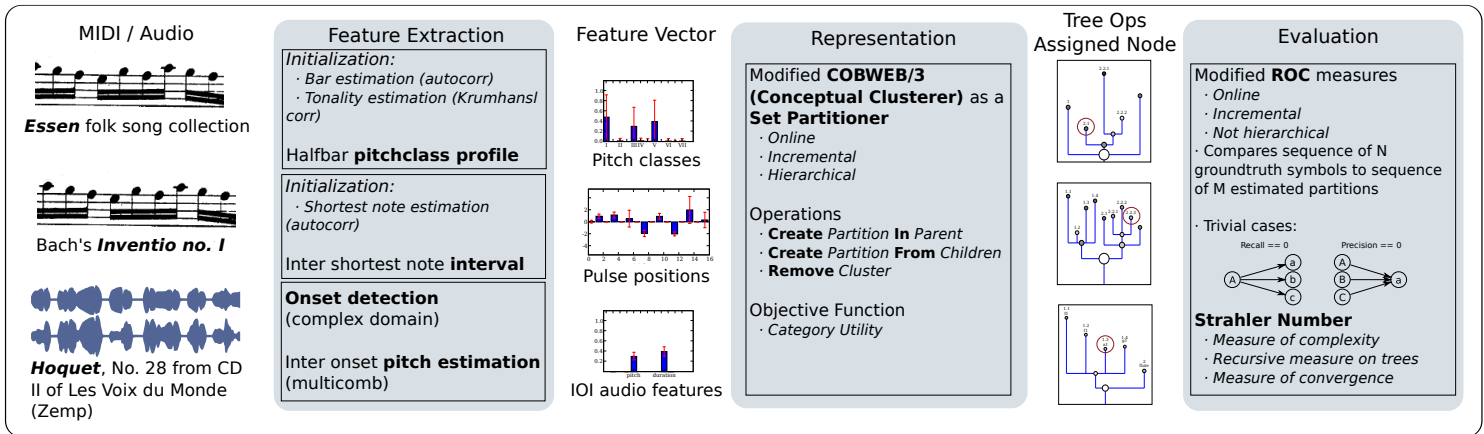# Dynamical Hierarchical Self-Organization Of Harmonic And Motivic Musical Categories

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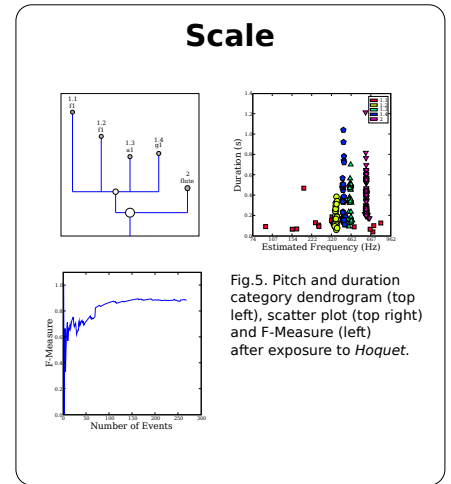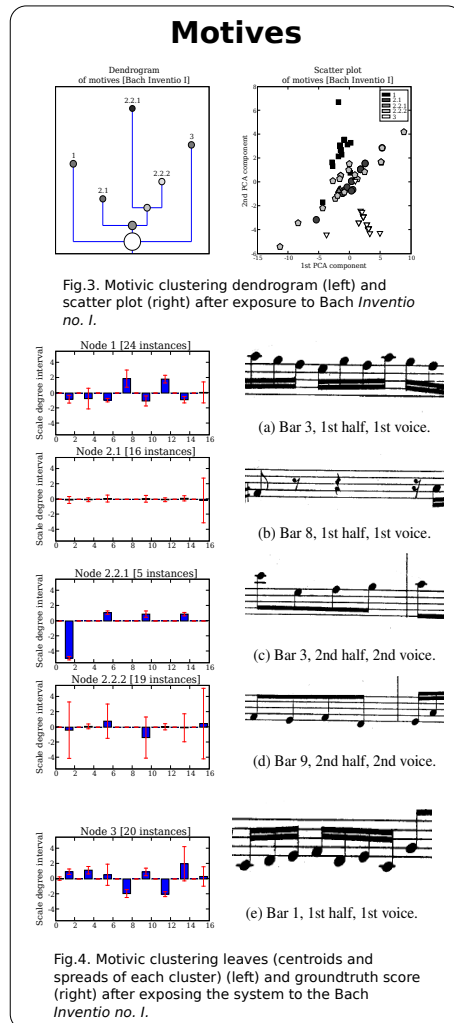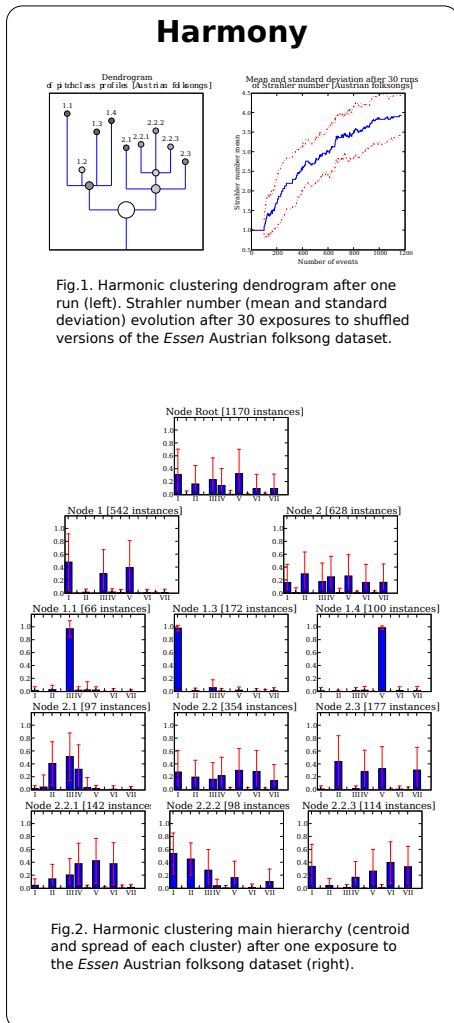
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We introduce a generic model of **emergence of musical categories** during the listening process. The model is based on a preprocessing and a categorization module.
Preprocessing results in a perceptually plausible representation of music events extracted from symbolic input. The categorization module lets a **taxonomy of musical entities** emerge according to a cognitively plausible **online learning** paradigm. We show the advantagesof using a conceptual clustering method in the musical domain. The system extracts multi-level hierarchiesand can be tuned to clustering at various resolutions. The potential of the model is exemplified by exposing it to two different datasets resulting in music **harmonic** and **motivic categorization** consistent with music theory.

System Overview

MIDI / Audio

Essen folk song collection

Bach's **Inventio no. I**

Hoquet, No. 28 from CD II of Les Voix du Monde (Zemp)

Feature Extraction

Initialization:
· Bar estimation (autocorr)
· Tonality estimation (Krumhansl corr)

Halfbar **pitchclass profile**

Initialization:
· Shortest note estimation (autocorr)

Inter shortest note **interval**

Onset detection (complex domain)

Inter onset **pitch estimation** (multicomb)

Feature Vector

Pitch classes

Pulse positions

IOI audio features

Representation

Modified **COBWEB/3 (Conceptual Clusterer)** as a **Set Partitioner**
· *Online*
· *Incremental*
· *Hierarchical*

Operations
· **Create** Partition **In** Parent
· **Create** Partition **From** Children
· **Remove** Cluster

Objective Function
· *Category Utility*

Tree Ops Assigned Node

Evaluation

Modified **ROC** measures
· *Online*
· *Incremental*
· *Not hierarchical*
· Compares sequence of N groundtruth symbols to sequence of M estimated partitions

· Trivial cases:

Recall == 0   Precision == 0

Strahler Number
· *Measure of complexity*
· *Recursive measure on trees*
· *Measure of convergence*

Results

Harmony

Fig.1. Harmonic clustering dendrogram after one run (left). Strahler number (mean and standard deviation) evolution after 30 exposures to shuffled versions of the *Essen* Austrian folksong dataset.

Fig.2. Harmonic clustering main hierarchy (centroid and spread of each cluster) after one exposure to the *Essen* Austrian folksong dataset (right).

Motives

Fig.3. Motivic clustering dendrogram (left) and scatter plot (right) after exposure to Bach *Inventio no. I.*

(a) Bar 3, 1st half, 1st voice.

(b) Bar 8, 1st half, 1st voice.

(c) Bar 3, 2nd half, 2nd voice.

(d) Bar 9, 2nd half, 2nd voice.

(e) Bar 1, 1st half, 1st voice.

Fig.4. Motivic clustering leaves (centroids and spreads of each cluster) (left) and groundtruth score (right) after exposing the system to the Bach *Inventio no. I.*

Scale

Fig.5. Pitch and duration category dendrogram (top left), scatter plot (top right) and F-Measure (left) after exposure to *Hoquet.*

Conclusions

· Motivation of using a **conceptual clustering** technique as a emergent partitioner in a **music listnening model**
· Interest of using a **hierarchical clusterer** for having musical representations at diferent **detail level**
· Introduced **evaluation measures** for **incremental clustering** techniques

Future work

· Test on **larger datasets**
· Apply to **other audio features** such as MFCCs, spectral and temporal features
· Use the output of the incremental clusterer as **input to an expectation/prediction model**
· Use the ouptut of an expectation/prediction model as **top-down feedback to the clusterer** (active perception)