Österreichisches Forschungsinstitut für Artificial Intelligence

Intonation Modelling

(Fujisaki and more)

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Austrian Research Inst. for Artificial Intelligence (OFAI)

presentation given XI.2004 at the
Technical University Graz, Austria

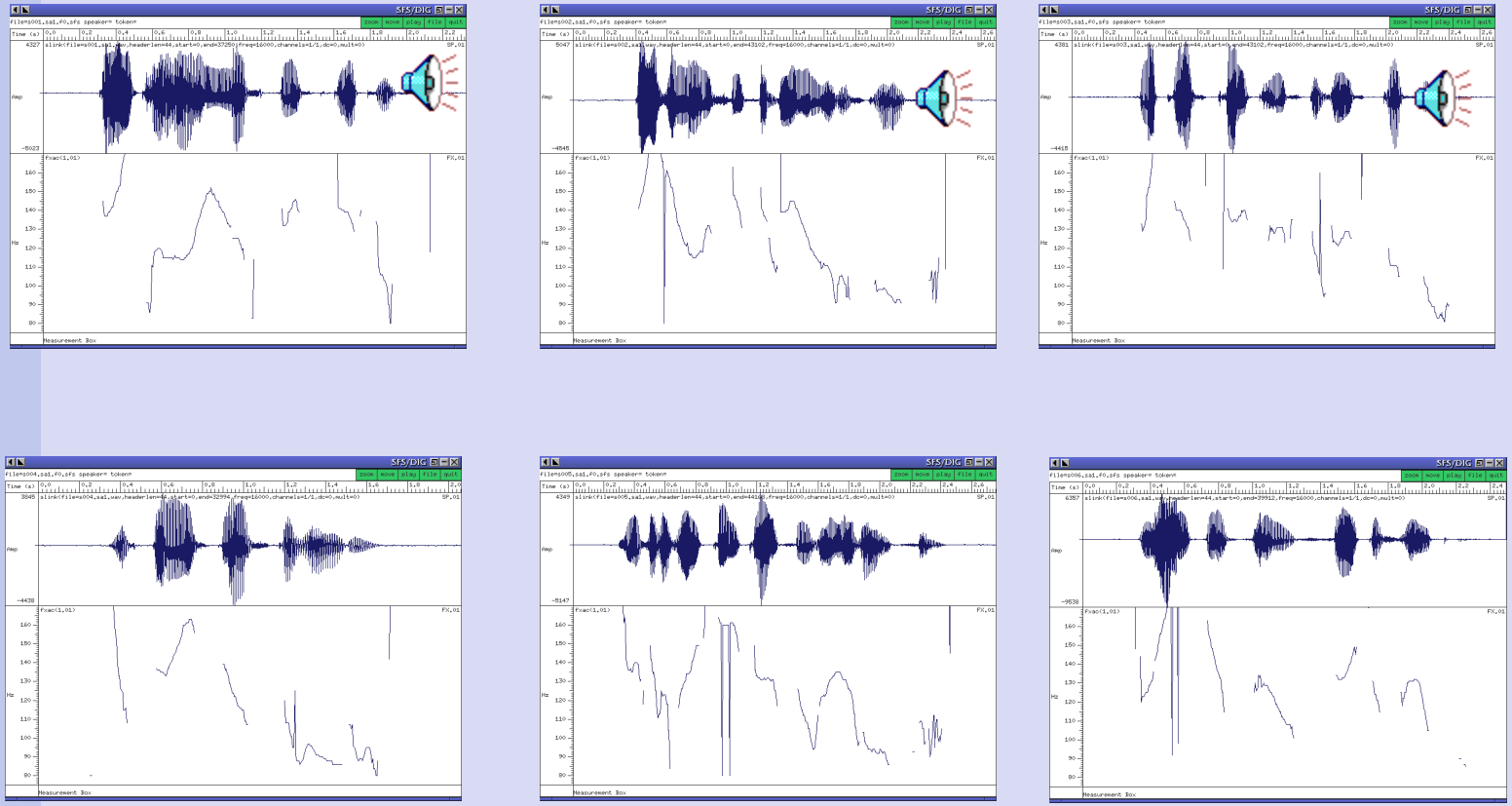
Intonation
Linguistic Functions

- Emphasisis
  - (Word) Stress
  - Accentuation
- Grouping together
  - Phrasing
- Sentence Mode
  - declarative vs. interrogative
  - (continuing vs. terminating)

Intonation
Paralinguistic & Nonlinguistic factors

- Speaking style
  - e.g. spontaneous vs. read
  - fairy tail vs. Newsreader
  - social status
- Emotion
  - e.g. aroused vs. bored
- Individual Factors
  - sex
  - age ...

Intonation/Pitch/F0



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Application of Intonation Models

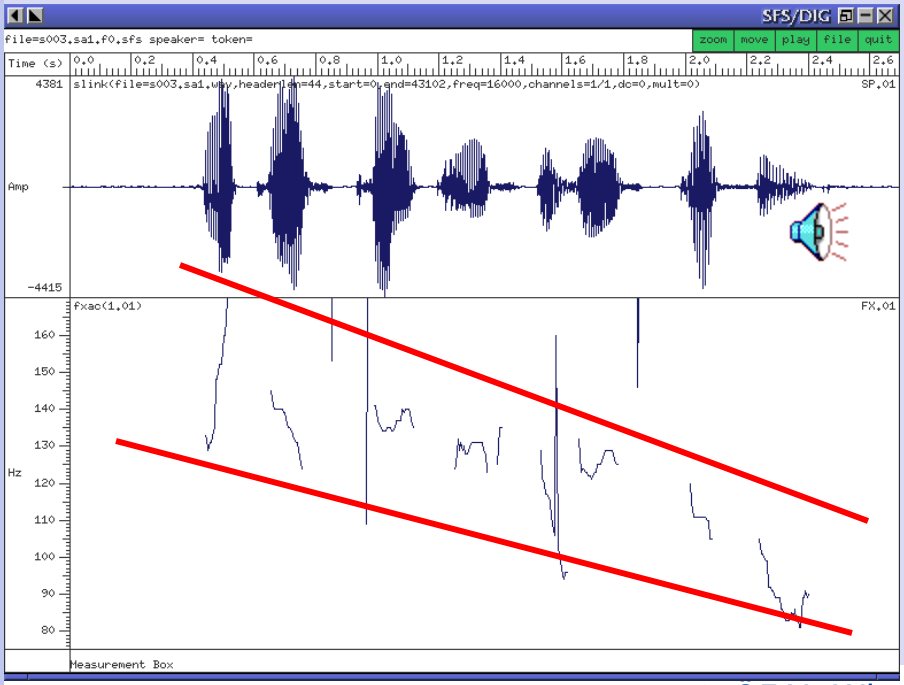
- Speech Synthesis
  - How to map linguistic function to intonation contours?
  - Aim for adequacy and naturalness
- Speech Recognition
  - Spot accents, focus stucture, sentence mode...
  - Analyse paralinguistic factors

Properties of F0-contours

- Microprosodic variaton
  - “dip” in contour at /l/
  - voiced/unvoiced transitions...

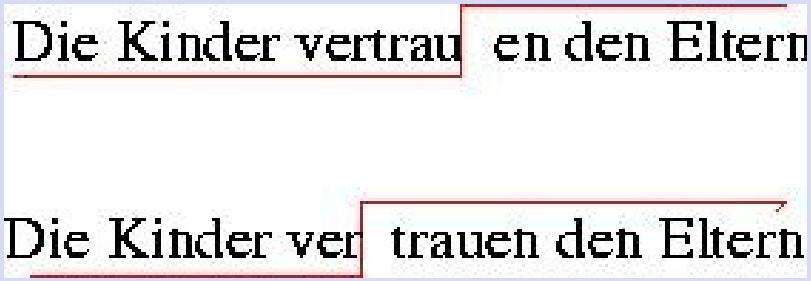
Properties of F0-contours: Declination

- Overall downtrend
  - of base- and topline.
  - reset at major phrase boundaries



Models of Intonation: Isacenko&Schaedlich 1964

- Simple switching of f0
  - between 150 : 178.6 Hz
- High correlation in listener's rating of linguistic function



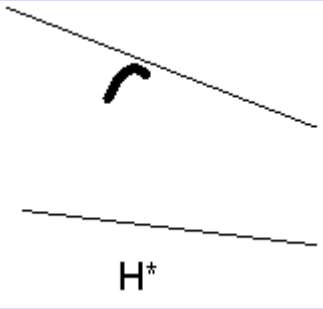
- question
- unfinished

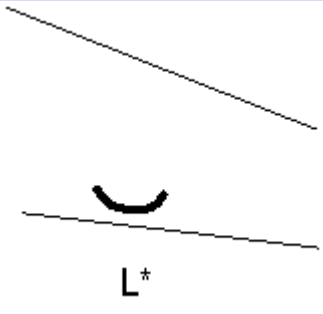
ToBI: Tones and Breaks Indices
Pierrehumbert, Hirschberg, Beckman

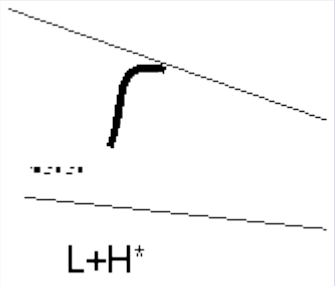
- Intonation described as series of H(igh) and L(ow) target tones
- Accent Tones
  - H*, L*, L+H*, H+L, ...
- Phrasal Tones
  - H, L
- Boundary Tones
  - H%, L%

ToBI: Tones and Breaks Indices
Accent Tones

- * denotes alignment with stressed syllable
- No direct quantitative information
  - e.g. H* can denote be a steep and high hill or a gentle slope



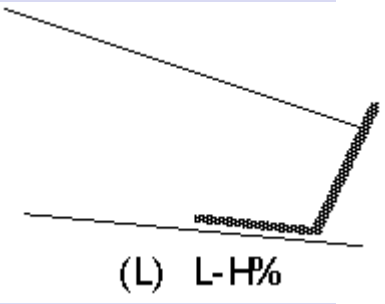


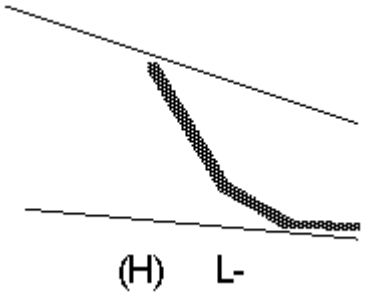


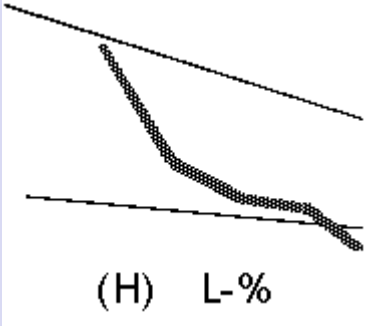
ToBI: Tones and Breaks Indices Boundaries

- Boundary tones H% and L%
- Combined with L- H-

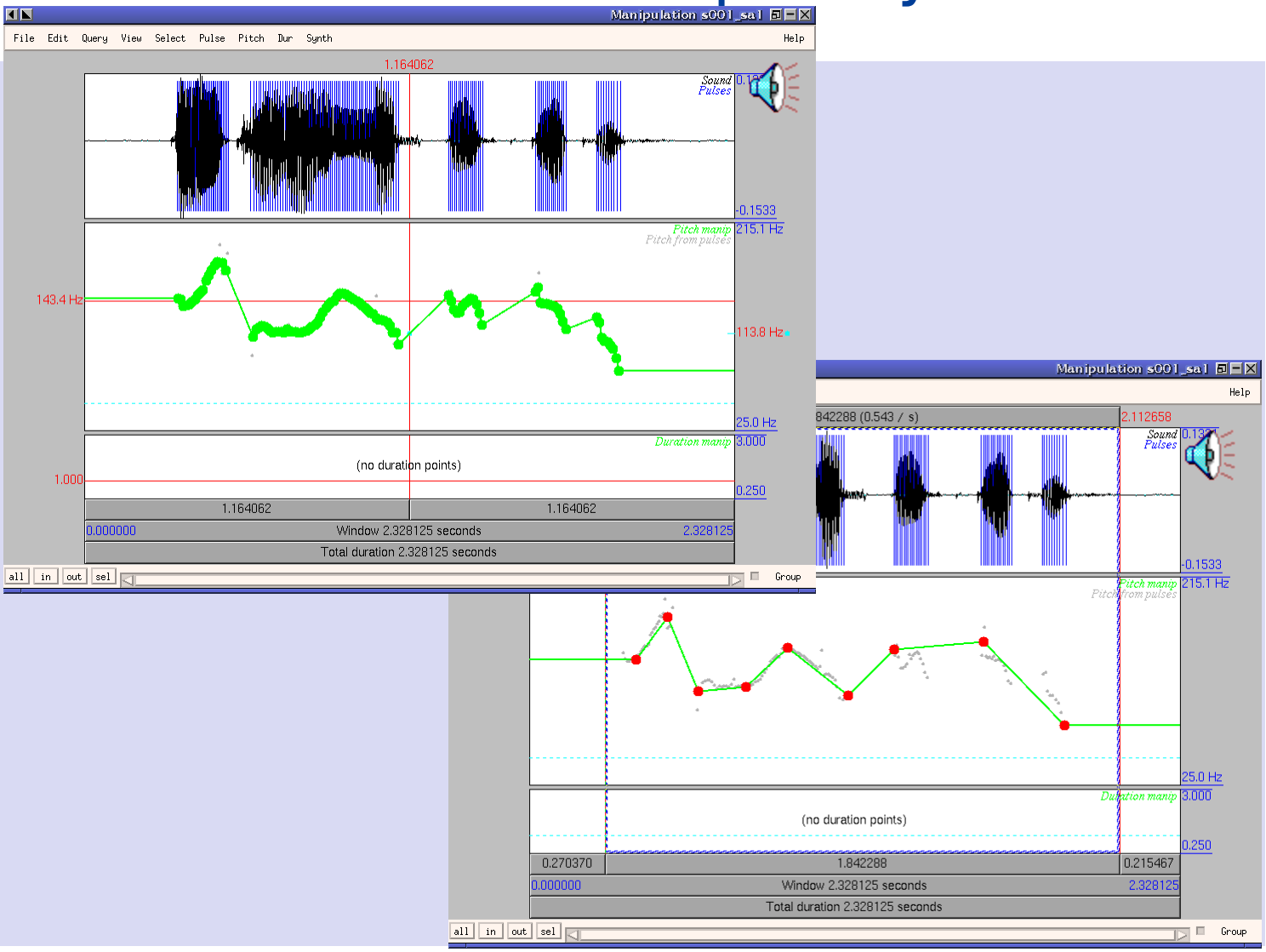
- E.g.
  - L-L% : typical final fall in declarative sentenes
  - H-H%: typical rise in questions





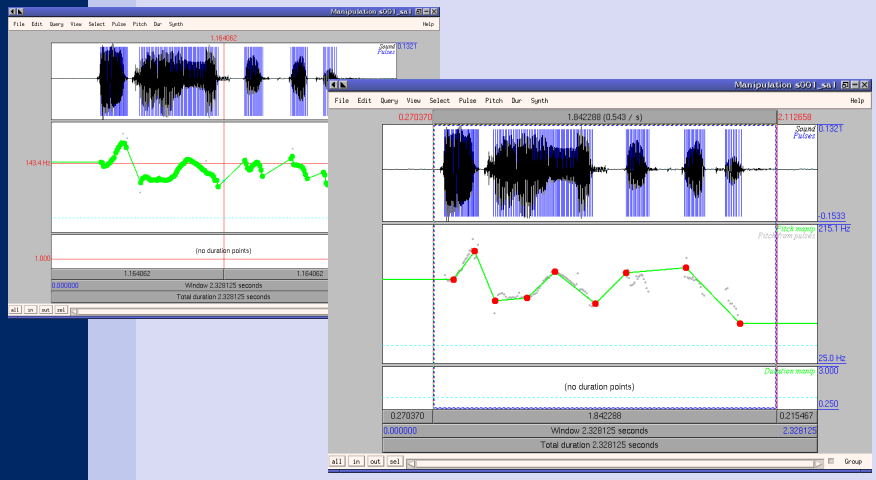


F0 - stylisation: getting rid of microprosdy, flaws, ...



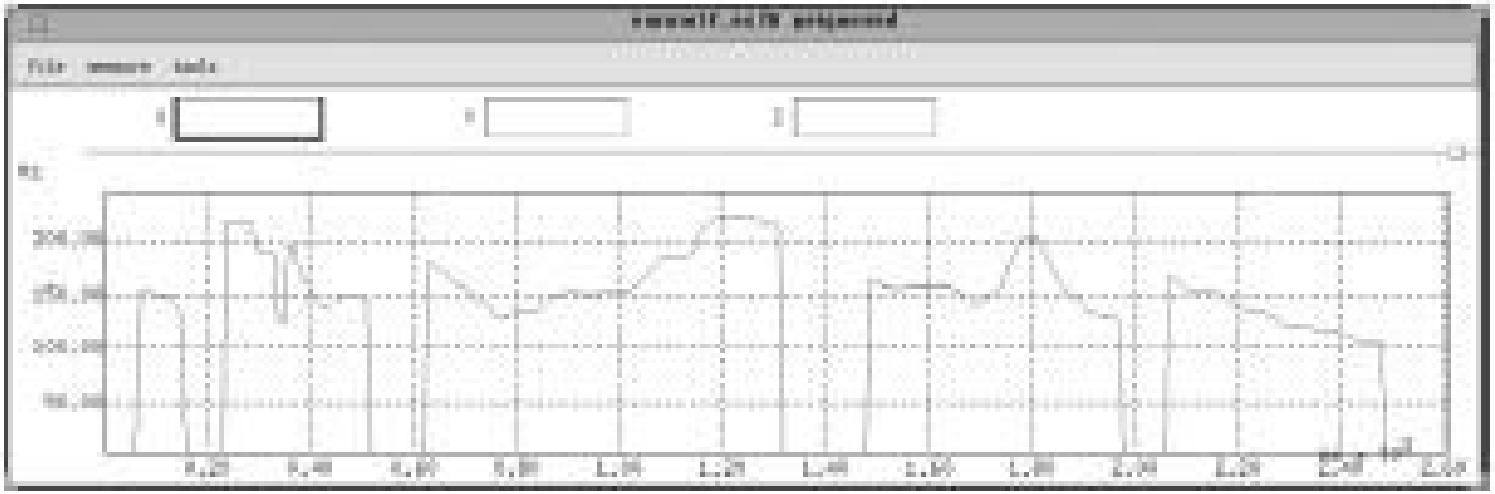
Quantitative Models of Intonation: IPO Model (tHart/Collier)

- 1. stylise to “perceptually identic”



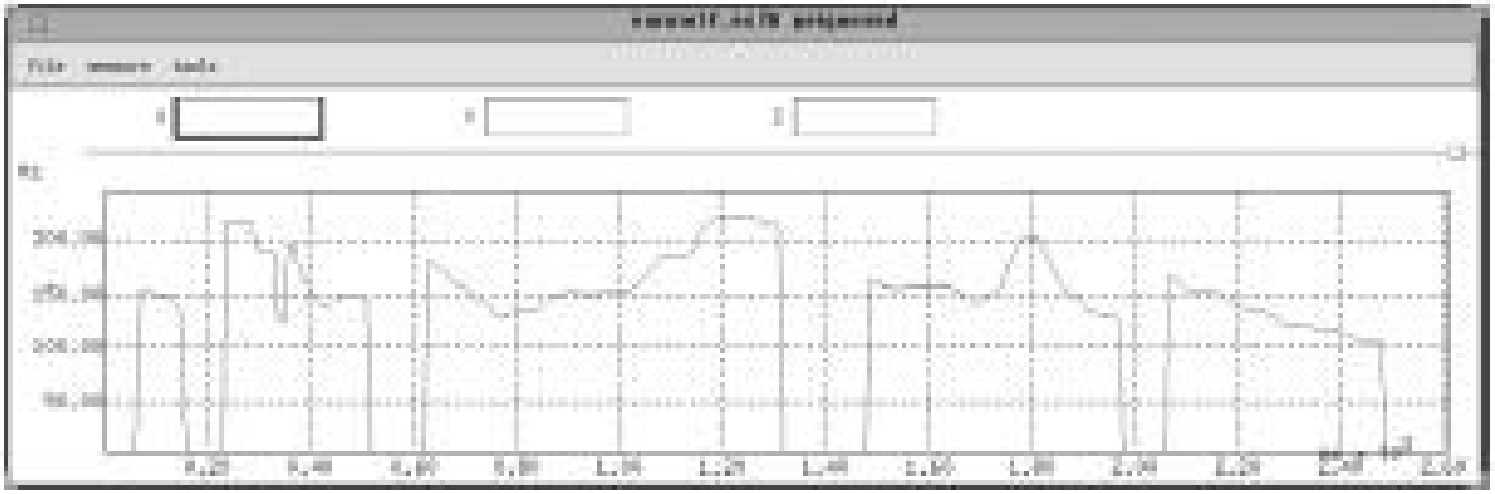
- 2. Functionally identic
- 3. Inventory of 11 accent-lending and phrase-marking movements

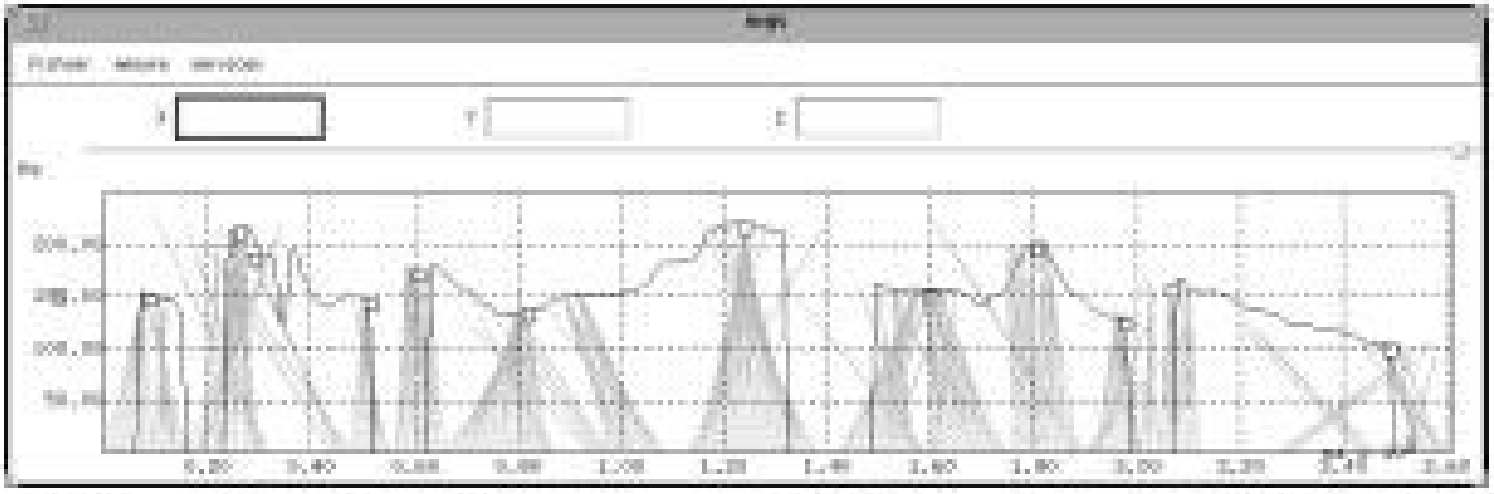
MOMEL
Melodic Modellisation (Hirst 1991)



- Modelling contour via quadratic splines
- Claimed universal (Language independent)

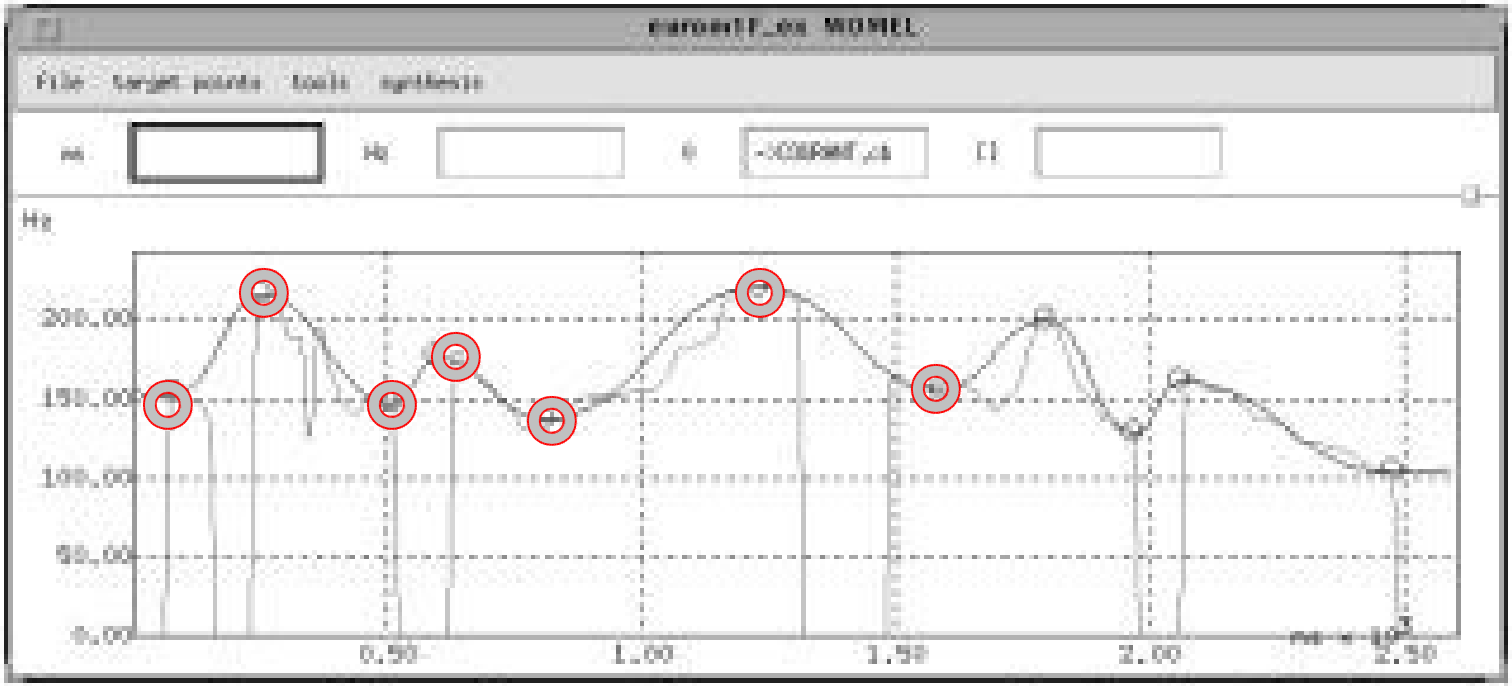
MOMEL
Melodic Modellisation (Hirst 1991)
Quadratic Splines





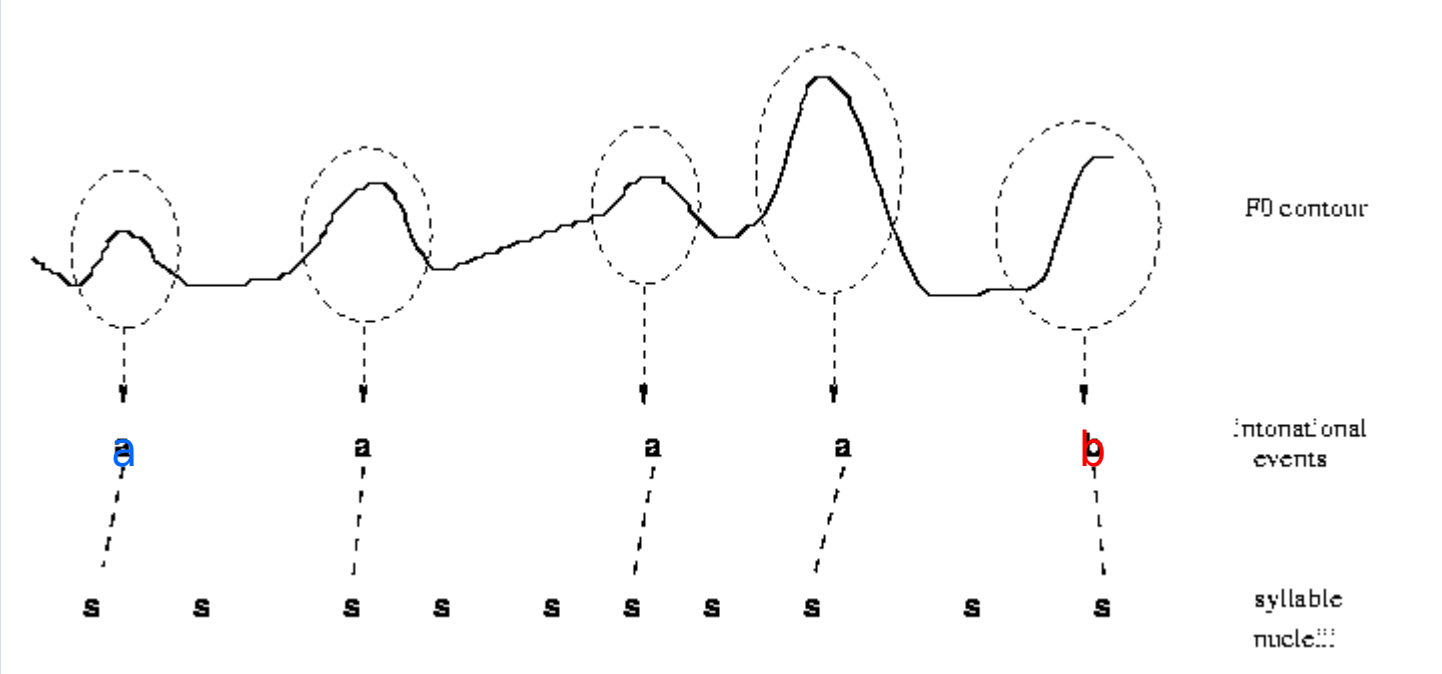
MOMEL
Melodic Modellisation (Hirst 1991)

- Freely available
- Valid smoothing method

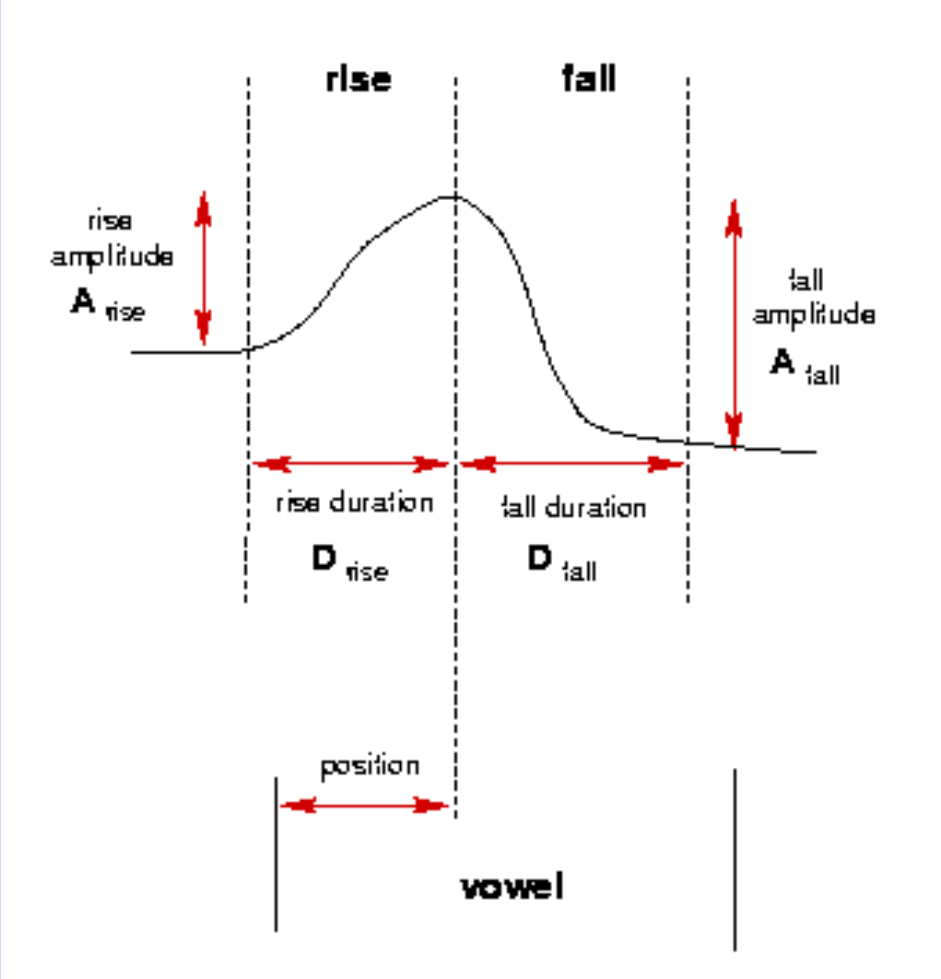


Tilt (Taylor & Black/ EST)

- Intonation contour as a series of (a)ccent and (b)oundary events



Events modelled by Rise-Fall-Coefficients (RFC)



- Amplitude
  - A_{rise}
  - A_{all}
- Duration
  - D_{rise}
  - D_{fall}
- *„Absolute Position“*
  - *Some absolute f0 value (peak, start)*
  - *Some absolut positon in timeline*

Tilt –value:
Ratio between difference and sum

$$tilt_{amp} = \frac{|A_{rise}| - |A_{fall}|}{|A_{rise}| + |A_{fall}|}$$

$$tilt_{dur} = \frac{D_{rise} - D_{fall}}{D_{rise} + D_{fall}}$$

- Tilt values
  - +1 rise component only
  - -1 fall component only
  - 0 rise and fall symetrical

Tilt –model
Reduction of necessay parameters to 3

- Intonation events encoded via:
- Dur_{event} (sum of fall and rise)
- $Amplitude_{event}$ (sum of fall and rise)
- $Tilt_{event}$
- (absolute positioning)

Combined into global Tilt value

- tiltAmp and tiltDur highly correlated
- Combined into:
- tilt = (tiltAmp + tiltDur) / 2

$$tilt = \frac{|A_{rise}| - |A_{fall}|}{2(|A_{rise}| + |A_{fall}|)} + \frac{D_{rise} - D_{fall}}{2(D_{rise} + D_{fall})}$$

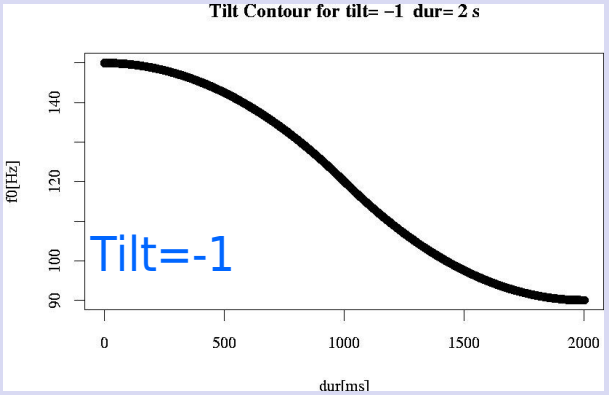
Tilt –value:
Ratio between difference and sum

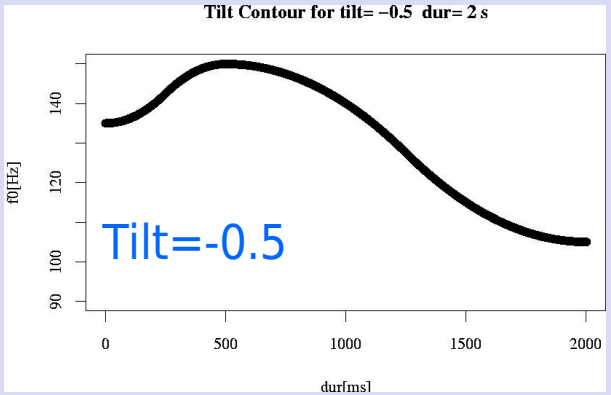
$$tilt_{amp} = \frac{|A_{rise}| - |A_{fall}|}{|A_{rise}| + |A_{fall}|}$$

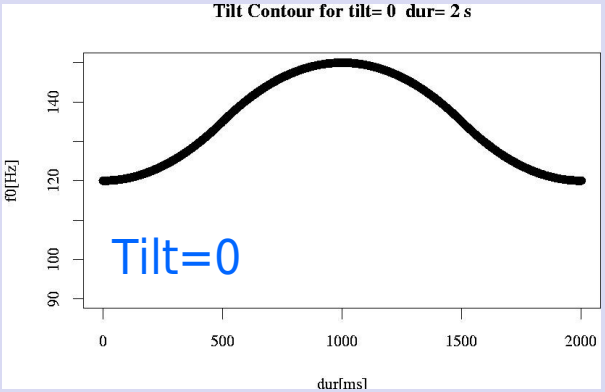
$$tilt_{dur} = \frac{D_{rise} - D_{fall}}{D_{rise} + D_{fall}}$$

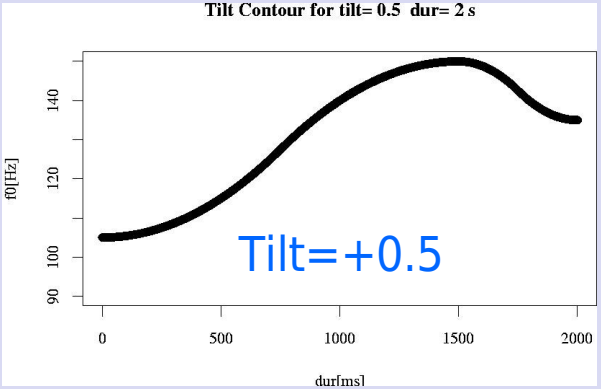
$$tilt = \frac{|A_{rise}| - |A_{fall}|}{2(|A_{rise}| + |A_{fall}|)} + \frac{D_{rise} - D_{fall}}{2(D_{rise} + D_{fall})}$$

Tilt
Dur=2sec, Amp=60, F0peak=150



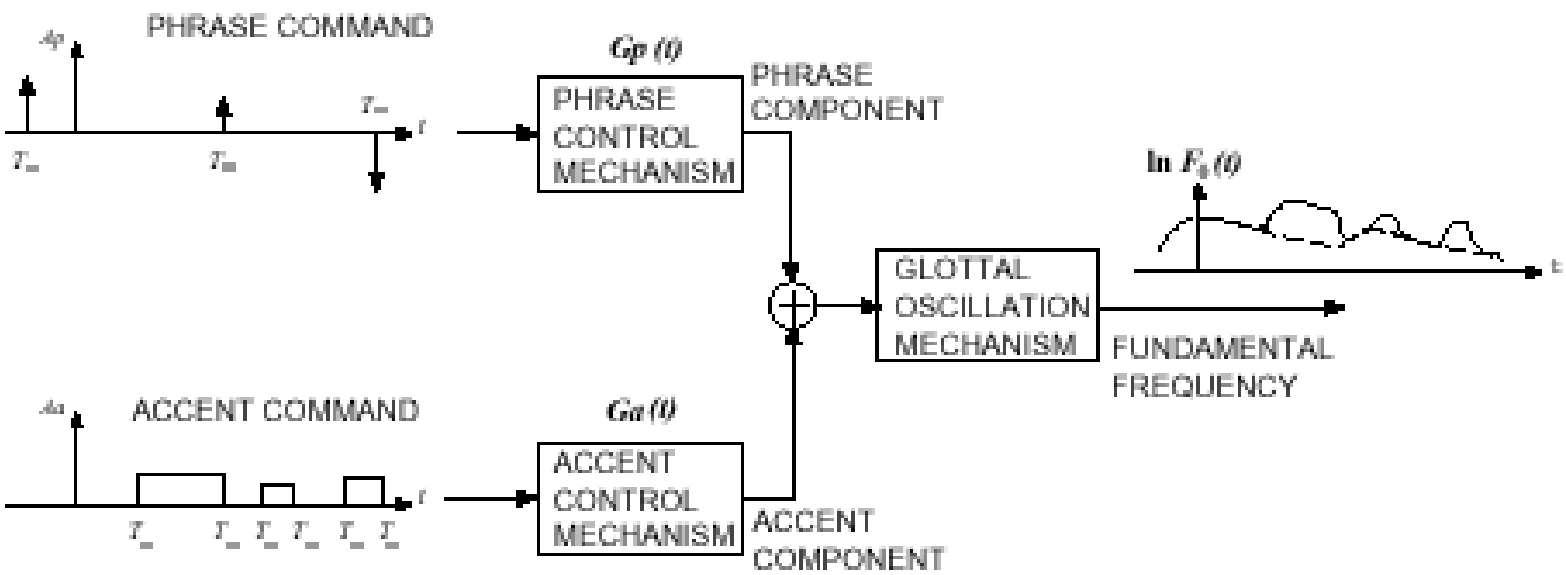






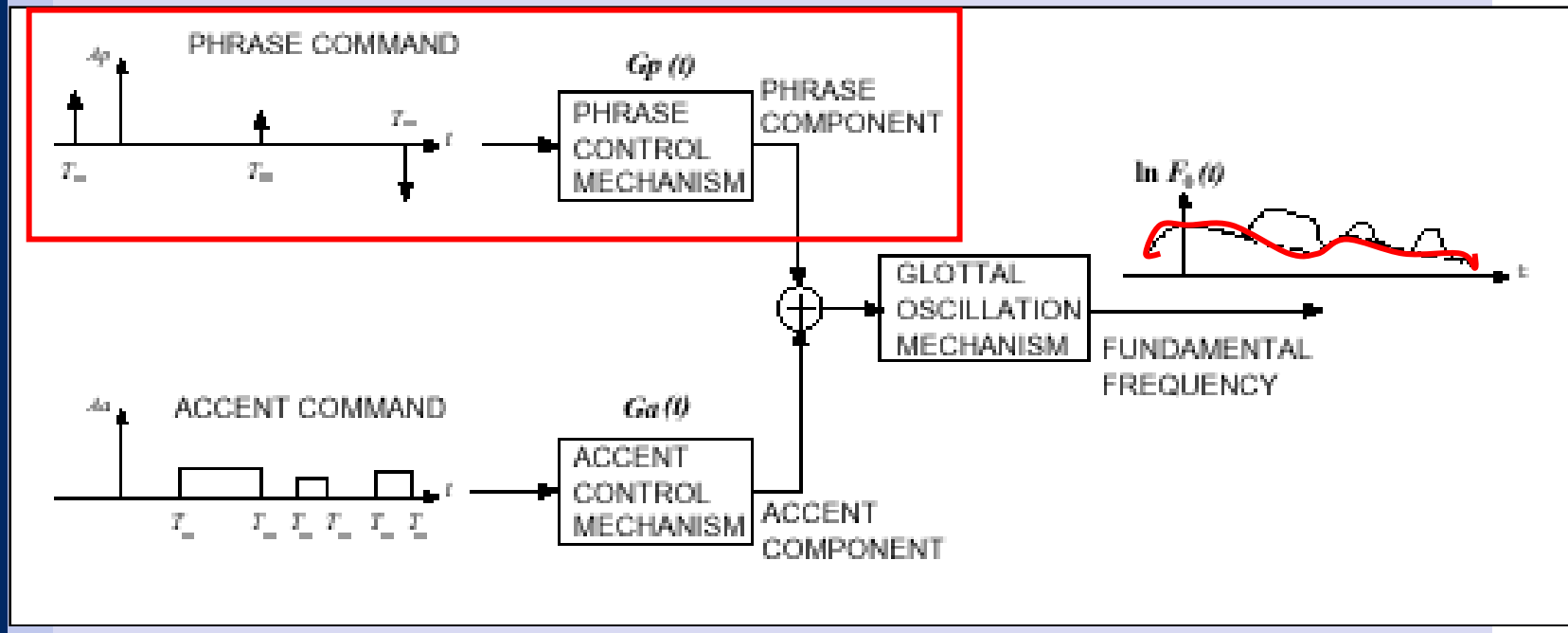
Fujisaki-Model
Hiroya Fujisaki 1984

- Superpositional Model: F0 production modelled by 2 separate components



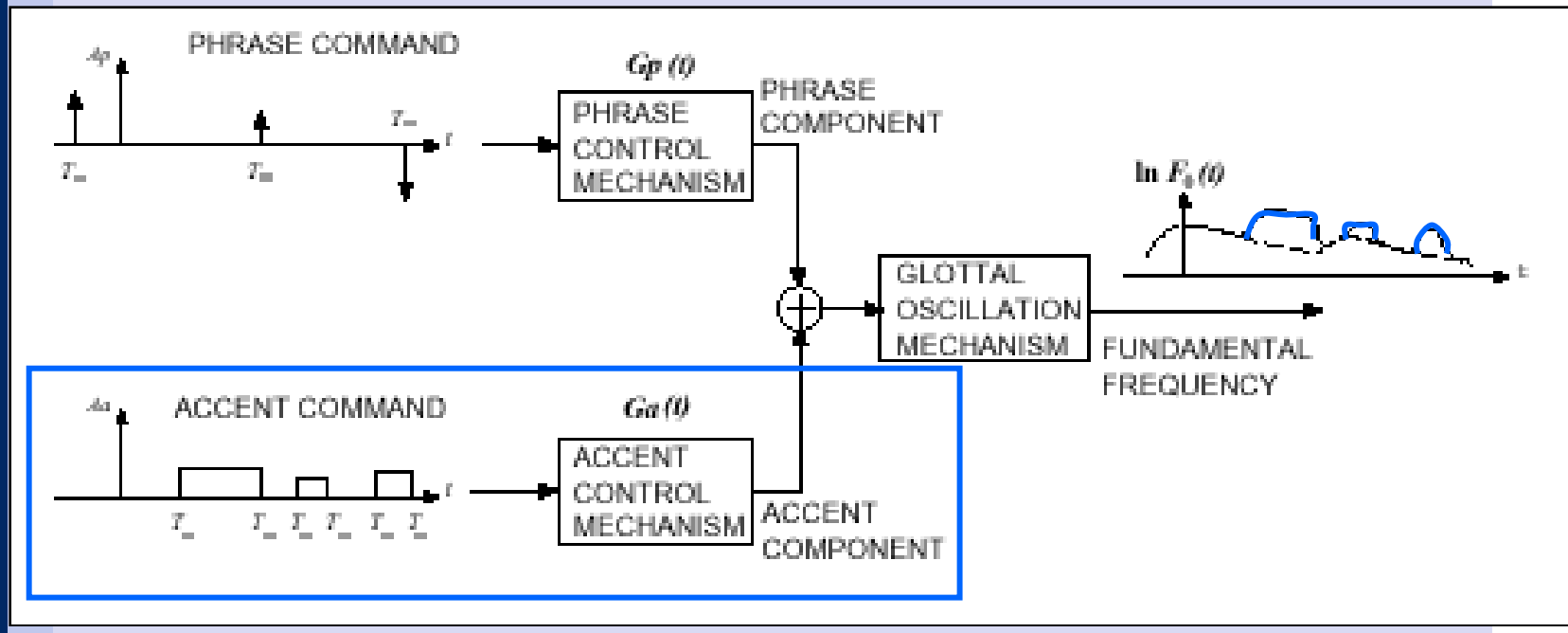
Fujisaki-Model
Hiroya Fujisaki 1984

- PHRASE component driven by:
  - Phrase commands: Tp and Ap



Fujisaki-Model
Hiroya Fujisaki 1984

- ACCENT component driven by:
  - Accent commands: switch on and off at T1, and T2, Aa



Addition in the logarithmic domain

- F0 = Baseline + PhraseComponent + AccentComponent

$$\ln F_0(t) = \ln F_b + \sum_{i=1}^{I} A_{pi} G_p(t - T_{0i}) + \sum_{j=1}^{J} A_{aj}[G_a(t - T_{1j}) - G_a(t - T_{2j})].$$

$$G_p(t) = \begin{cases} \alpha^2 t \exp(-\alpha t), & \text{for } t \geq 0, \\ 0, & \text{for } t < 0. \end{cases}$$

$$G_a(t) = \begin{cases} \min\left[1 - (1 + \beta t) \exp(-\beta t), \gamma\right], & \text{for } t \geq 0, \\ 0, & \text{for } t < 0. \end{cases}$$

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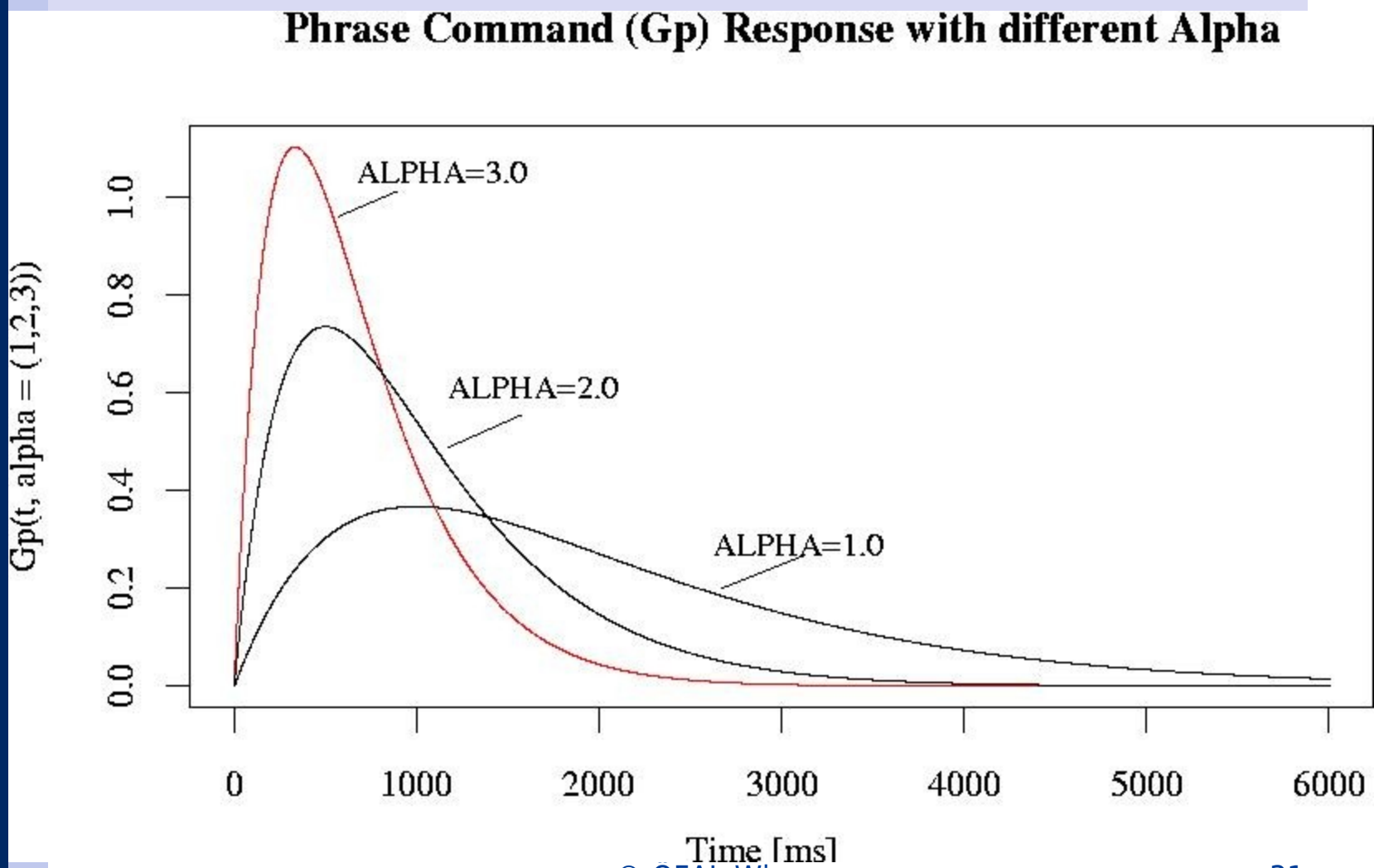
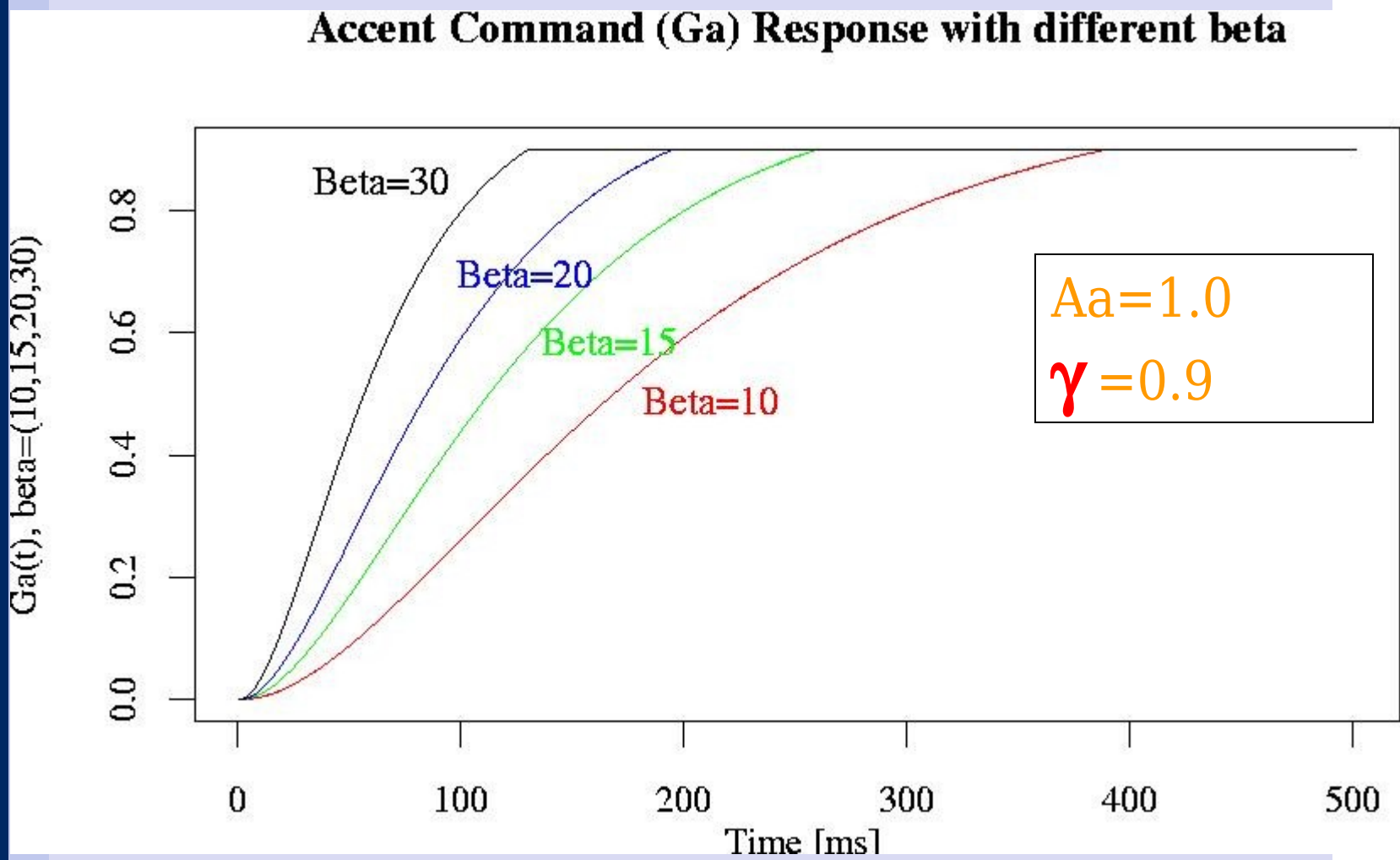
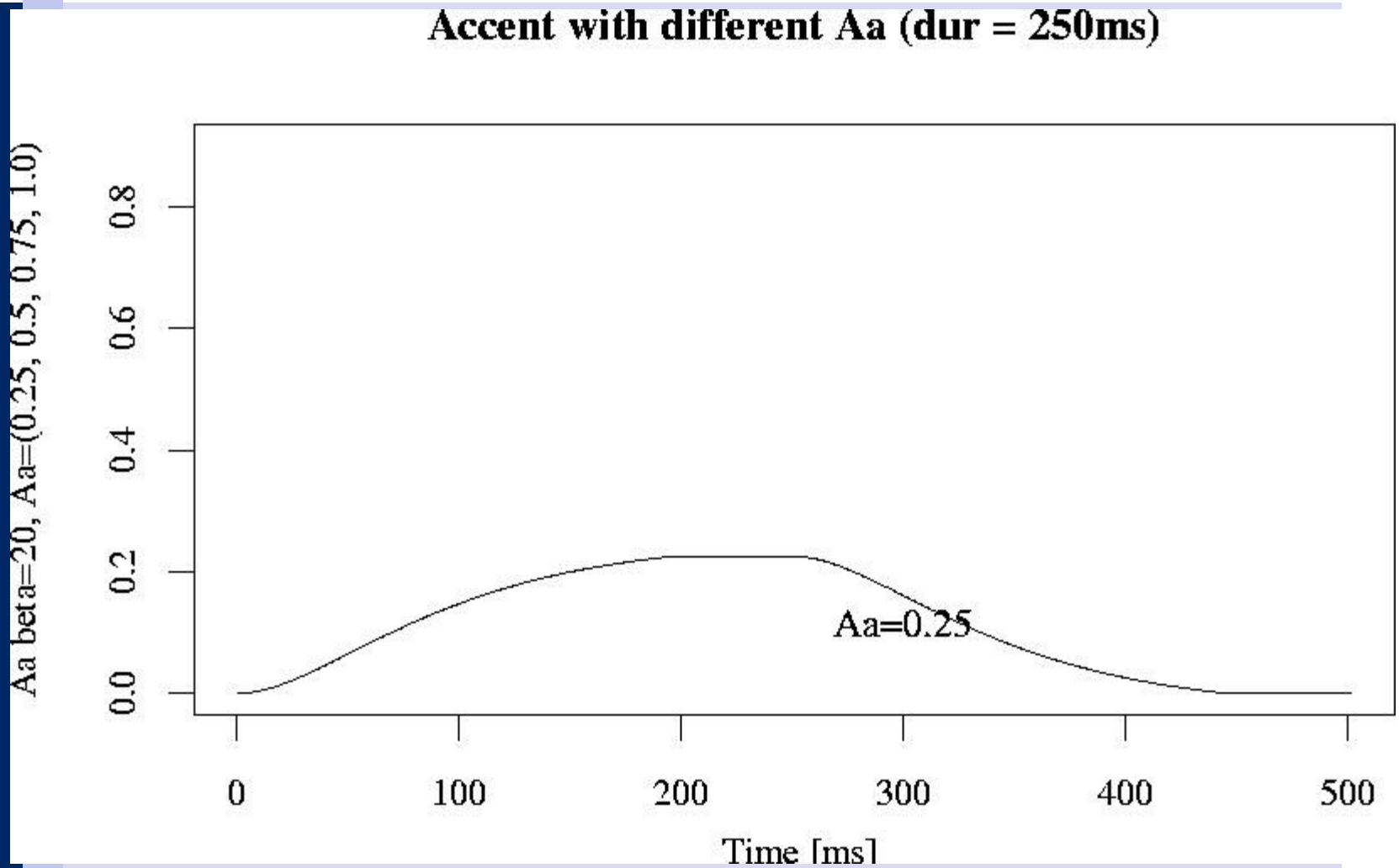
Phrase Component
$Gp(t) = \alpha^2 t \exp(-\alpha t))$



Accent Command:
$Ga(t)=\min[1 - (1+\beta t) * \exp(-\beta t), \gamma]$



Accent form with different Amplitude Aa



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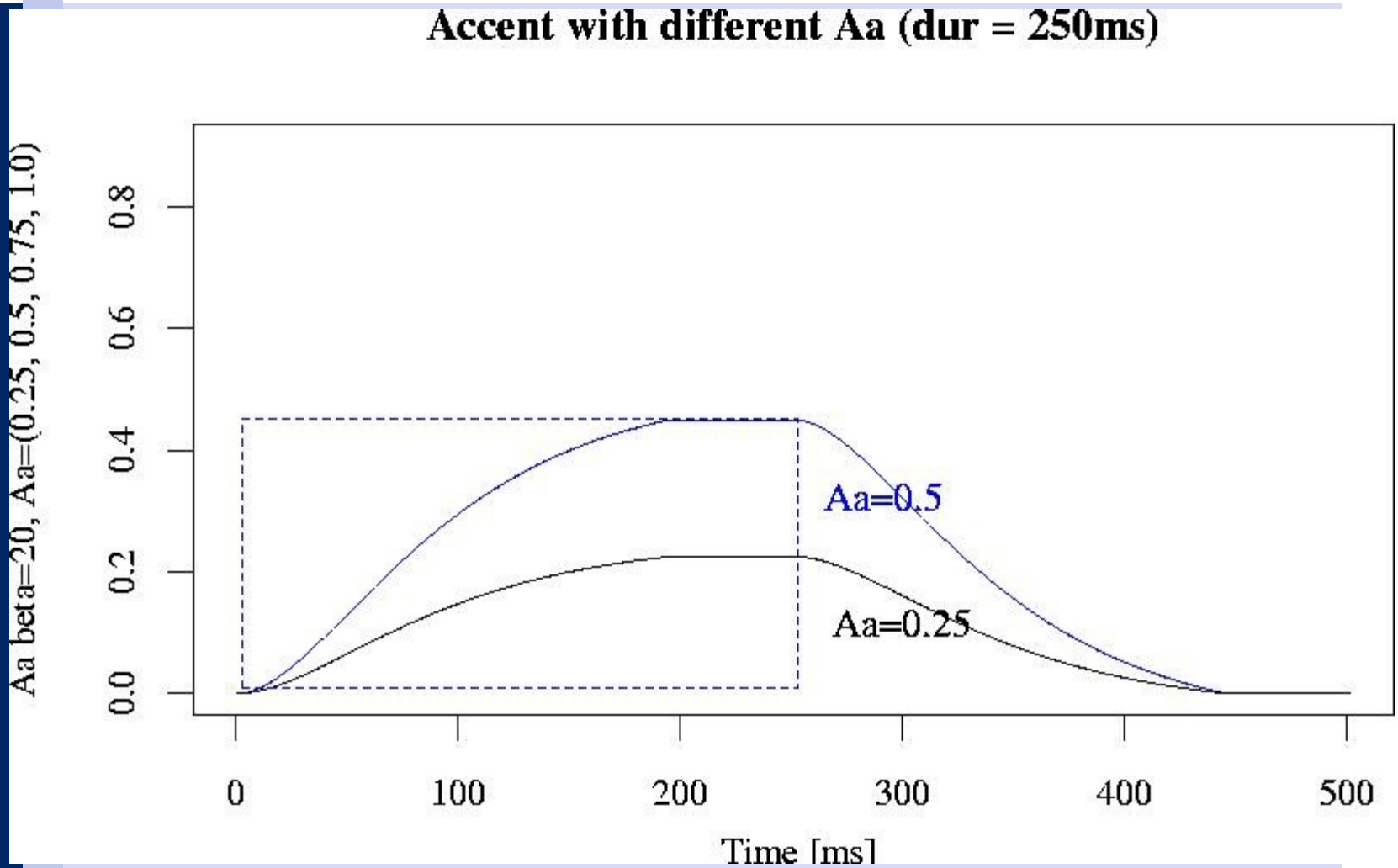

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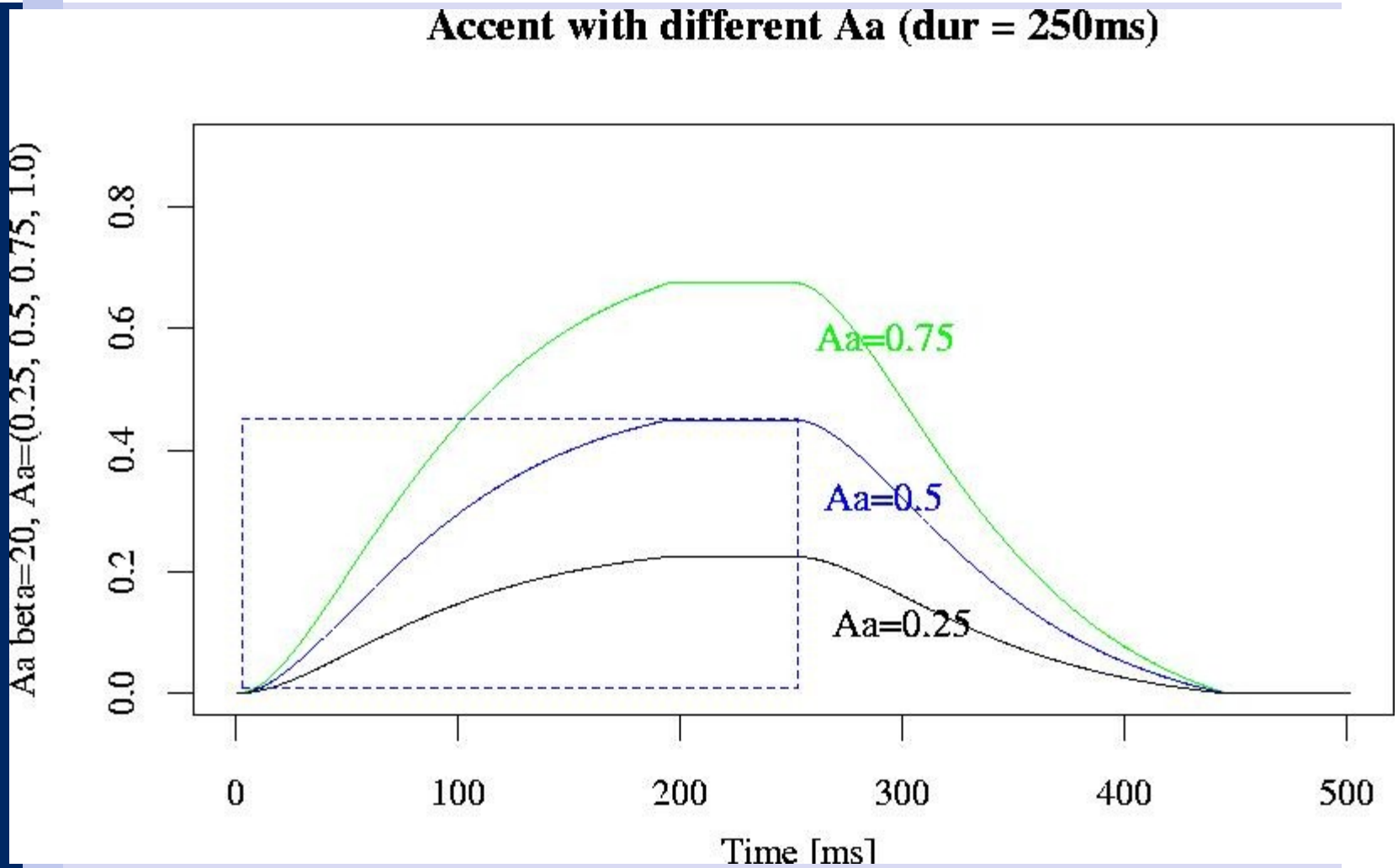
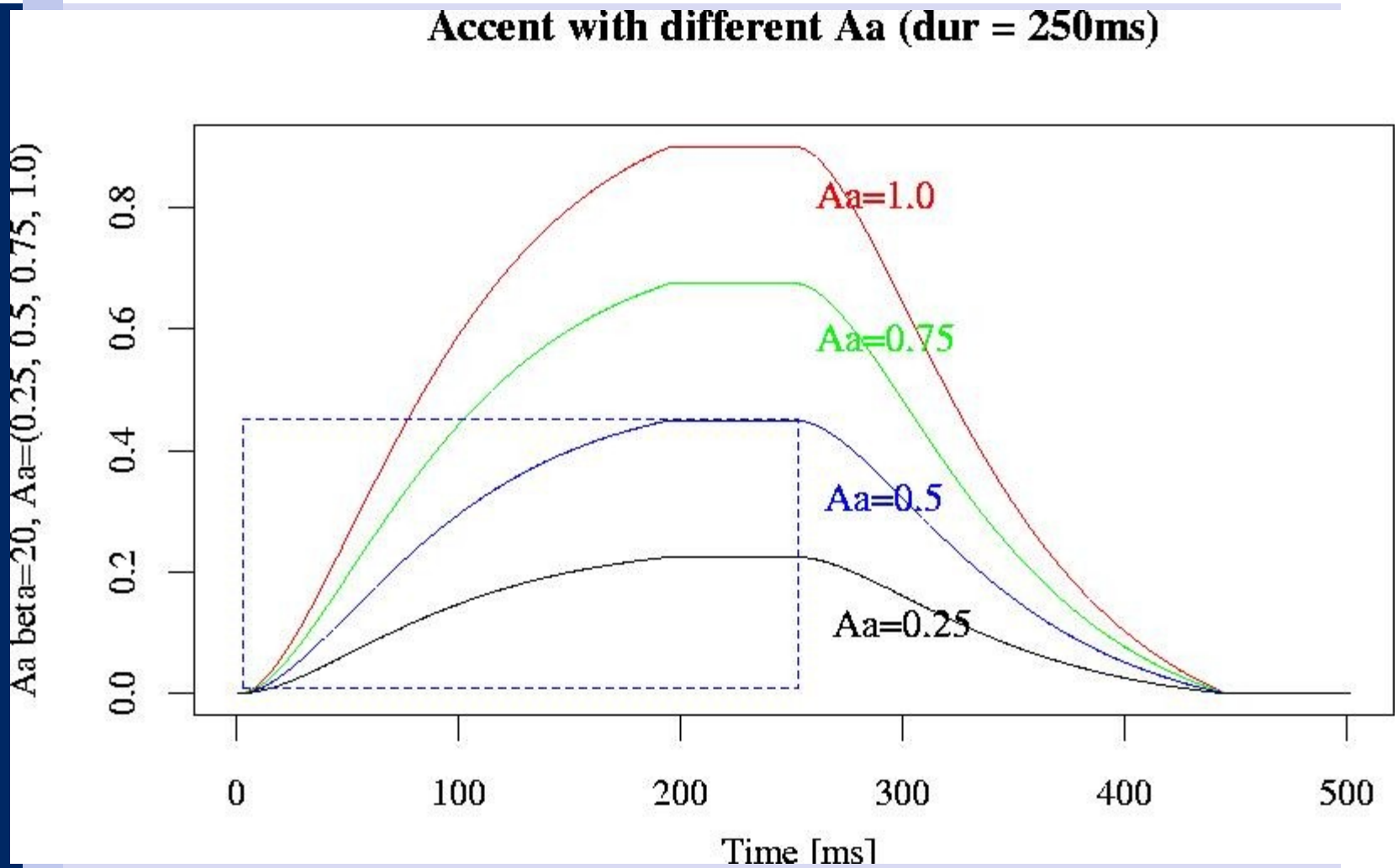
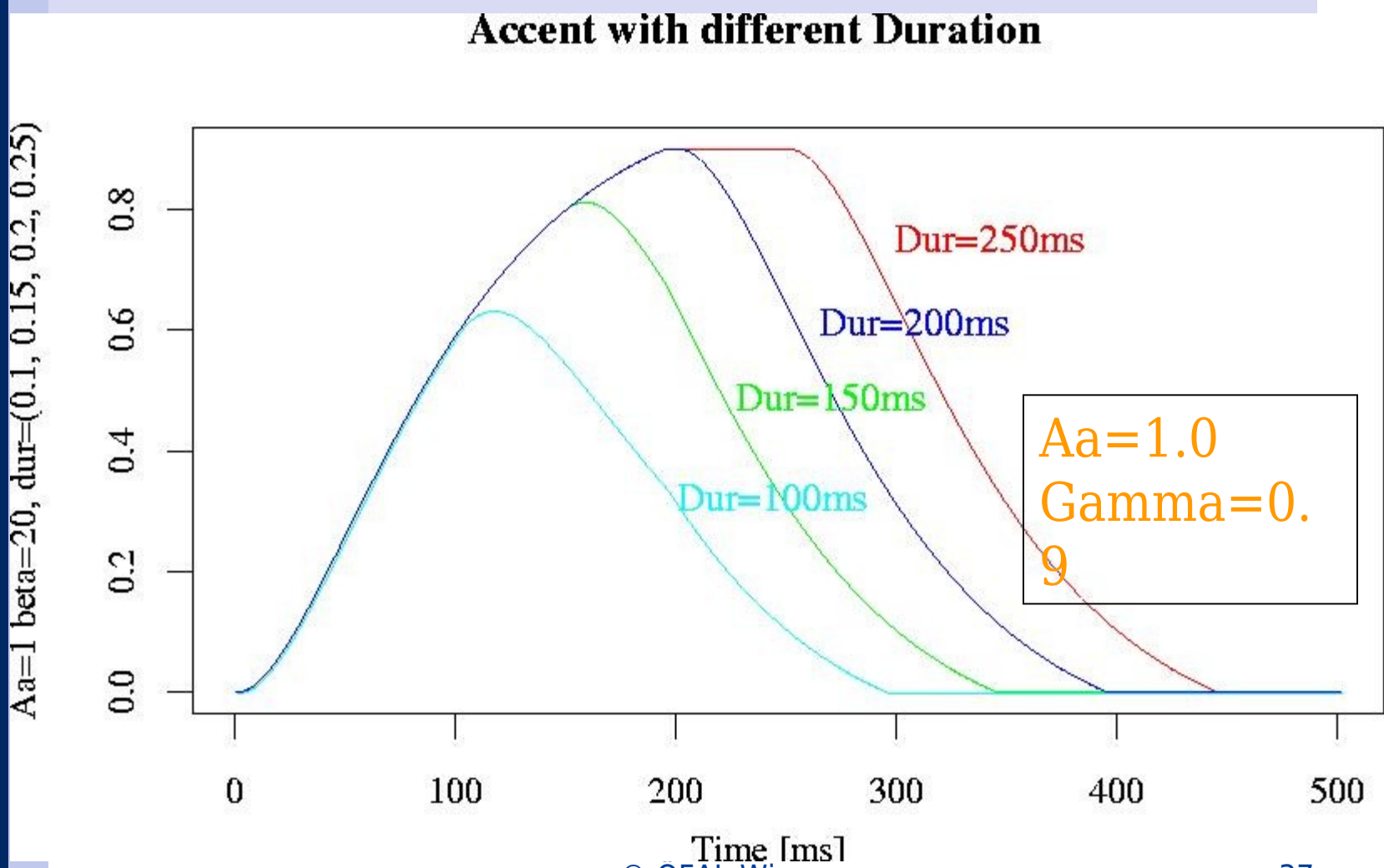


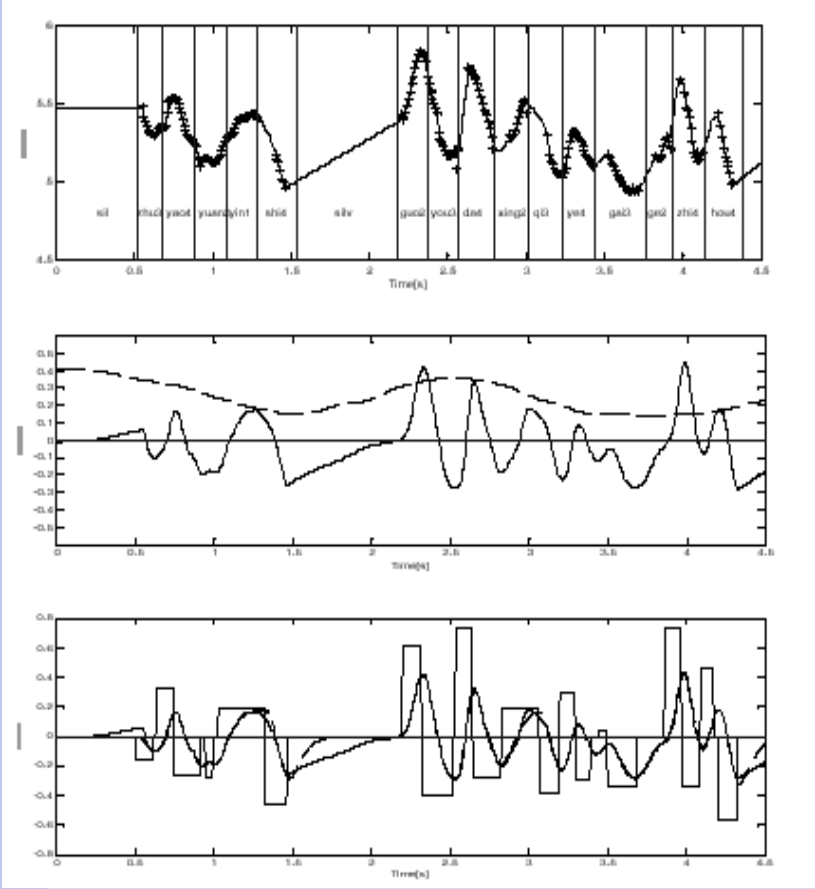
Accent form with different Amplitude Aa



Accent form with different Duration



How to extract Phrase- and Accent-Commands



- 1. Smoothing
- 2. Highpassfilt (0.5 Hz): HFC
- 3. Subtract: LFC
  - Minima ->Tp
  - Maxima -> ~ Ap
- 4. HFC
  - Minima -> Ta1
  - Maxima -> Ta2
- 5. Hillclimb search

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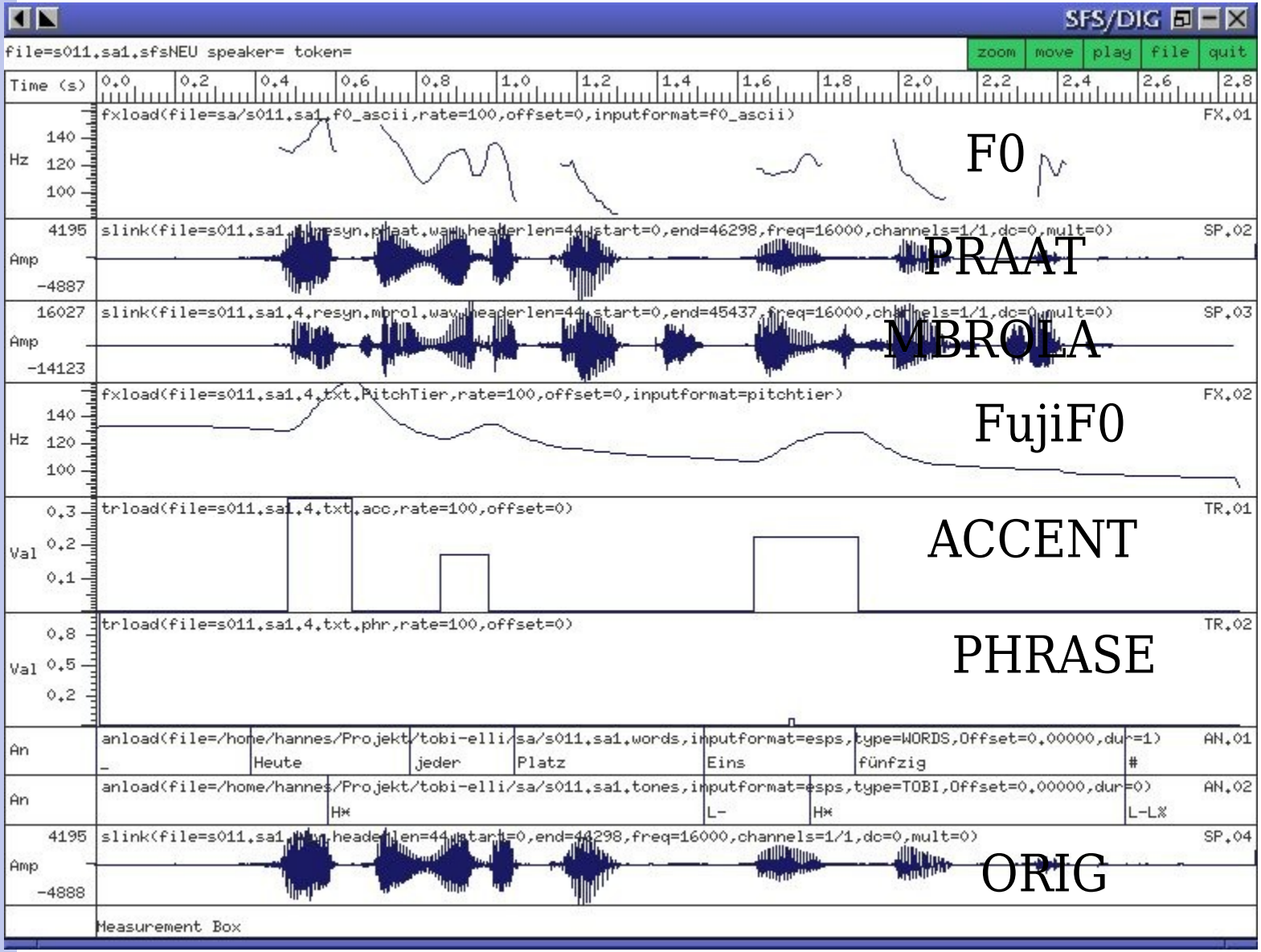
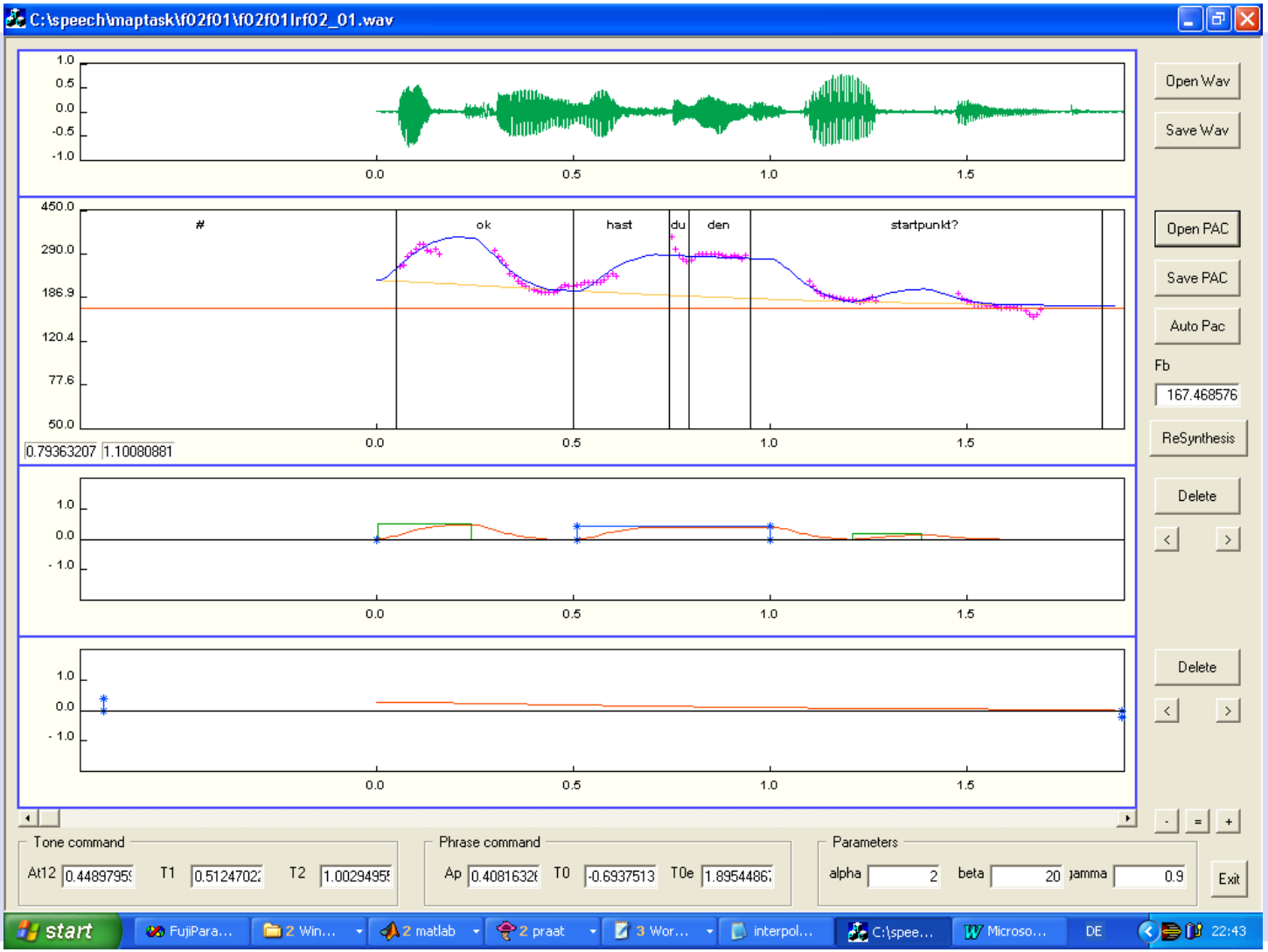
Example



FujiParamEditor



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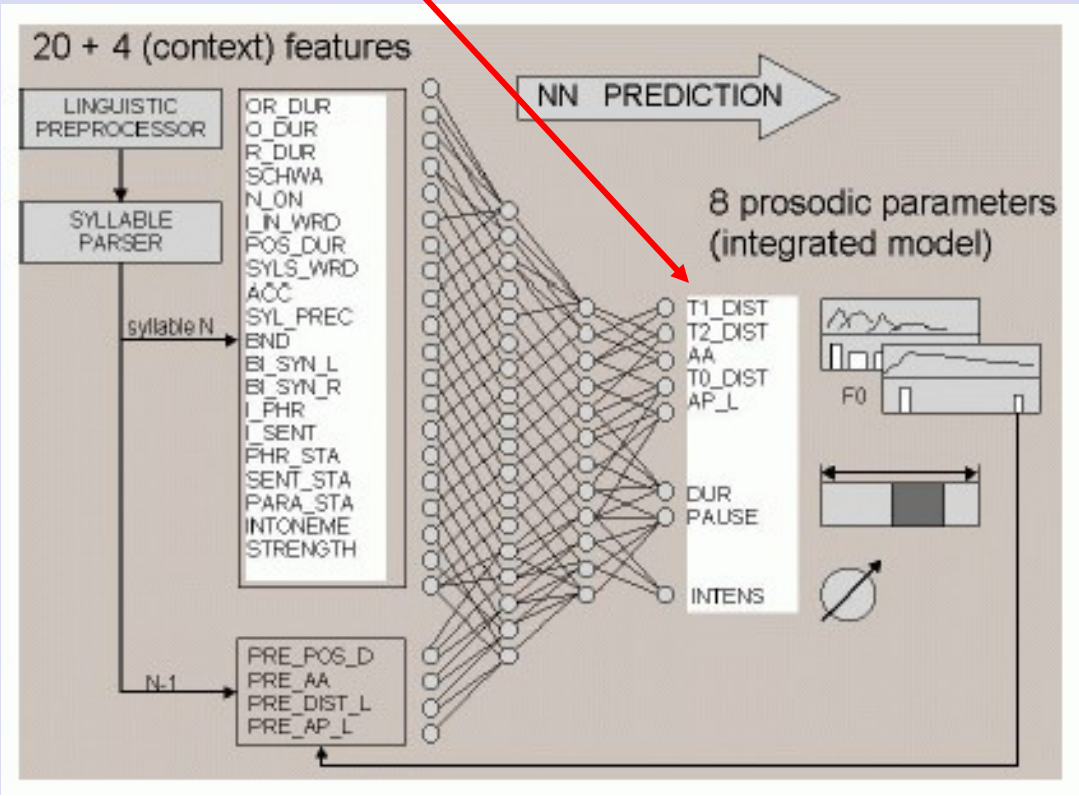
Application Example: Using Fujisaki-Model in DRESS

- Fuji params predicted together with Duration and Intensity



Summary

- Overview on some quantitative models of intonation
- IPO
- MOMEL
- Tilt
- Fujisaki

- http://www.ofai.at/~hannes.pirker

Resources, Literature etc.

- Homepage of Hansjoerg Mixdorff where you find lots of references to his work on using Fujisaki's model for German and other languages and can download the FujisakiEditor http://www.tfh-berlin.de/~mixdorff/Research.htm
- Praat: The indispensible tool for speech analysis http://www.fon.hum.uva.nl/praat/
- A praat implementation for MOMEL http://www.icp.inpg.fr/~loeven/Praat/momel_english.html
- The Edinburgh Speech Tools (EST) which contain the Tilt-model. http://festvox.org/docs/speech_tools-1.2.0/