# Mining Rules for Cadences in Dutch Folk-Song Melodies

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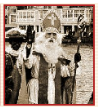
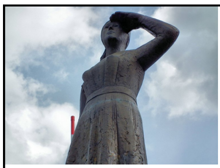
## Background

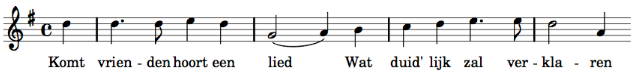
At the Meertens Institute (Amsterdam):

*Onder de groene linde*: c. 7000 recordings from the Netherlands.

Recorded 1950s – 1980s by Will Scheepers and Ate Doornbosch.



# Example

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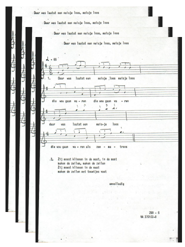
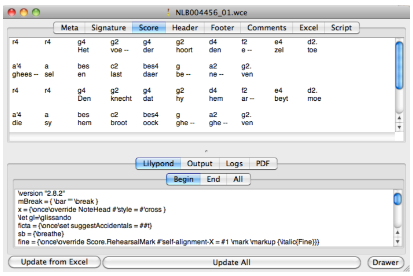
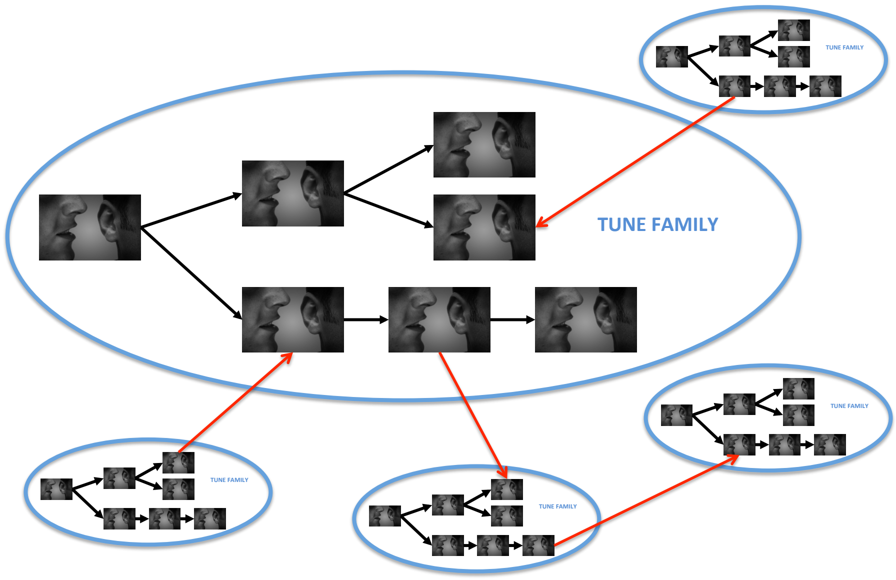


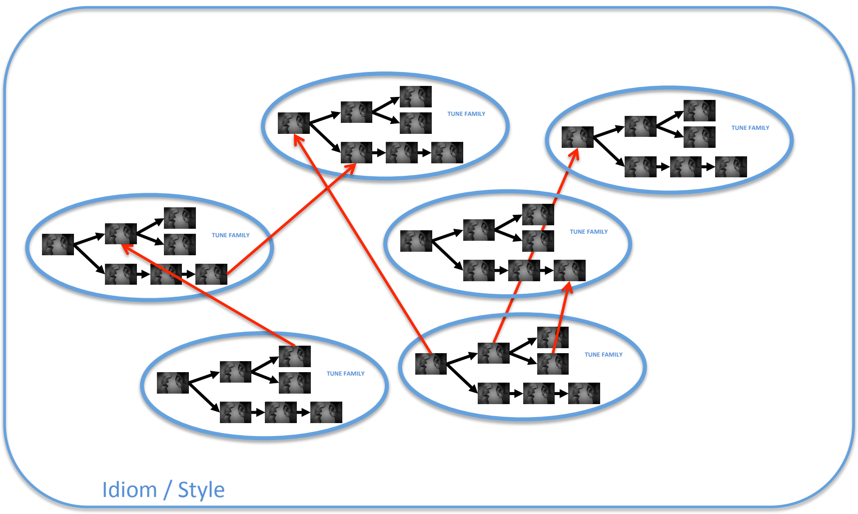



Accessible at: http://www.liederenbank.nl

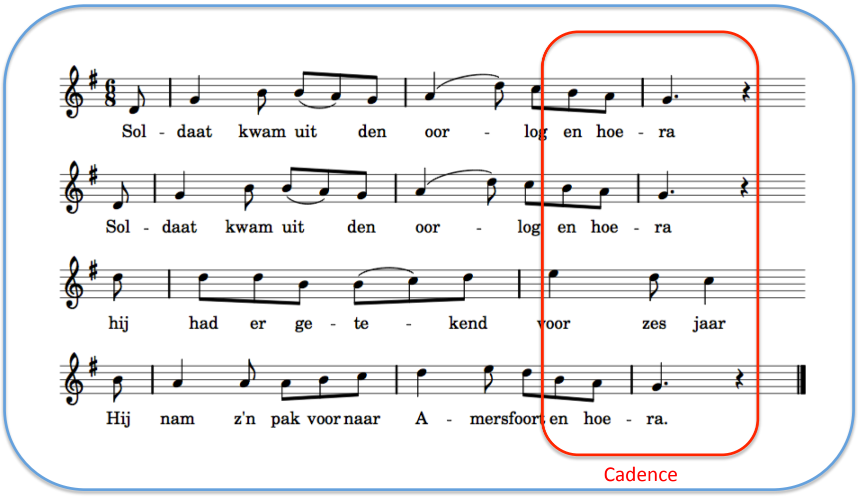
# Melody in Oral Culture




# Melody in Oral Culture



# Cadence




# Related Topics

- Closure (music perception)
- Segmentation (music information retrieval)
- Tonic (music theory)
- Final (music theory)

# Main Approaches in Modelling

Gestalt Principles -> rule based model

- Narmour (1992): Implication-Realization model
- Lehrdal & Jackendoff (1983): GTTM
- Cambouropoulos (2001): LBDM

Statistical Learning -> Probabilistic model

- Huron (2006): Expectation (ITPRA)
- Pearce et al. (2010): IDyOM
- Juhász (2004): EBLM
- Bod (2001): Data oriented parsing

# Gestalt Principles

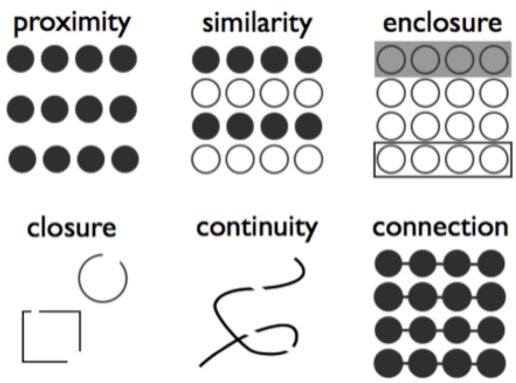



Figure by Farooq Ali

## Main Approaches in Modelling

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Bod (2001): Data oriented parsing

## Current Approach

- Data-driven rather than theory-driven
- No pre-defined rules
- No strong theoretic grounding

- Method: Automatic Rule Discovery

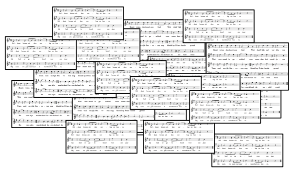
if 4 wheels and engine => car
if 2 wheels and pedals => bicycle
if 2 wheels and engine => motorcycle

# Procedure

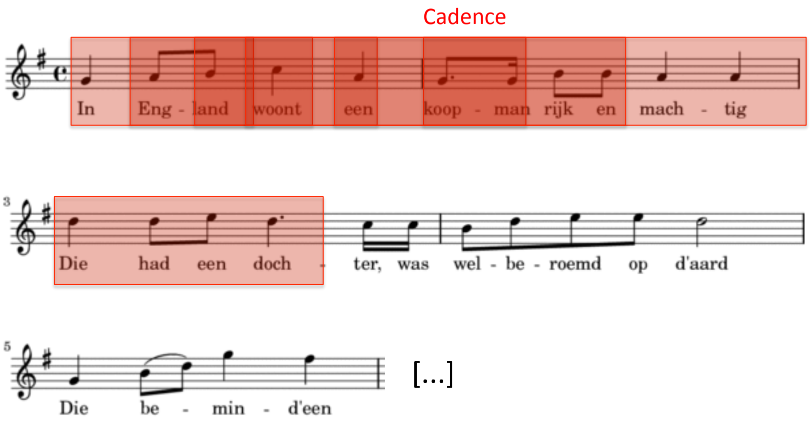
Procedure:
- Obtain symbolic representation (notes)
- Extract all trigrams from the melody
- Extract features from the trigrams
- Perform rule-mining algorithm (RIPPER)
- Study and adapt the rules

# Data Set

- 4121 Dutch folk songs
- Symbolic representation (*kern)
- Phrase endings are annotated
- Key is annotated
- Lyrics included in digitization



# Trigrams




# Features


PITCH

| | |
|---|---|
| scaledegree first | 1 |
| scaledegree second | 2 |
| scaledegree third | 3 |
| ambitus | 2 |
| contains leap | FALSE |

CONTOUR

| | |
|---|---|
| is ascending | TRUE |
| arrive ascending | TRUE |
| is descending | FALSE |
| arrive descending | FALSE |

METRIC FEATURES

| | |
|---|---|
| time signature | '4/4' |
| metric weight first | 1.0 |
| metric weight second | 0.25 |
| metric weight third | 0.125 |

# Rule Mining

RIPPER (Cohen, 1995)

Basic procedure:

1. split data into two folds
2. grow rules using the one fold
3. prune rules using the other fold
4. remove covered items from data
5. size(data) == 0 ? stop : goto 1

# Results on Dutch Songs

On balanced dataset (c. 25,000 cadence, and c. 25,000 nocadence)
70 rules found.
2/3 train, 1/3 test:

| | Precision | Recall | F-measure |
|---|---|---|---|
| cadence | 0.723 | 0.754 | 0.738 |
| nocadence | 0.759 | 0.729 | 0.744 |
| weight. avg. | 0.741 | 0.741 | 0.741 |

Evaluation on full dataset (c. 25,000 cadence, c. 98,000 nocadence):

| | Precision | Recall | F-measure |
|---|---|---|---|
| cadence | 0.445 | 0.741 | 0.556 |
| nocadence | 0.926 | 0.777 | 0.845 |
| weight. avg. | 0.832 | 0.77 | 0.789 |

# Results on Dutch Songs

RULE 1
scaledegree third == 1
arrive descending == TRUE
metric weight third >= 0.5
=> class=cadence (5940/821)

RULE 3
scaledegree third == 1
scaledegree second == 7
metric weight third == 1
=> class=cadence (1050/153)

RULE 2
scaledegree third == 5
is descending == TRUE
metric weight third >= 0.5
=> class=cadence (2323/433)

# Examples


RULE 1
scaledegree third == 1
arrive descending == TRUE
metric weight third >= 0.5

RULE 2
scaledegree third == 5
is descending == TRUE
metric weight third >= 0.5

RULE 3
scaledegree third == 1
scaledegree second == 7
metric weight third == 1

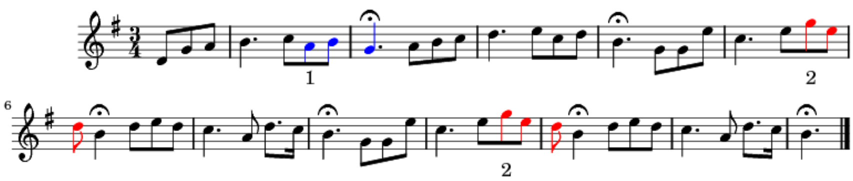
# Examples

RULE 1
scaledegree third == 1
arrive descending == TRUE
metric weight third >= 0.5

RULE 2
scaledegree third == 5
is descending == TRUE
metric weight third >= 0.5

RULE 3
scaledegree third == 1
scaledegree second == 7
metric weight third == 1

# Examples



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scaledegree third == 1
arrive descending == TRUE
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RULE 2
scaledegree third == 5
is descending == TRUE
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RULE 3
scaledegree third == 1
scaledegree second == 7
metric weight third == 1

# Examples


RULE 1
scaledegree third == 1
arrive descending == TRUE
metric weight third >= 0.5

RULE 2
scaledegree third == 5
is descending == TRUE
metric weight third >= 0.5

RULE 3
scaledegree third == 1
scaledegree second == 7
metric weight third == 1

# Observation

Cadence should not occur too early.
What is ‘early’?

We add a new feature: phrase offset

# New Results on Dutch Songs

On balanced dataset (c. 25,000 cadence, and c. 25,000 nocadence)
98 rules found.
2/3 train, 1/3 test

| | Precision | Recall | F-measure |
|---|---|---|---|
| cadence | 0.813 | 0.818 | 0.815 |
| nocadence | 0.828 | 0.823 | 0.826 |
| weight. avg. | 0.821 | 0.821 | 0.821 |

Evaluation on full dataset (c. 25,000 cadence, c. 98,000 nocadence):

| | Precision | Recall | F-measure |
|---|---|---|---|
| cadence | 0.533 | 0.828 | 0.649 |
| nocadence | 0.952 | 0.825 | 0.884 |
| weight. avg. | 0.871 | 0.826 | 0.839 |

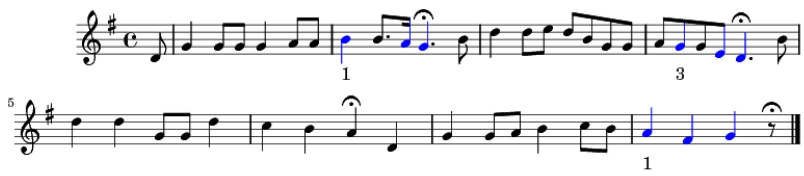
# New Results on Dutch Songs

RULE 1
phrase offset >= 7
scaledegree third == 1
metric weight third >= 0.5
=> class=cadence (2289/90)

RULE 2
phrase offset >= 4
scaledegree third == 1
arrivedescending == TRUE
metric weight third >= 0.5
timesig = 6/8
=> class=cadence (910/51)

RULE 3
phrase offset >= 6
scaledegree third == 5
isdescending == TRUE
metric weight third >= 0.5
=> class=cadence (1012/47)

# Examples




RULE 1
phrase offset >= 7
scaledegree third == 1
metric weight third >= 0.5

RULE 2
phrase offset >= 4
scaledegree third == 1
arrivedescending == TRUE
metric weight third >= 0.5
timesig = 6/8

RULE 3
phrase offset >= 6
scaledegree third == 5
isdescending == TRUE
metric weight third >= 0.5

# Examples


RULE 1
phrase offset >= 7
scaledegree third == 1
metric weight third >= 0.5

RULE 2
phrase offset >= 4
scaledegree third == 1
arrivedescending == TRUE
metric weight third >= 0.5
timesig = 6/8

RULE 3
phrase offset >= 6
scaledegree third == 5
isdescending == TRUE
metric weight third >= 0.5

# Examples


RULE 1
scaledegree third == 1
arrive descending == TRUE
metric weight third >= 0.5

RULE 2
scaledegree third == 5
is descending == TRUE
metric weight third >= 0.5

RULE 3
scaledegree third == 1
scaledegree second == 7
metric weight third == 1


RULE 1
phrase offset >= 7
scaledegree third == 1
metric weight third >= 0.5

RULE 2
phrase offset >= 4
scaledegree third == 1
arrivedescending == TRUE
metric weight third >= 0.5
timesig = 6/8

RULE 3
phrase offset >= 6
scaledegree third == 5
isdescending == TRUE
metric weight third >= 0.5

# Conclusions

- Cadence patterns do obey general rules
- It is possible to derive these general rules from melodic data
- Arrival at the tonic implies a cadence
- This confirms music theory

# Future Work

- Add more features
- Incorporate parallelism in the model
- Incorporate relation with lyrics in the model
- Evaluate theories of melody (e.g. IR-model)
- Apply the same method to melodies from other cultures

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