Smoothing of micromelodic effects in fundamental frequency contours

Raphael Winkelmann
raphael@phonetik.uni-muenchen.de

Institute of Phonetics and Speech Processing, Ludwig-Maximilians-Universität München

Hauptseminar Prosodie und Intonation II at Venice International University
2009-04-16

table of contents

definition

- prosody:
  - prosody is the rhythm, stress and intonation of connected speech
- macroprosody:
  - intentional manipulation of duration, fundamental frequency and amplitude
- microprosody:
  - non-intentional segmental influences on duration, fundamental frequency and amplitude

definition

- microprosody can be subdivided into:
  - intrinsic pitch (**IF0**)
    - intrinsic pitch is positively correlated with vowel hight: [i] > [e] > [a]
  - cointrinsic pitch (**CF0**)
    - cointrinsic pitch studies indicate a higher F0 in the vicinity of voiceless as opposed to voiced obstruents

motivation

The goal is to separate micro- from makro-prosody and find factors in fundamental-frequency-contours that are responsible for IF0 and CF0. This method has to work without any knowledge about segmental information. After finding the factors that are responsible for IF0/CF0 these factors can be set to zero to then calculate the resulting "pure" macro-prosody

tool requirements/goals

- developing a tool to filter micromelody effects while retaining macro-intonation
- pure bottom up
  - tool has to work on any voiced segment independent of segmental information
- integrate tool in EMU Speech Database System

previous studies

previous studies have shown that there are global differences in IF0 and CF0.

- global comparisons of IF0 have shown that IF0 is positively correlated with vowel-height
- global comparisons of CF0 have shown that F0 is higher in the vicinity of voiceless obstruents as opposed to voiced obstruents

previous applications

- with previous smoothing applications (e.g. Momel) it is unclear whether the smoothing only effects the IF0/CF0 and if it fully extracts all of the micro-prosodic effects

A short introduction to Momel(MELodic MOdelisation)

- iterative approximation through parabels
- windowing of F0-contour
- in every window a parabel p gets iteratively fitted to the original F0 segment so that p fits the contour best in an LMS sense.
- through every new fitting original-F0 values that deviate from the last fitted parabel by a certain measure are ignored: removal of micro-prosody and measurement errors
- the iteration procedure ends, when no more original-F0 values are found that deviate from the last fitted parabel by a certain measure
- extrema of the parabels are used as anker-points for a spline function to smooth the F0-contour

data used/preprocessing

- Kiel spont. Corpus
  - (quasi-)spontaneous speech
  - turn-based file segmentation
  - hand-labeled
  - not controlled for macro- or microprosody

preprocessing (Kiel spont. Corpus)

1. data alignment
   - alignment of fundamental frequency information with hand-labeled transcription and syllable separators
2. calculate derived data
   - for further studies a few derived data values were calculated (e.g. average segmental F0, baseline values, time-normalized values, ...)

Kiel Corpus: data evaluation

global studies of the Kiel Corpus data:

- mean over whole vowel contour (zeros omitted) in CVC sequences
- one-way ANOVA, factor: tongue height
- Tukey-Kramer posthoc

Kiel Corpus: data evaluation

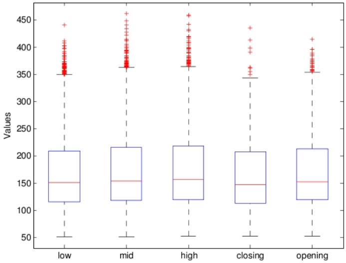


Figure: global analysis IF0

Kiel Corpus: data evaluation

IF0 results:

- ANOVA: means significantly different (p=0)
- posthoc: significant mean differences (alpha=0.05): **low** < **mid**, **mid** < **high**

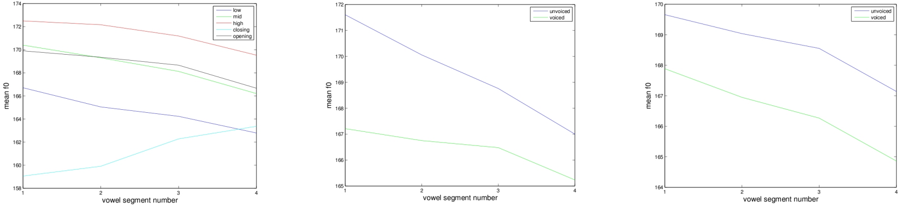
Kiel Corpus: data evaluation

CF0 studies

- motivation:
  - determine the length of the scope of the vowel on intrinsic f0
  - determine the length of the scope of neighboring consonants on co-intrinsic f0
- method
  - dividing vowels in CVC sequences into 4 segments of equal size (overlap: 0.5*window length)
  - mean for each segment (zeros omitted)
  - three-way ANOVA for each segment , factors: tongue height, voice(C1), voice(C2)
  - Tukey-Kramer posthoc

Kiel Corpus: data evaluation

plots



(a) mean.F0 in CVCs

(b) mean-F0 C1 voiced vs. unvoiced

(c) mean-F0 C2 voiced vs. unvoiced

Figure: F0 contours with and without micro-melodic effects

Kiel Corpus: data evaluation

- results
  - ANOVA, posthoc:
    - significant mean differences in dependence of factor tongue height in all segments (p=0; same as for global means)
    - voice(C1): **unvoiced** greater than **voiced** for segments 1–3 (p=[0.0000 0.0002 0.0306 0.1739])
    - voice(C2): **unvoiced** greater than **voiced** for segments 1–4 (p=[0.0406 0.0107 0.0009 0.0000])
- conclusions
  - intrinsic f0 related to vowel height in whole vowel
  - co-intrinsic f0 of C1 related to voice in 1st-3rd quarter of vowel
  - co-intrinsic f0 of C2 related to voice in whole vowel

Kiel Corpus: filtering

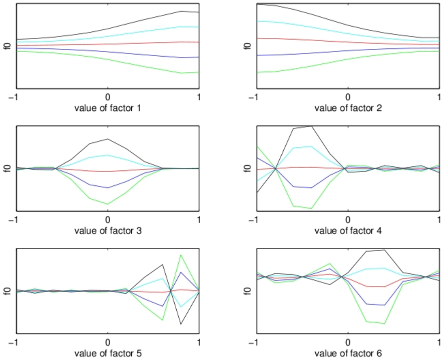
- idea:
  1. separation of F0-contour into macro- and micro-prosodic components
  2. in application: analysis-by-synthesis + smoothing due to setting the respective components to a value of zero
- separation: uniqueness of the approximation has to be given (as is the case with: polyfit, dct)
- the search for microprosodic-components
  - required: segmental information (hence segmented corpus)
  - question: are there components that only differentiate significantly according to segmental differences?

Kiel Corpus: PCA, factor analysis

- motivation:
  - find principal components/ factors related to intrinsic or co-intrinsic f0
- method:
  - orthogonalise f0 contour by PCA or factor analysis
  - case FA: oblique promax rotation
  - n-way ANOVA for all PCs or factors: vowel height, voice(C1), voice(C2), etc.
  - identify PCs whose means differ significantly with the factors
  - do the same after baseline subtraction
- results:
  - no interpretable results, large differences for the majority of components and factors

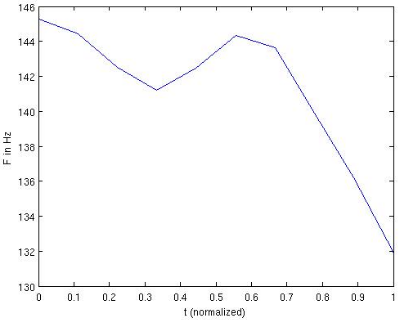
Kiel Corpus: PCA, factor analysis

plots: factor analysis



Kiel Corpus: example

time normalised F0 contour for [i:] segment from Kiel Corpus



Kiel Corpus: example

perform dct to get the following values:

number	DCTvalue	number	DCTvalue
1	446.4617	6	-0.5944
2	9.4029	7	-0.7546
3	-5.2135	8	0.4906
4	6.5519	9	-0.3732
5	-0.4011	10	0.2295

Kiel Corpus: example

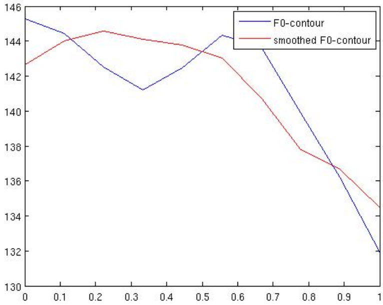
perform dct to get the following values:

number	DCTvalue	number	DCTvalue
1	446.4617	6	-0.5944
2	9.4029	7	-0.7546
3	-5.2135	8	0.4906
4	**6.5519**	9	-0.3732
5	-0.4011	10	0.2295

If we hypothesise that the fourth coefficient is responsible for the micro-melodic effects. We can then set its value to zero and resynthesize the new smoothed F0-contour

Kiel Corpus: example

the smoothed contour:



<u>the end</u>