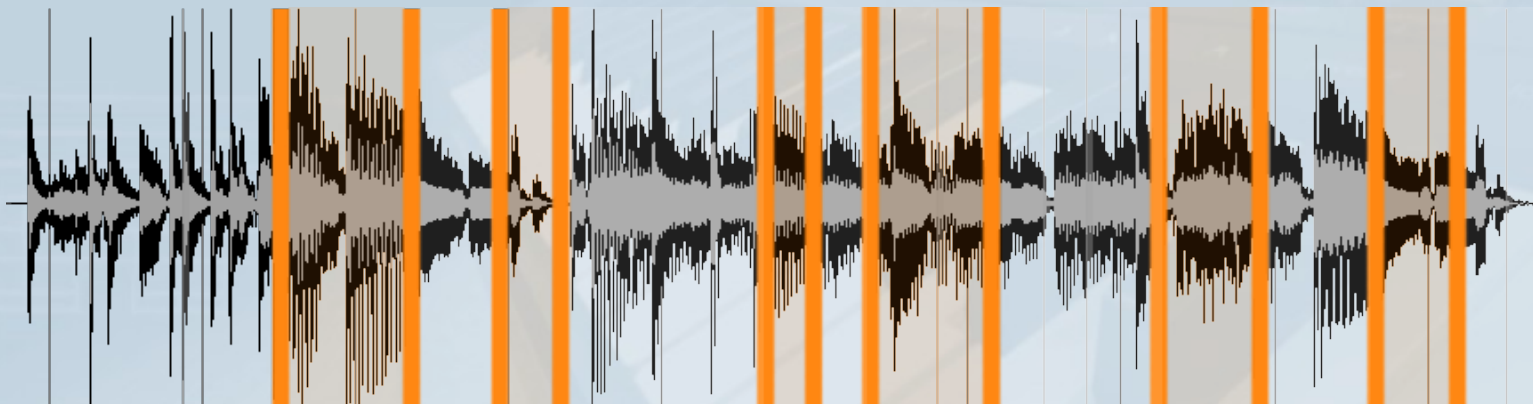
CEbBb  DEAbBb DG      C#F#      DGAB      CBb  DGbAbBb

# Example analysis

Hiromi

010101 (Binary System)

$$TC_{AVG} = \textbf{4,24}$$
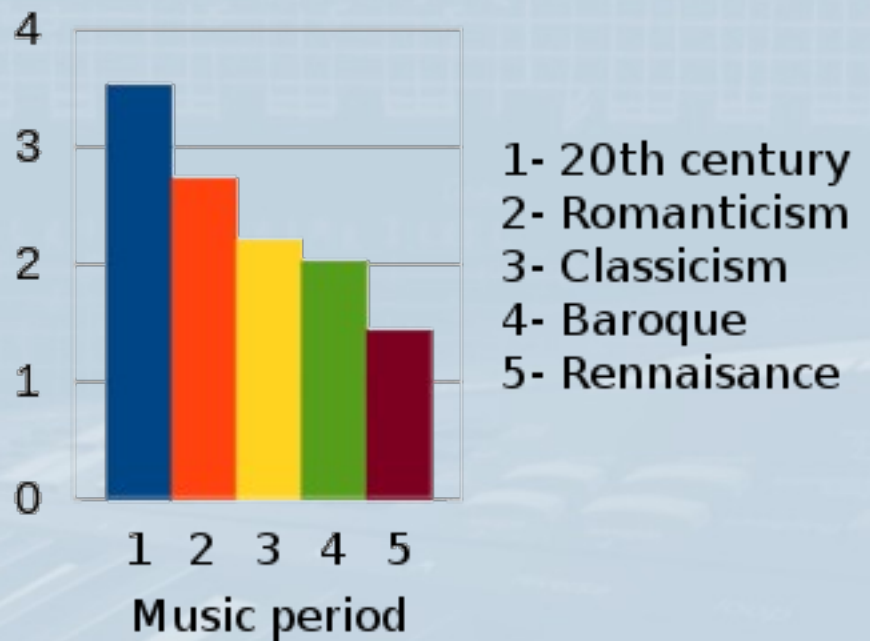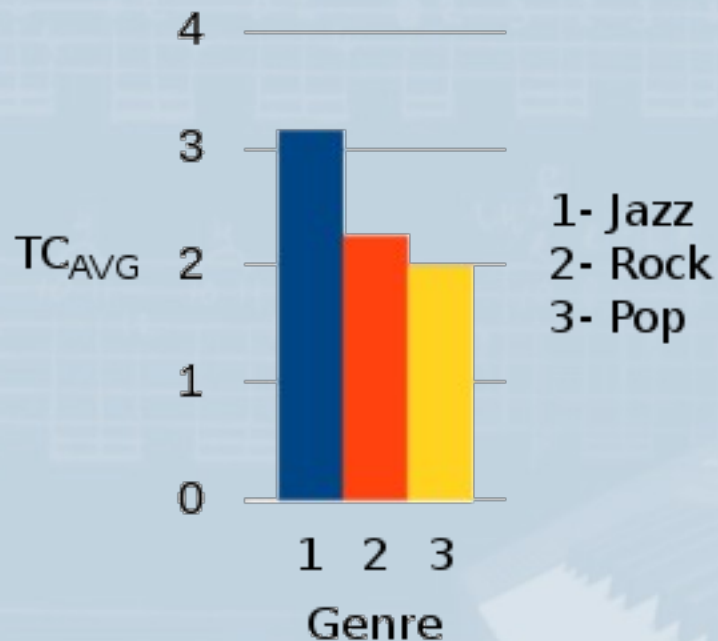
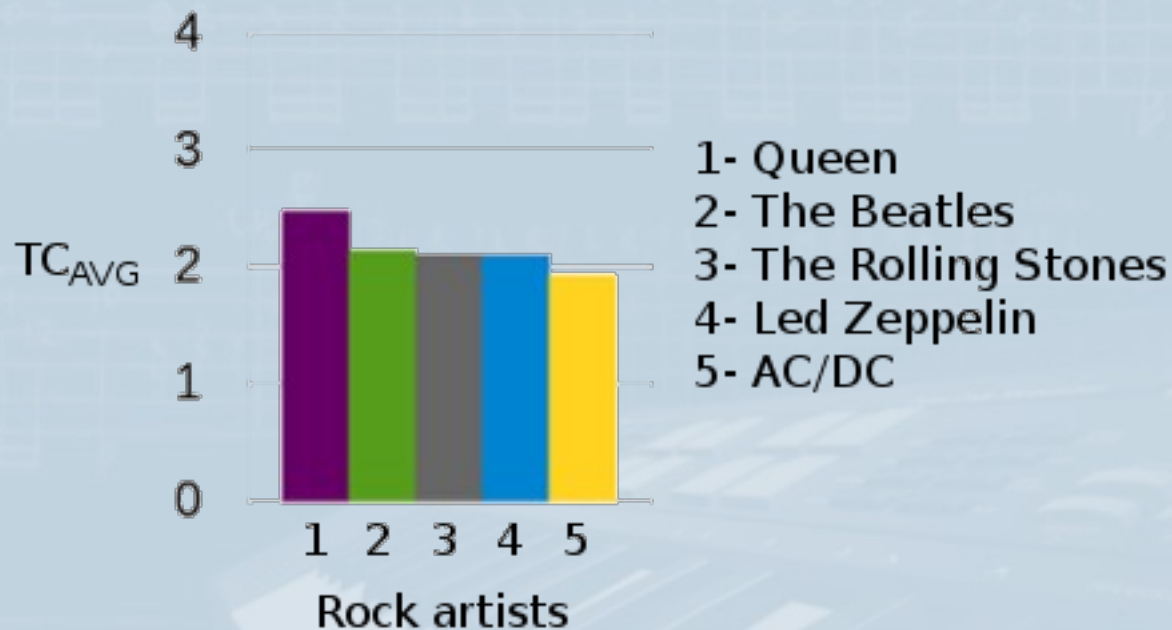**Complexity:**   **1   3  7      1 7 2     (0)      4    7    1    7**

# Experiments

- Rock, Pop, Jazz (5 best-selling artists)

- Classical music periods

- 3 parts
  - $TC_{AVG}$ for different genres and music periods
  - $TC_{AVG}$ for different artists
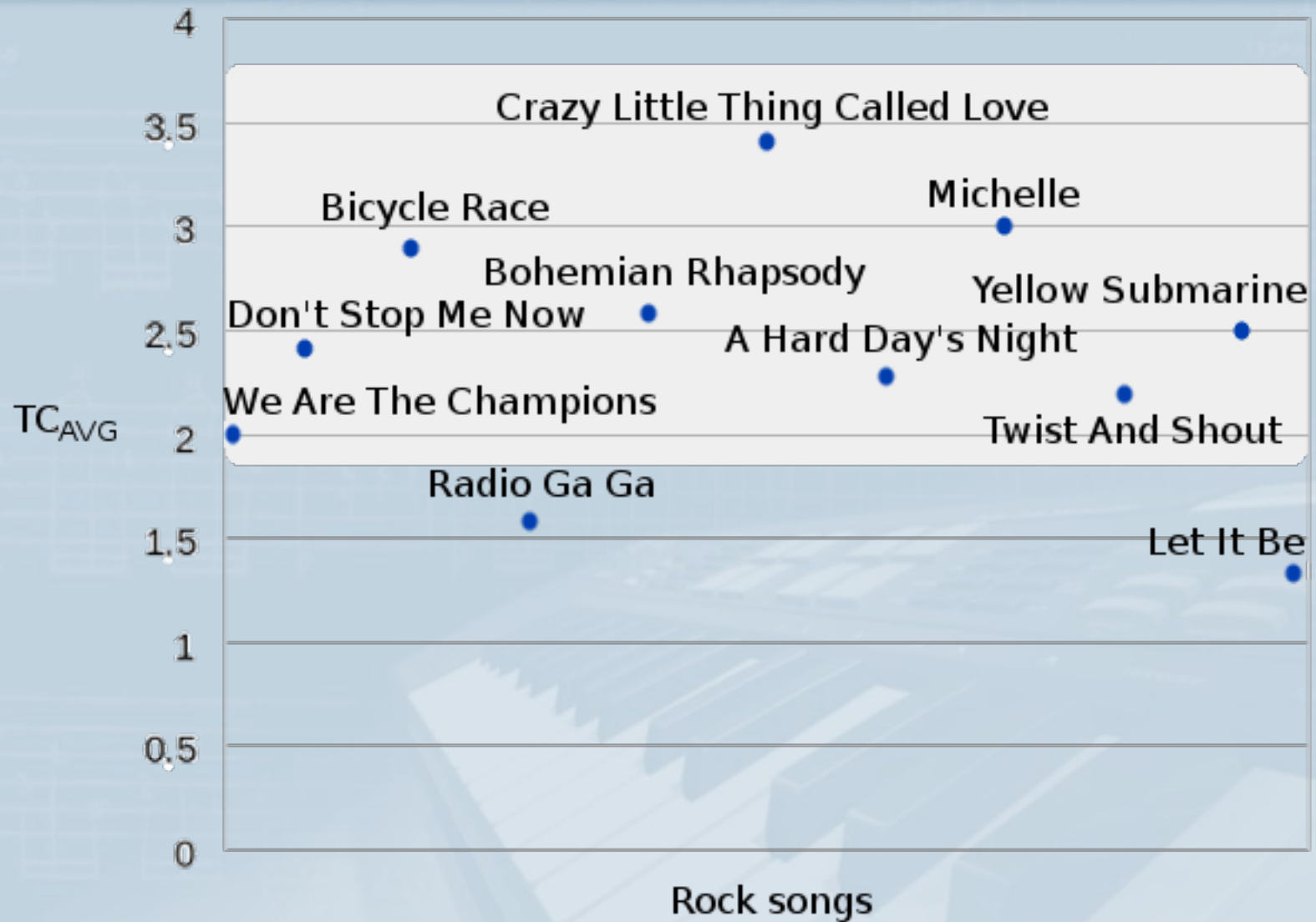  - $TC_{AVG}$ for different songs (The Beatles, Queen)

# 1. Genres and Music Periods

# 2. Artists



1- Queen
2- The Beatles
3- The Rolling Stones
4- Led Zeppelin
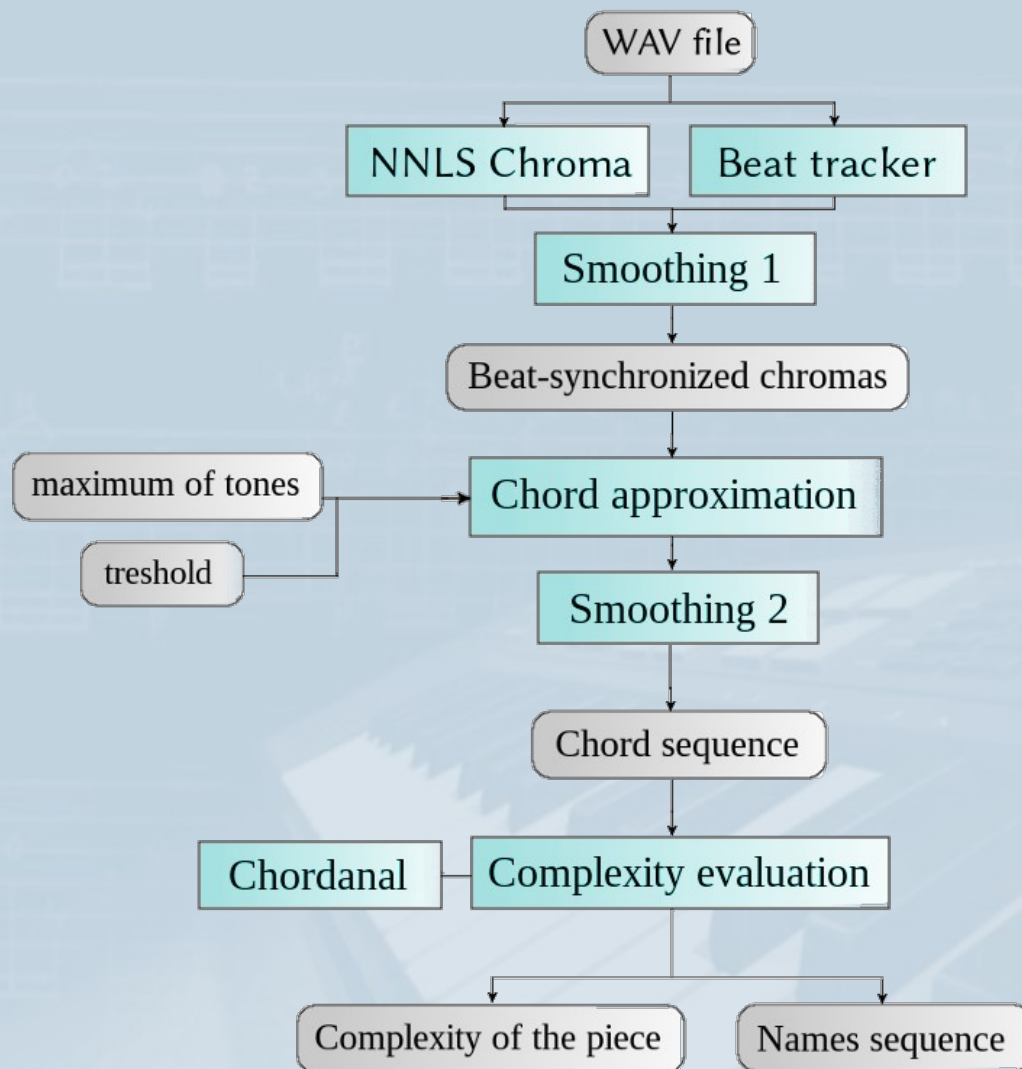5- AC/DC

# 3. Songs – Queen, The Beatles

# Conclusion

- New *mathematical model* for harmony analysis

- Distinguish *complex* and *simple* music – defining **Harmonic complexity**

- Analysis of music in **MP3 format**, interesting **results**

# Thank you for your attention

# System Harmanal - diagram

# Chord Transcription Example

Haas et al. (Utrecht University)



Chroma features extraction
Beat locations