MODELING OF PHONEME DURATIONS FOR ALIGNMENT BETWEEN POLYPHONIC AUDIO AND LYRICS

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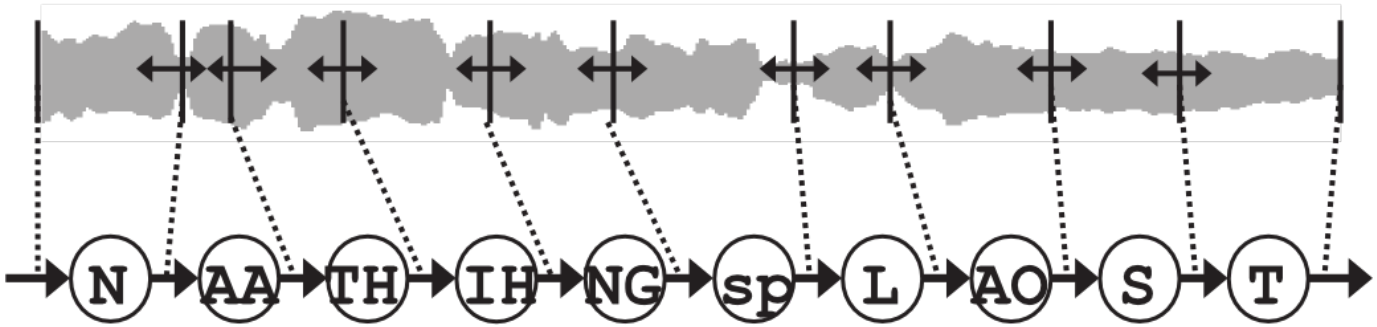
Contents

Goal

automatic synchronization between audio and lyrics (a.k.a. lyrics-to-audio alignment)

- input: audio lyrics
- output: boundary timestamps of phonemes
- analogous to score-to-audio alignment



Dataset

Excerpt from classical Turkish Makam

Motivation

- Why automate lyrics-to-audio alignment?
  - automatic karaoke generation
  - structural navigation by lyrics
  - educational purposes: explore interpretations of same lyrics

Lyrics visualization

State of the art

[Mesaros and Virtanen(2008)]
[Fujihara et al.(2011)Fujihara, Goto, Ogata, and Okuno]

	Mesaros et al.	Fujihara et al.
approach	phoneme-HMMs Viterbi forced alignment	
refinements	singing adaptation	singer adaptation
test dataset	English pop	Japanese + English pop

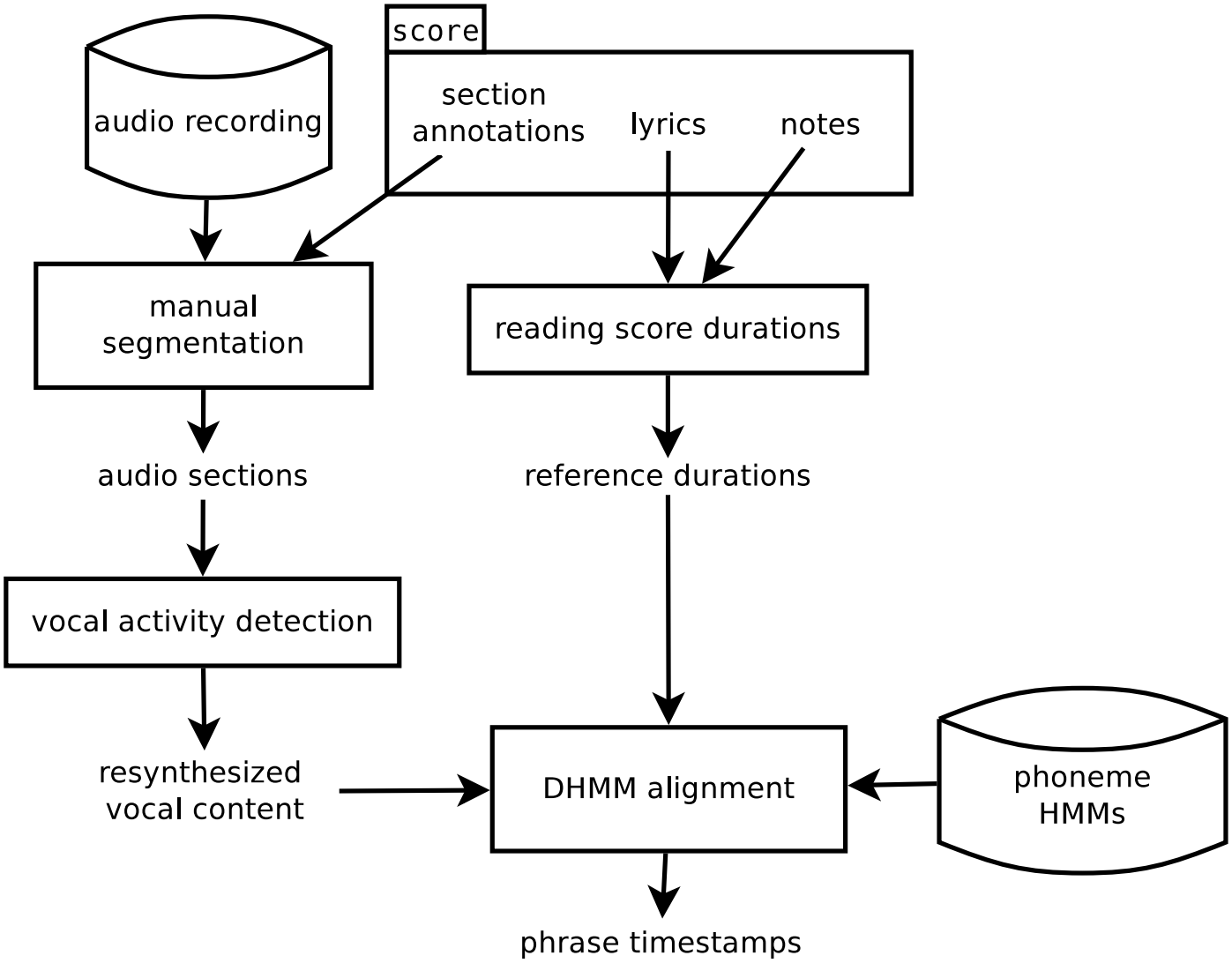
Motivation

- Why research lyrics-to-audio alignment?
  - no work on non-eurogenetic music (singing style and language)
  - state of the art accuracy could be improved
  - build reproducible research

Approach
Main ideas

- extend the phoneme-HMMs Viterbi forced alignment
- explicitly model phoneme durations by use of musical score

Approach Overview



DHMM: Duration-explicit Hidden Markov Model

Dataset

12 recordings (19 min) of classical Turkish Makam

- drawn from CompMusic collection
- segmented into sections
- evaluate phrase boundaries

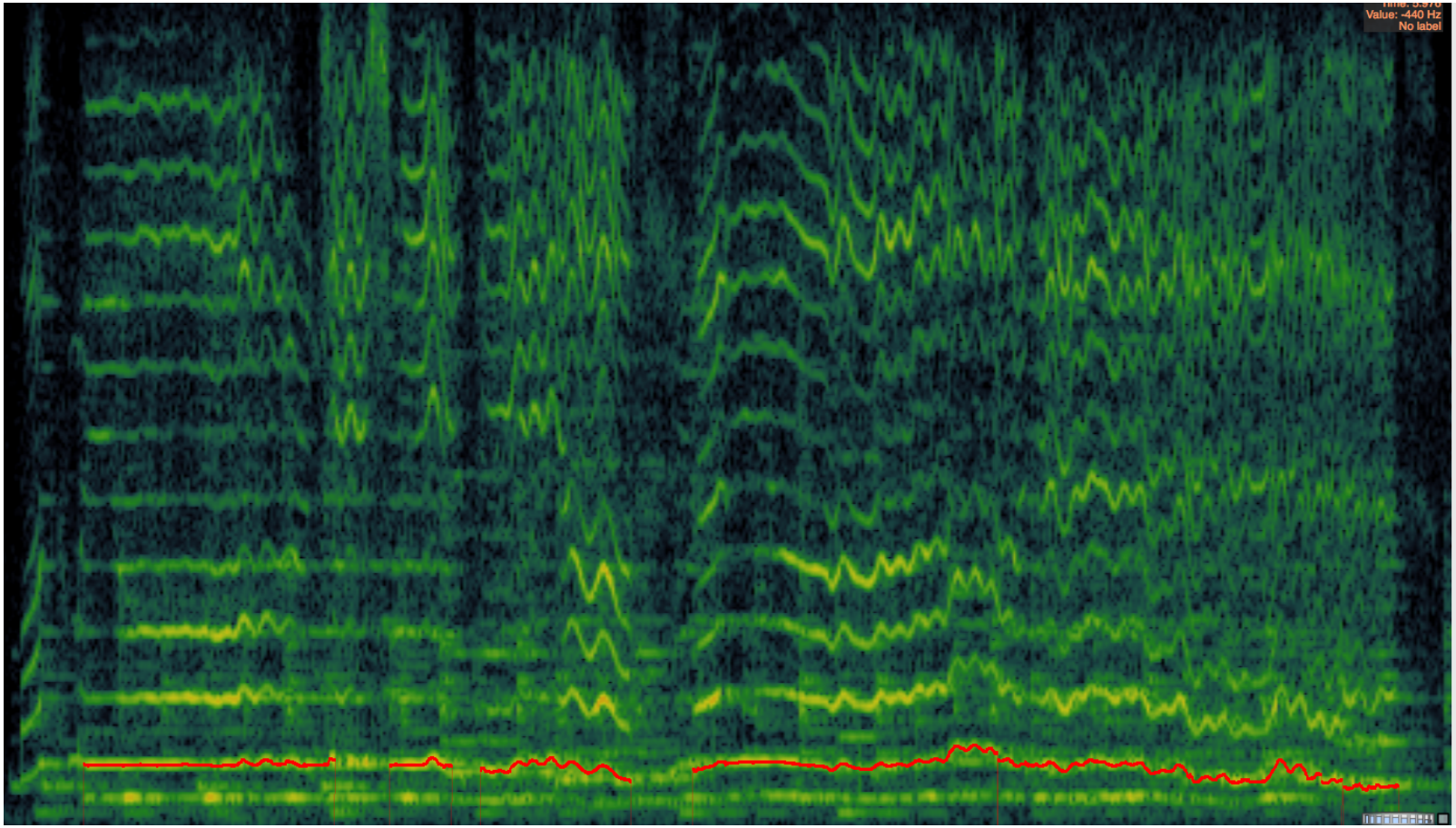
total #phrases	#phrases per section	#words in phrase
220	2 to 5	1-5

Table: Section and phrase statistics for test dataset.

Vocal Activity Detection

original polyphonic audio

Vocal Activity Detection



predominant melody extraction: [Salamon and Gómez(2012)]

- vocal activity detection at the same time

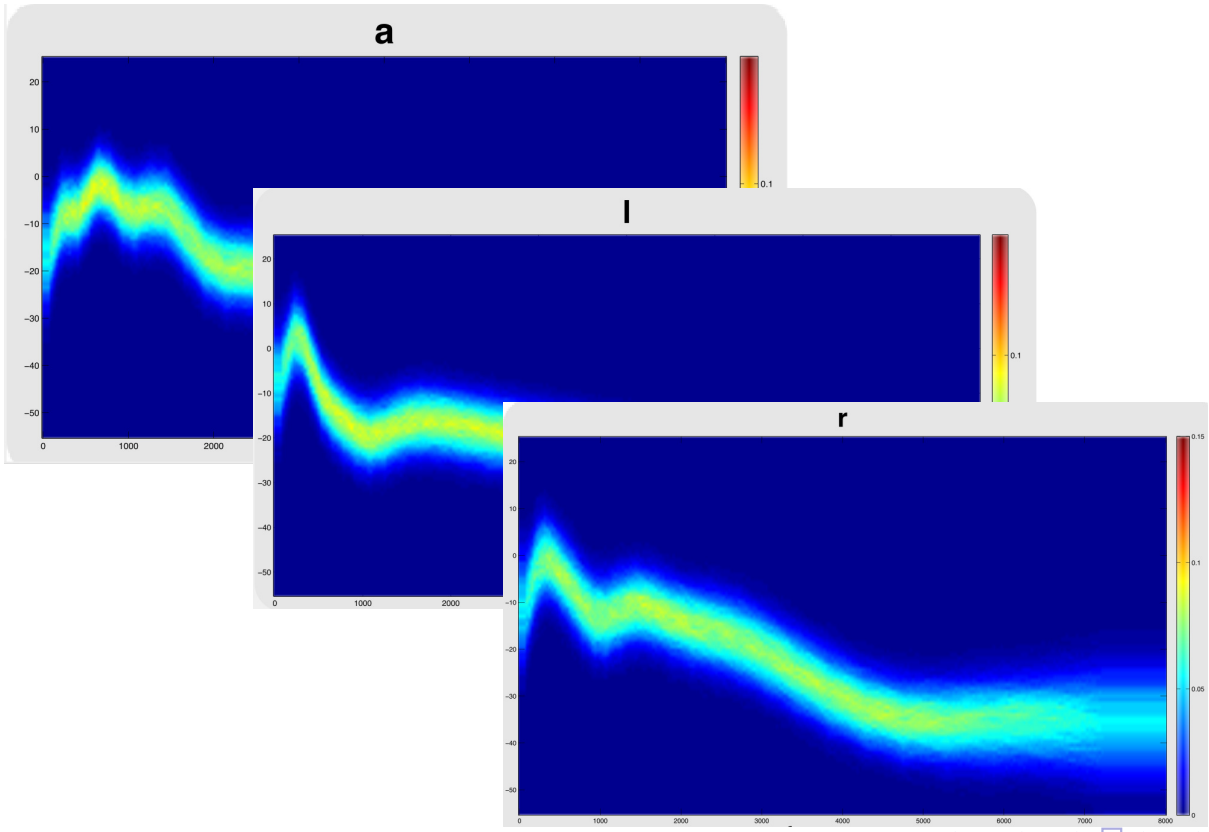
Resynthesis of main vocal

[Serra(1989)]

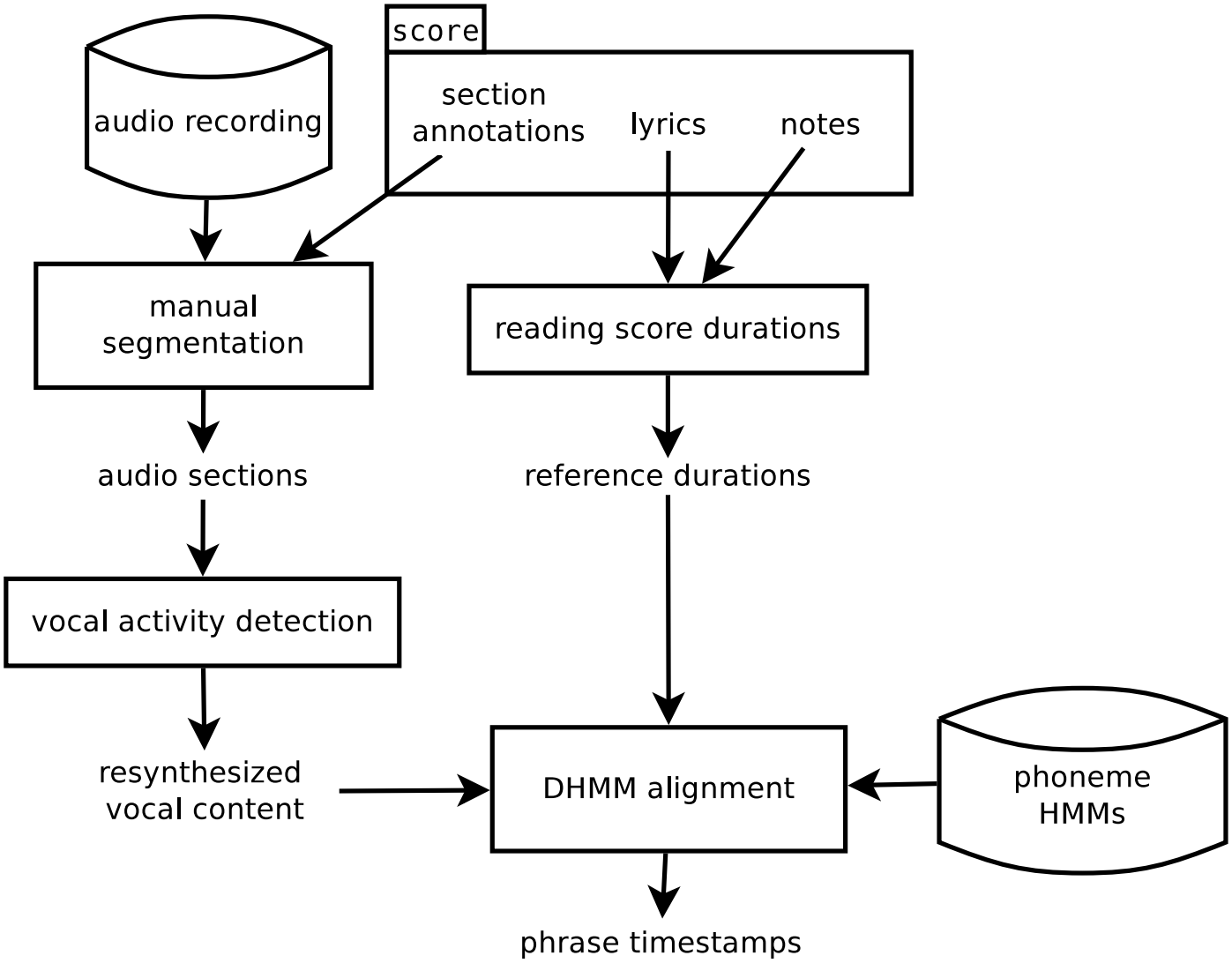
- extract 12 MFCCs from resynthesized vocal

Phoneme models

- 38 Phoneme HMMs trained on clean speech
  - trained on ~6 hours Turkish speech
- $b_i(O_s)$ - from GMM with 9-mixture Normal distribution

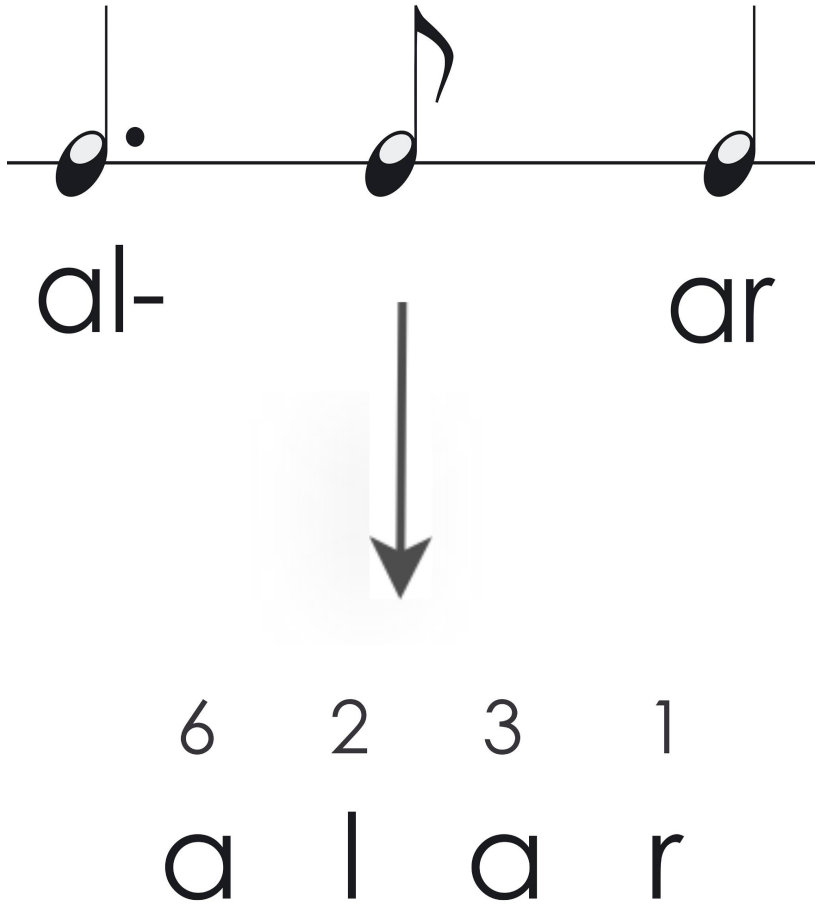


Approach Overview



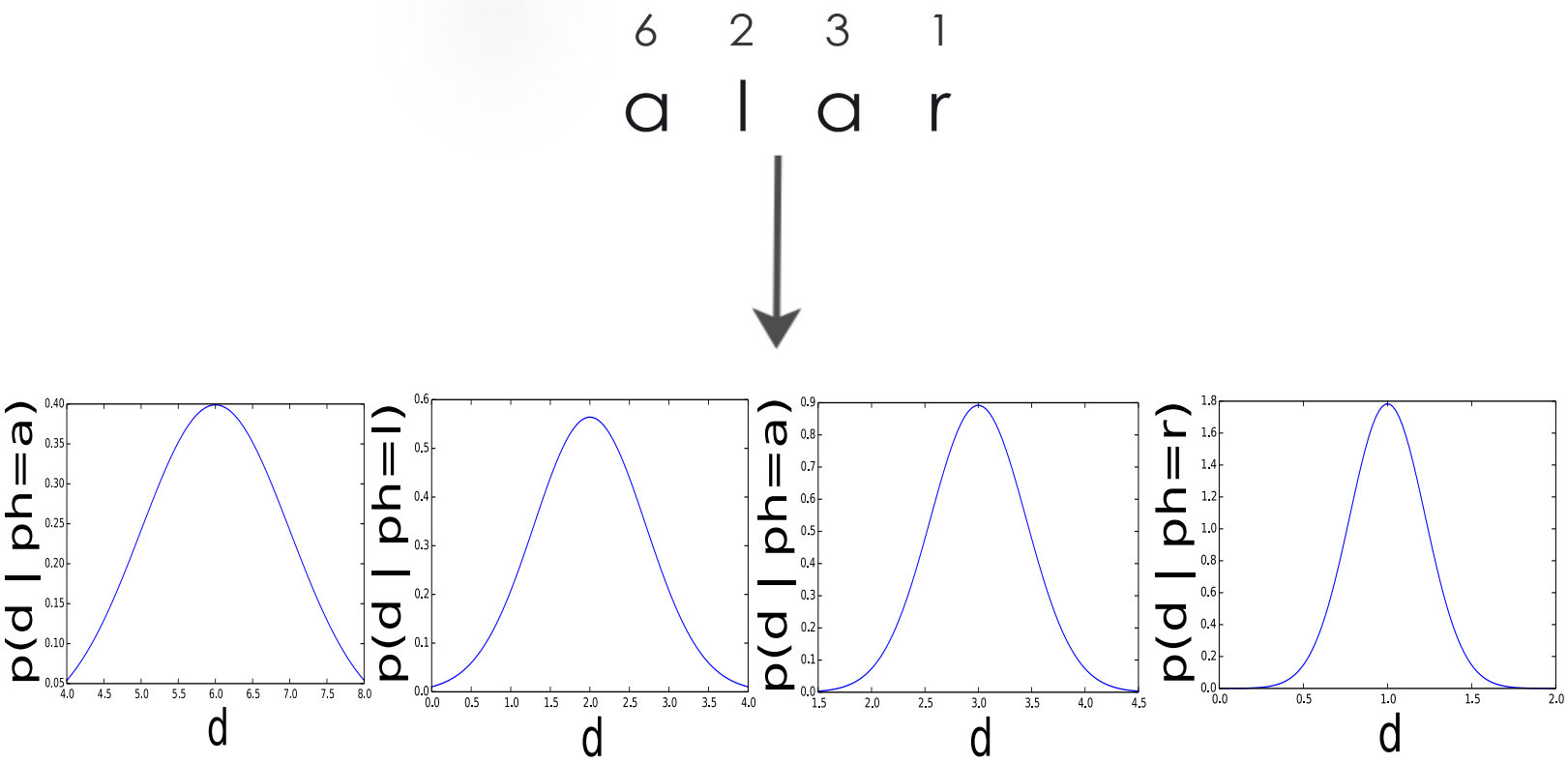
DHMM: Duration-explicit Hidden Markov Model

Read score reference durations



relative reference durations

Model duration distributions $P_i(d)$



durations distributions

Duration-explicit HMM alignment

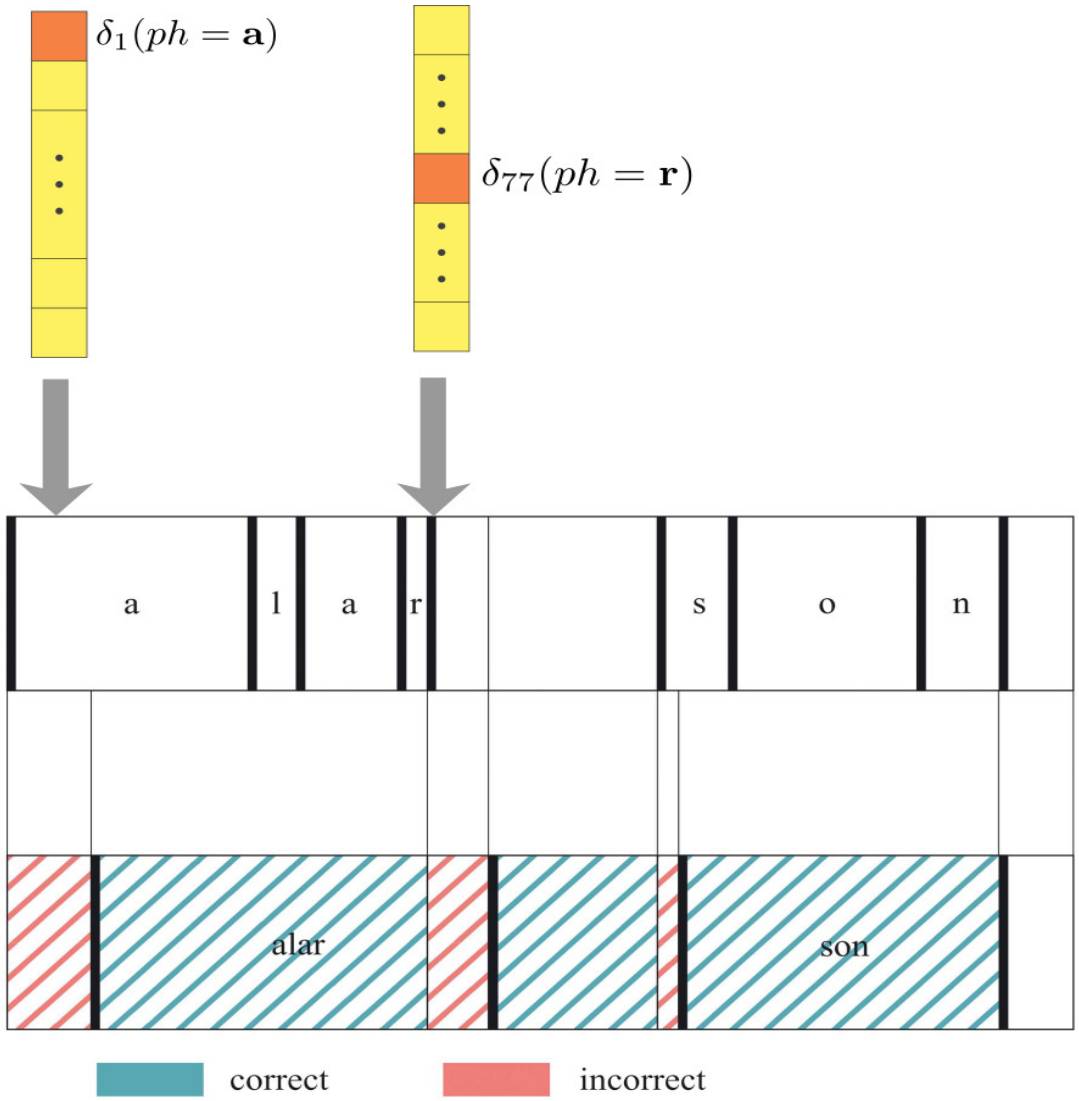
$\delta_t(i)$: probability for optimal path ending in state i at time t

$$\delta_t(i) = \max_d \{\delta_{t-d}(i-1). P_i(d)^{\alpha} [B_t(i,d)]^{1-\alpha}\}$$

and

$$B_t(i,d) = \Pi_{s=t-d+1}^{t} b_i(O_s)$$

Duration-explicit HMM alignment



Results

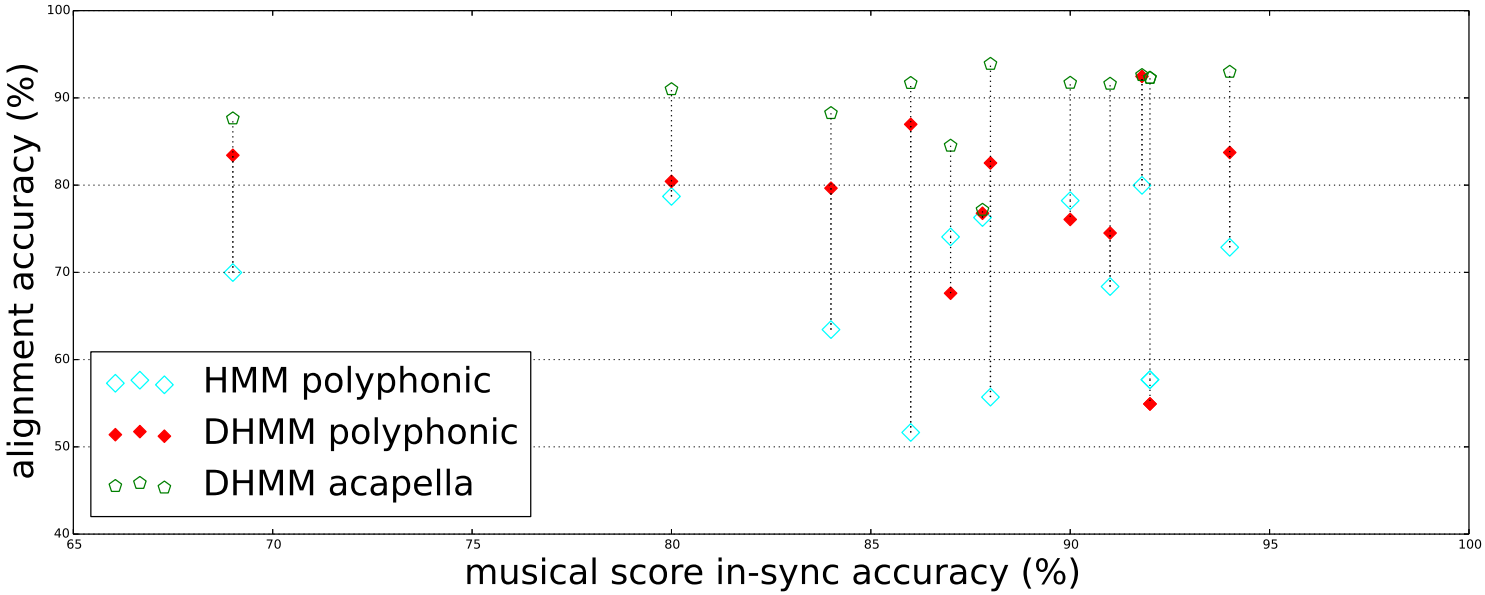
System variant	accuracy	error
HMM polyphonic	67.46	1.04
DHMM polyphonic	77.74	0.63
DHMM acapella	90.04	0.26

Table: Alignment accuracy and error for baseline HMM and DHMM

System variant	accuracy	error
HMM+singing adaptation [2]	-	1.4
HMM+singer adaptation [1]	85.2	-

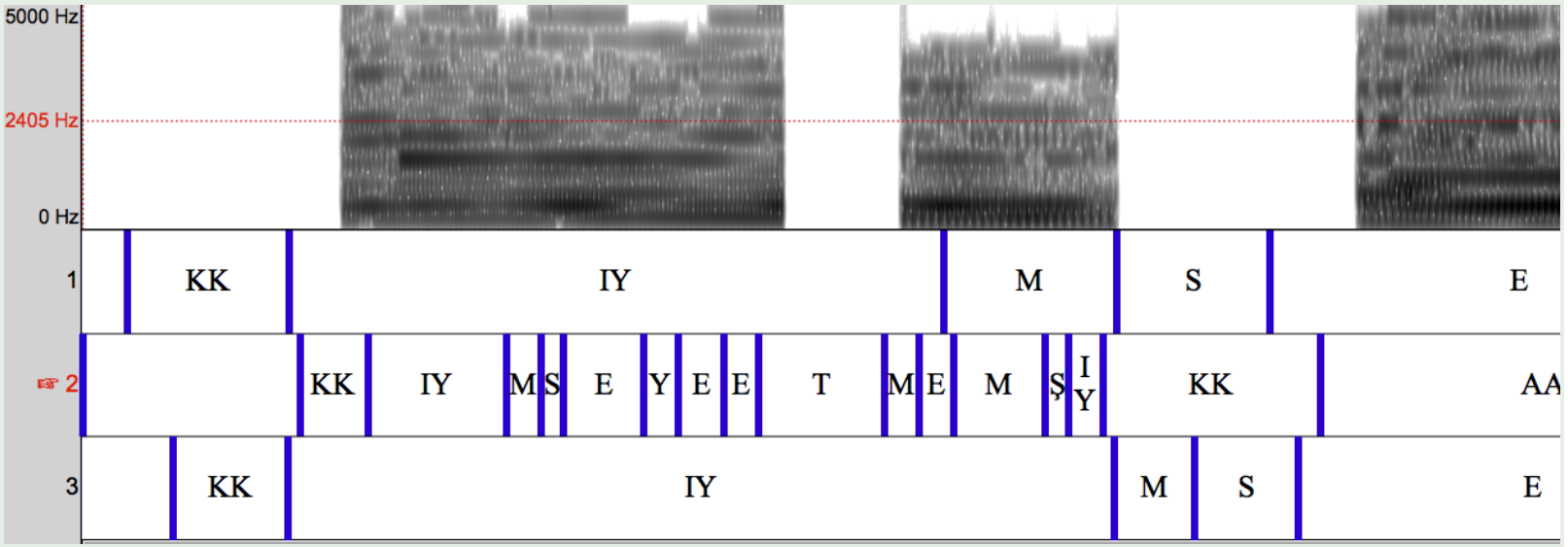
Table: Alignment accuracy and error for related work

Results


alignment accuracy (%)
musical score in-sync accuracy (%)
HMM polyphonic
DHMM polyphonic
DHMM acapella
100
90
80
70
60
50
40
65
70
75
80
85
90
95
100

Results

Example phoneme-level alignment



Conclusion and Future

- extension to a HMM decoding with duration modeling
  - reference durations extracted from score
  - allows tracking duration variability
- vocal segregation by harmonic modeling

Conclusion and Future

- extension to a HMM decoding with duration modeling
  - reference durations extracted from score
  - allows tracking duration variability
- vocal segregation by harmonic modeling

- improve vocal extraction
- rely on automatic note-segmentation instead of score

References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Melody extraction from polyphonic music signals using pitch contour characteristics.
Audio, Speech, and Language Processing, IEEE

Questions and answers

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http://twitter.com/georgi_d_
https://github.com/georgid/AlignmentDuration
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