Speech recognition and synthesis

Introduction

Uses of speech synthesis by computer

- Read aloud existing text, eg, news, email and stories
- Communicate volatile data as speech, eg, weather reports, query results
- The computer part of interactive dialogs

The building block is a Text-to-Speech system that can handle standard text with a Speech Synthesis (XML) markup. The TTS system has to be able to generate acceptable speech from plain text, but can improve the quality using the markup tags

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Computer Speech: Generating the sound

Speech Synthesizers can be classified on the way they generate speech sounds. This determines the type, and amount, of data that have to be collected.

Speech Synthesis

- Articulatory models
- Rules (formant synthesis)
- Diphone concatenation
- Unit selection

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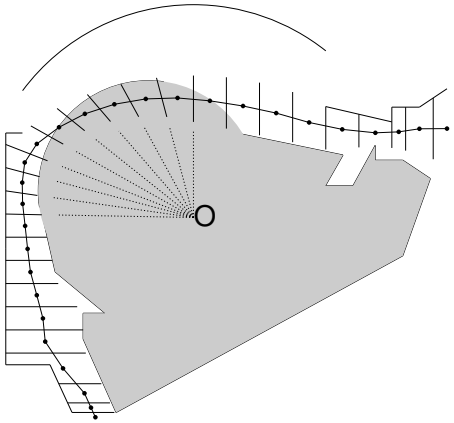

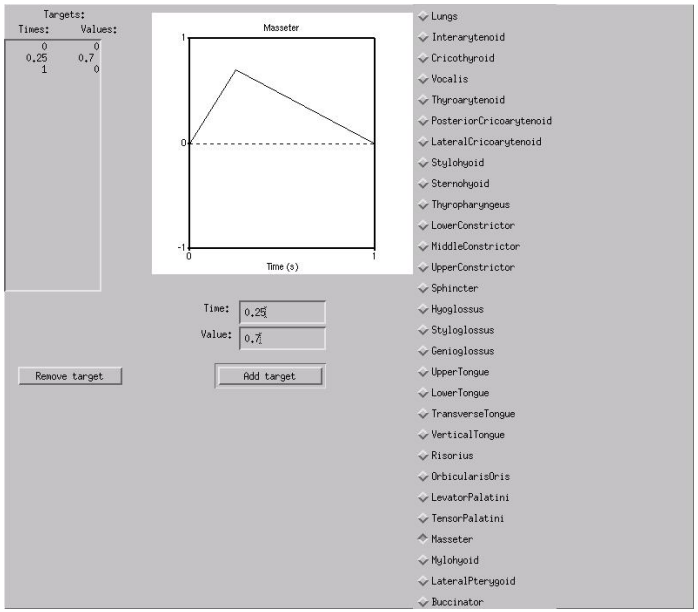

Characteristics (/ɛrə/ from Praat) [Boersma(1998)]

- Quantitative Source-Filter model of vocal tract
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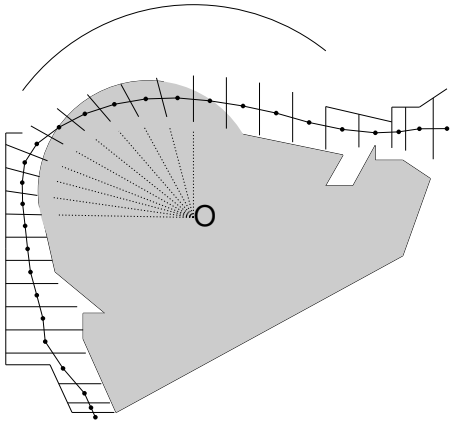

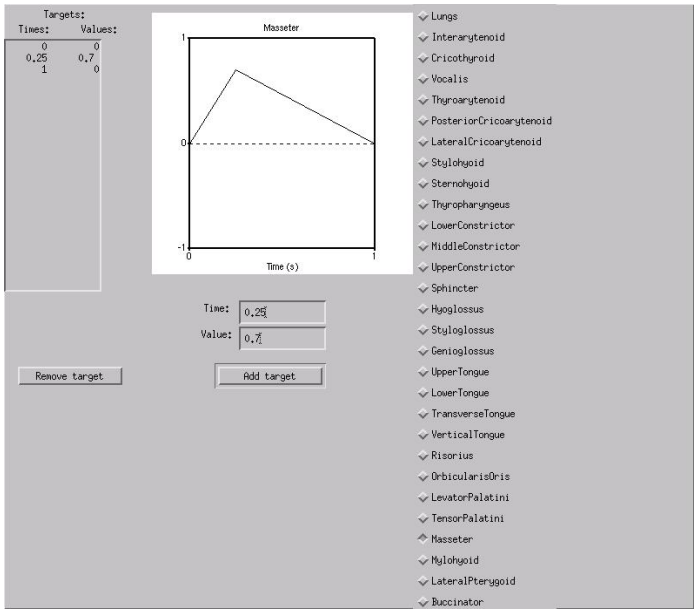

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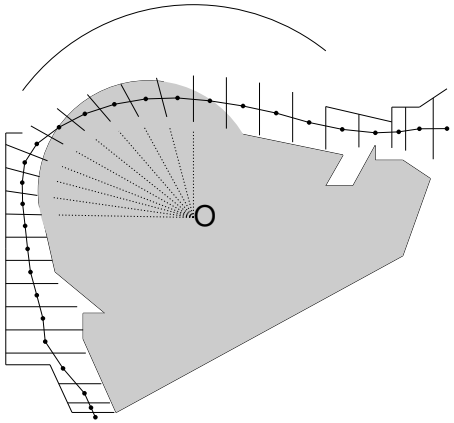

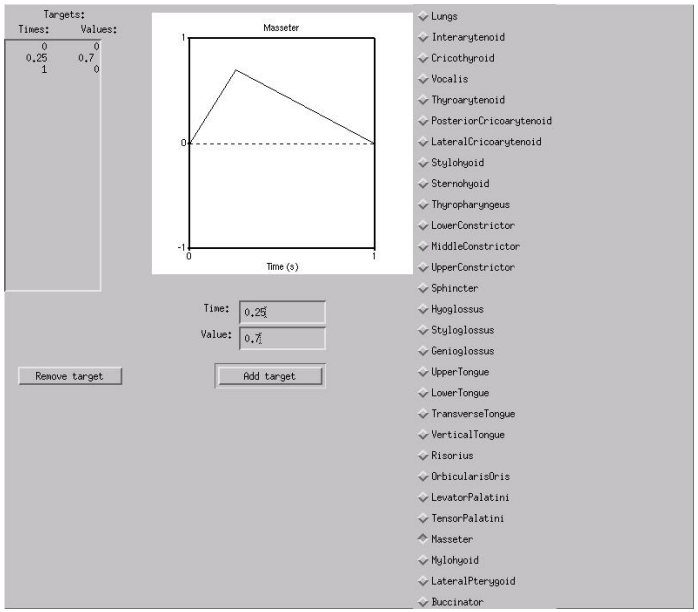

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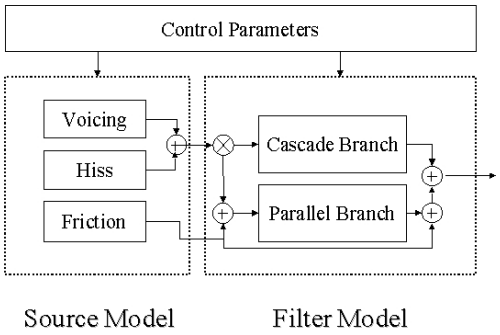

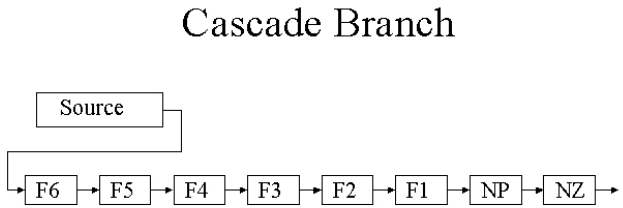

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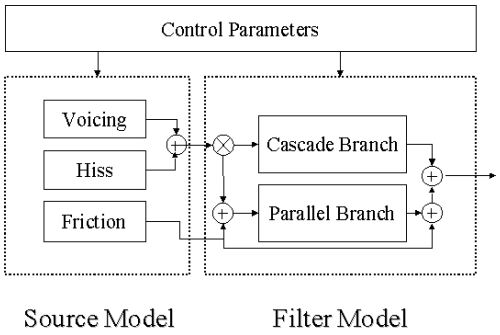

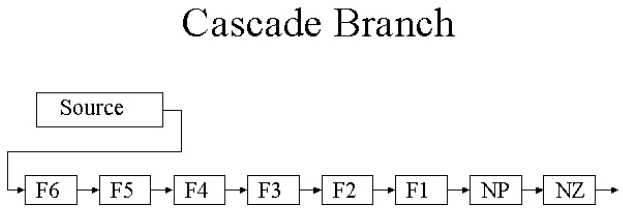

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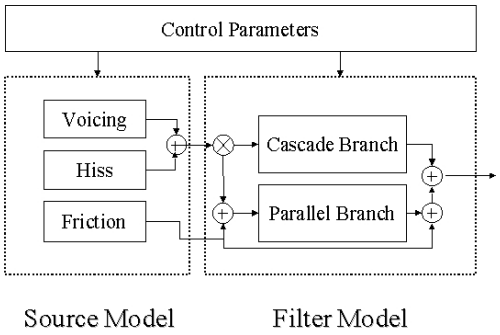

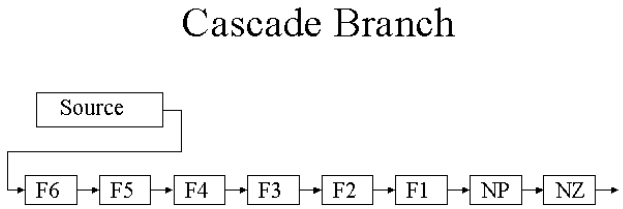

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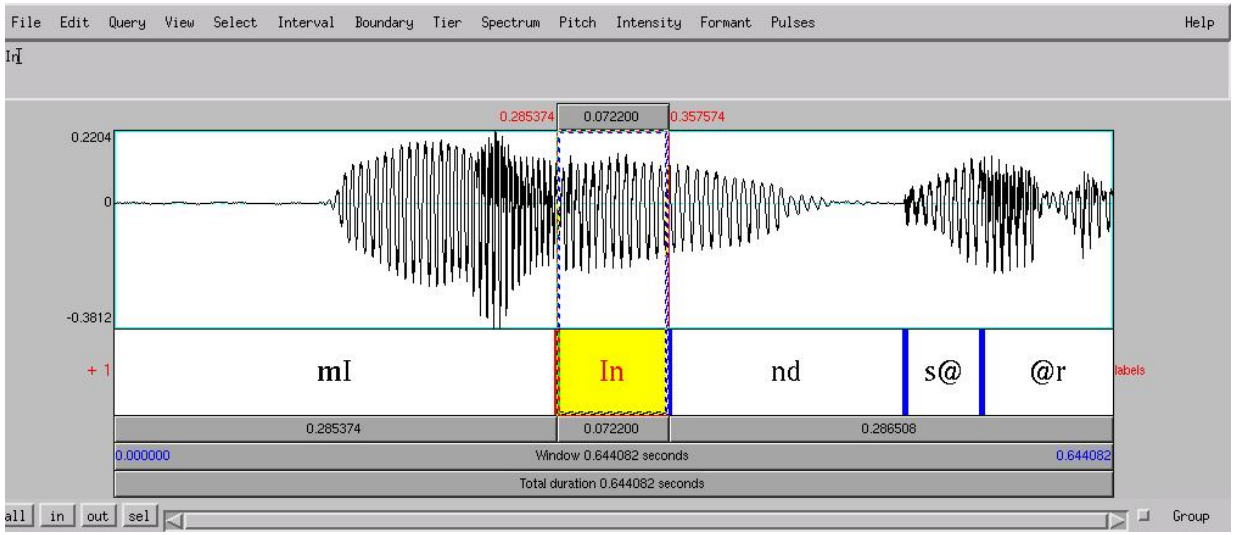

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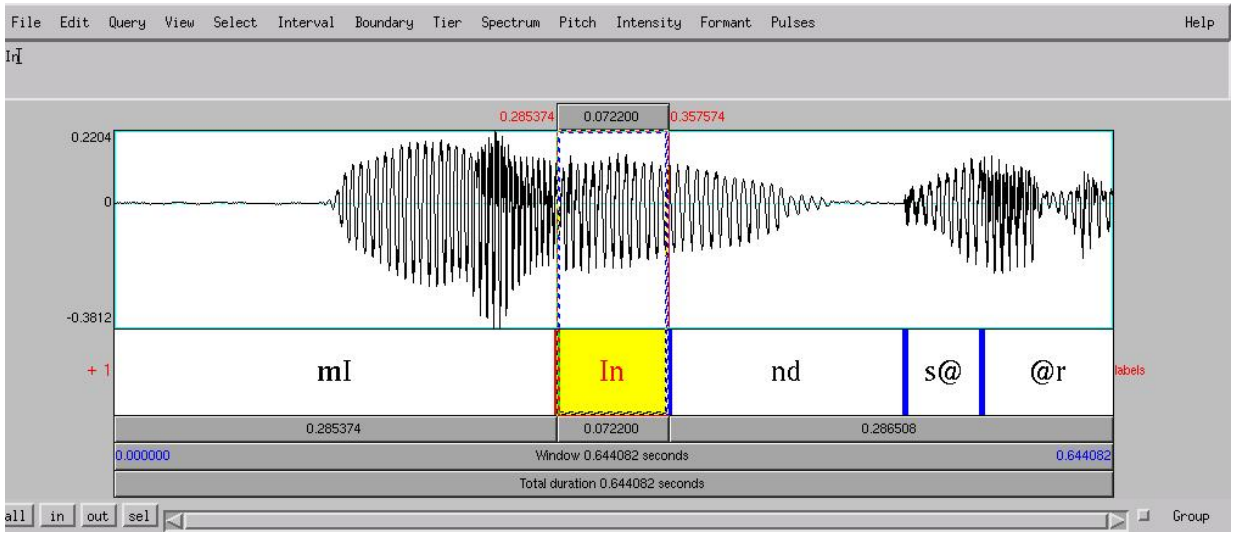

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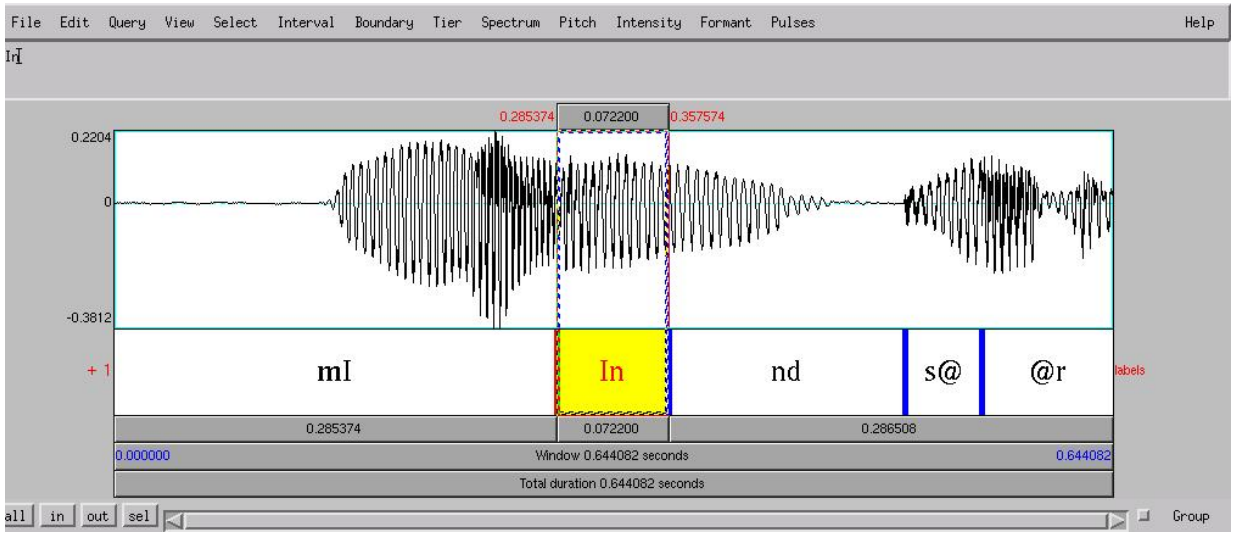

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Generalize diphone synthesis to use larger, non-uniform, units like: diphones, multiphones (clusters), demi-syllables, syllables, words, and short phrases

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Text in Speech out: Processing "steps"

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- Duration generation
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Text preprocessing: Normalize texts

Text should contain only pronounceable tokens

- Abbreviations
- Dates
- Times
- Telephone numbers
- Money
- Street Addresses
- General numbers
- Special characters

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Grapheme to Phoneme conversion: By dictionary and rules

Tokenize the text and look up the words in a pronunciation dictionary. If not found, use rules

- Dictionary entries: `("dictionary" nil (d ih1 k sh ax n eh1 r iy0))`
- Rules: `( LC [ alpha ] RC => beta )`
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After all words have been converted, there is a second pass to catch changes at word boundaries and general effects of running speech

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Compound words and other words not in the dictionary are common

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- Compound word consist of lexical words that are connected with infixes, eg, *-s-* and surrounded by affixes, eg, *a-*, *in-*, *-ed*
- Compounding or affixes can change the pronunciation and orthography of a word component, eg, *Kunst* $\rightarrow$ *Künst+ler*)
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- Compound word consist of lexical words that are connected with infixes, eg, *-s-* and surrounded by affixes, eg, *a-*, *in-*, *-ed*
- Compounding or affixes can change the pronunciation and orthography of a word component, eg, *Kunst* $\rightarrow$ *Künst+ler*)
- Parse complex words with a statistical weighted finite-state transducer (WFST) [Möbius(1998)]

Morphological decomposition: German examples

Unerfindlichkeitsunterstellung
"allegation of incomprehensibility"

WFST states: **START PREFIX ROOT INFIX SUFFIX END**

German decompositions [Möbius(1998)]

- *gener+ator* "generator"
- *honor+ar* "fee"
- *Schwind+sucht* "consumption"
- *Arbeit+s+amt* "employment agency"
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Morphological decomposition: Decomposition

noun forming prefixes					noun forming suffixes				
	N	Ftyp	n1	P		N	Ftyp	n1	P
*schwind-	1	1	1	1	-chen	1140	255	42	0.0368
vor-	104	14	2	0.0192	-ling	278	20	3	0.0108
be-	600	6	1	0.0017	-heit	604	7	2	0.0033
ge-	8125	164	10	0.0012	-schaft	11109	171	15	0.0014
semi-	12	3	0	0.0000	-ett	51	1	0	0.0000
adjective forming prefixes					adjective forming suffixes				
	N	Ftyp	n1	P		N	Ftyp	n1	P
*wiss-	1	1	1	1	-haft	1107	102	14	0.0126
ur-	108	10	1	0.0093	-voll	132	6	1	0.0076
un-	10010	601	64	0.0064	-är	502	17	1	0.0020
in-	219	49	1	0.0046	-lich	32168	569	51	0.0016
aller-	42	2	0	0.0000	-ig	3966	40	3	0.0008
verb forming prefixes					verb forming suffixes				
	N	Ftyp	n1	P		N	Ftyp	n1	P
weit-	94	11	3	0.0318	-er	65	24	5	0.0769
vor-	1401	31	4	0.0029	-el	1197	86	11	0.0092
ent-	13007	200	18	0.0014	-isier	1019	75	7	0.0069
ver-	53899	930	71	0.0013					
dar-	1071	6	1	0.0009					

Use a dictionary and include a morphological compound list with pronunciations. [Möbius(1998)]

Lexical stress and sentence accent: Prominence

In every utterance, one or more words are more prominent than others. They are:

- Accented, ie, carry a pitch movement
- Longer
- Louder
- Less reduced

Prominence is determined by

- Word type, function words are almost never prominent
- Word frequency, rare words are prominent more often
- New information is prominent, given is not
- Not too many prominent words in a row

There are rules for assigning prominence, but they need good POS tagging. Just accenting every content words works too

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In every word, one or more syllables are more prominent than others. They are:

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- Syllable weight, "heavy" syllable are stressed
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Mostly, you can get away with either the lexicon, or fixed positions. Syllable stress shifts in compound words. Morphological decomposition gives rules for these shifts

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Intonation covers utterances of a few words at a time (around 5-7). Breaking up sentences at acceptable places is difficult

- Use punctuation
- Guess boundaries on POS tags (HMM style)
- Do a partial syntactic parse and use phrases

In general, it is difficult to go beyond punctuation and some simple heuristics without syntactic parsing

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Phoneme duration is determined by:

- Phoneme identity
- Surrounding phonemes
- Sentence accent/prominence
- Syllable stress
- Syllable length and position (Onset, Coda)
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These factors are used to construct statistical models from annotated speech corpora. Golden standard is Correlation and Regression Trees (CART). But many other statistical methods are used

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Intonation

With the durations known, the pitch contour can be calculated

- Speaker and style determine the pitch range
- Give each accent a pitch movement shape and size
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- Interpolate the values into a valid contour
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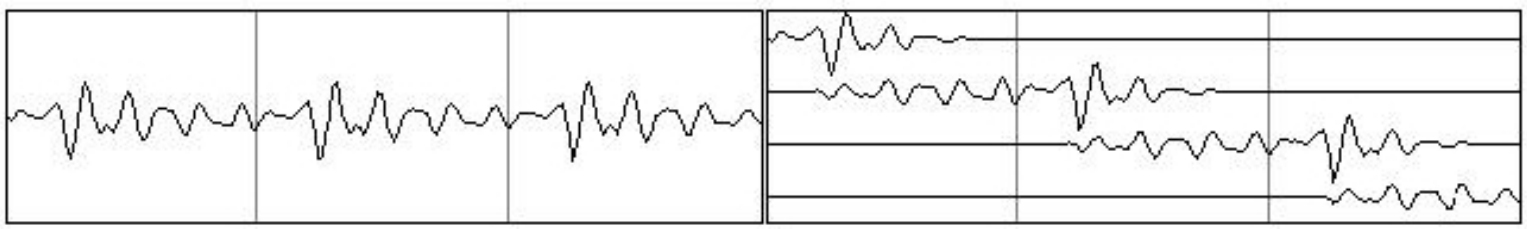

Multi Band Excitation (Time Domain) Pitch Synchronous Overlap Add [MBROLA(2005)]

- Mark all pitch periods (blue pulses in *Praat*)
- Fixed periods for voiceless speech
- Window speech around each mark
- To lengthen/shorten a sound, reduplicate/delete periods
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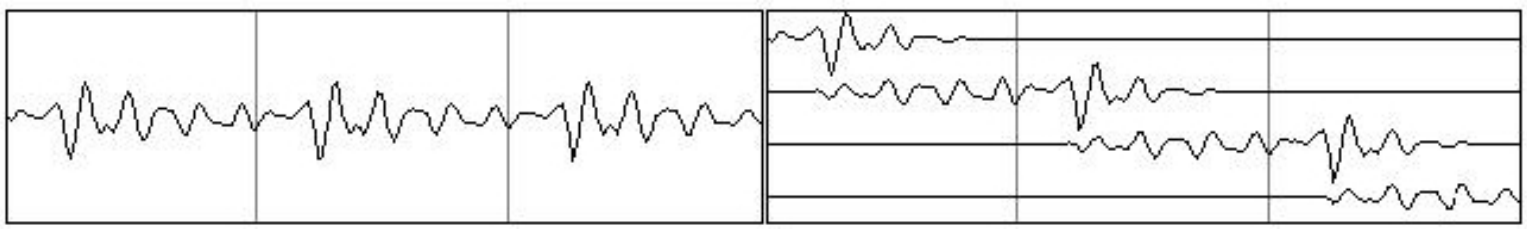

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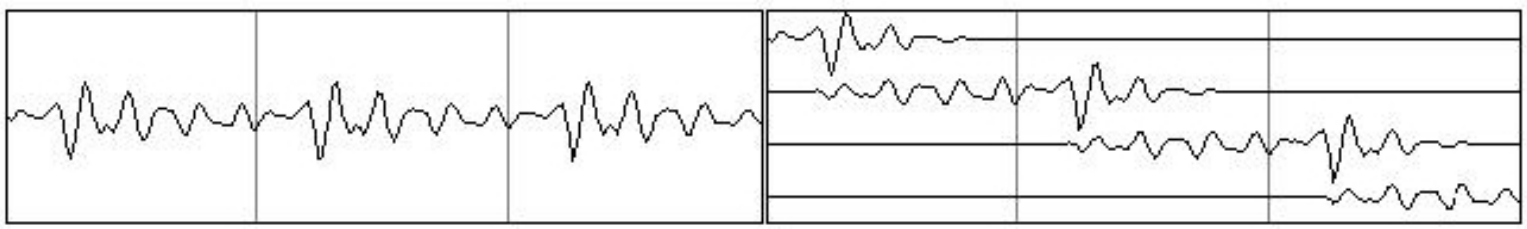

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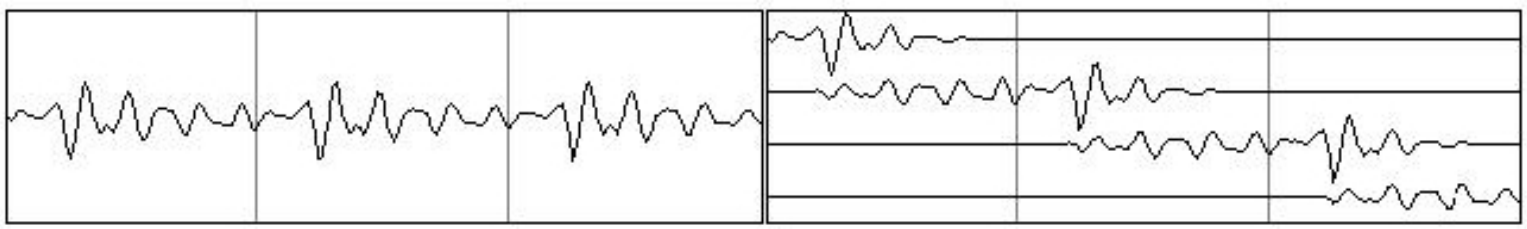

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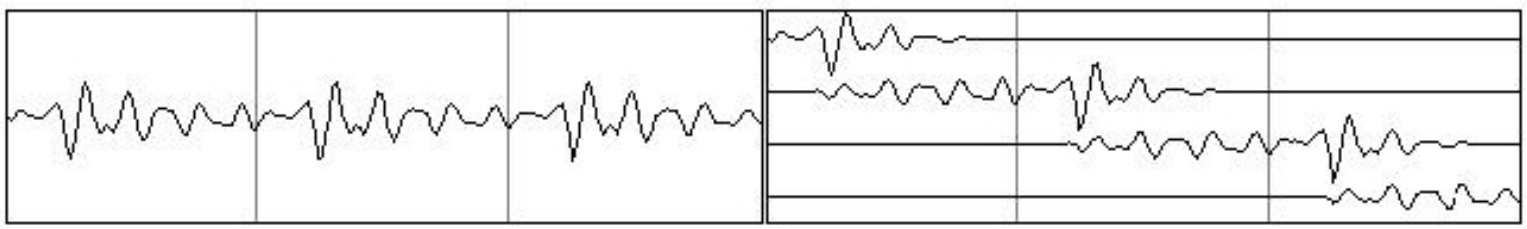

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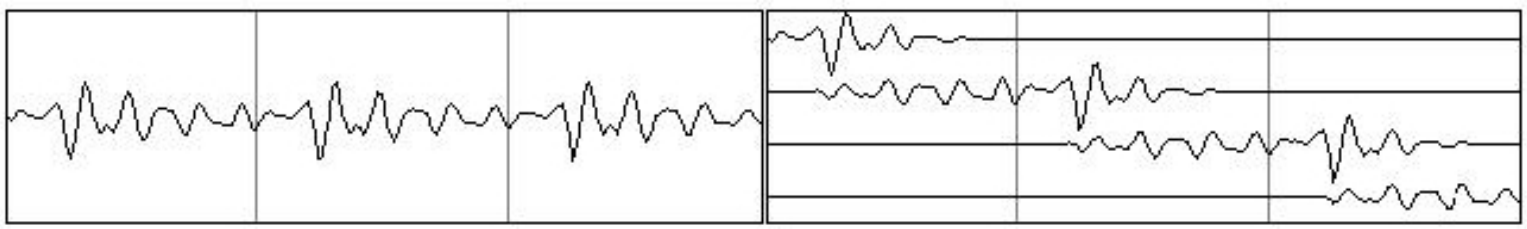

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Nextens runs on top of Festival [Nextens(2003), Festvox(2005)]

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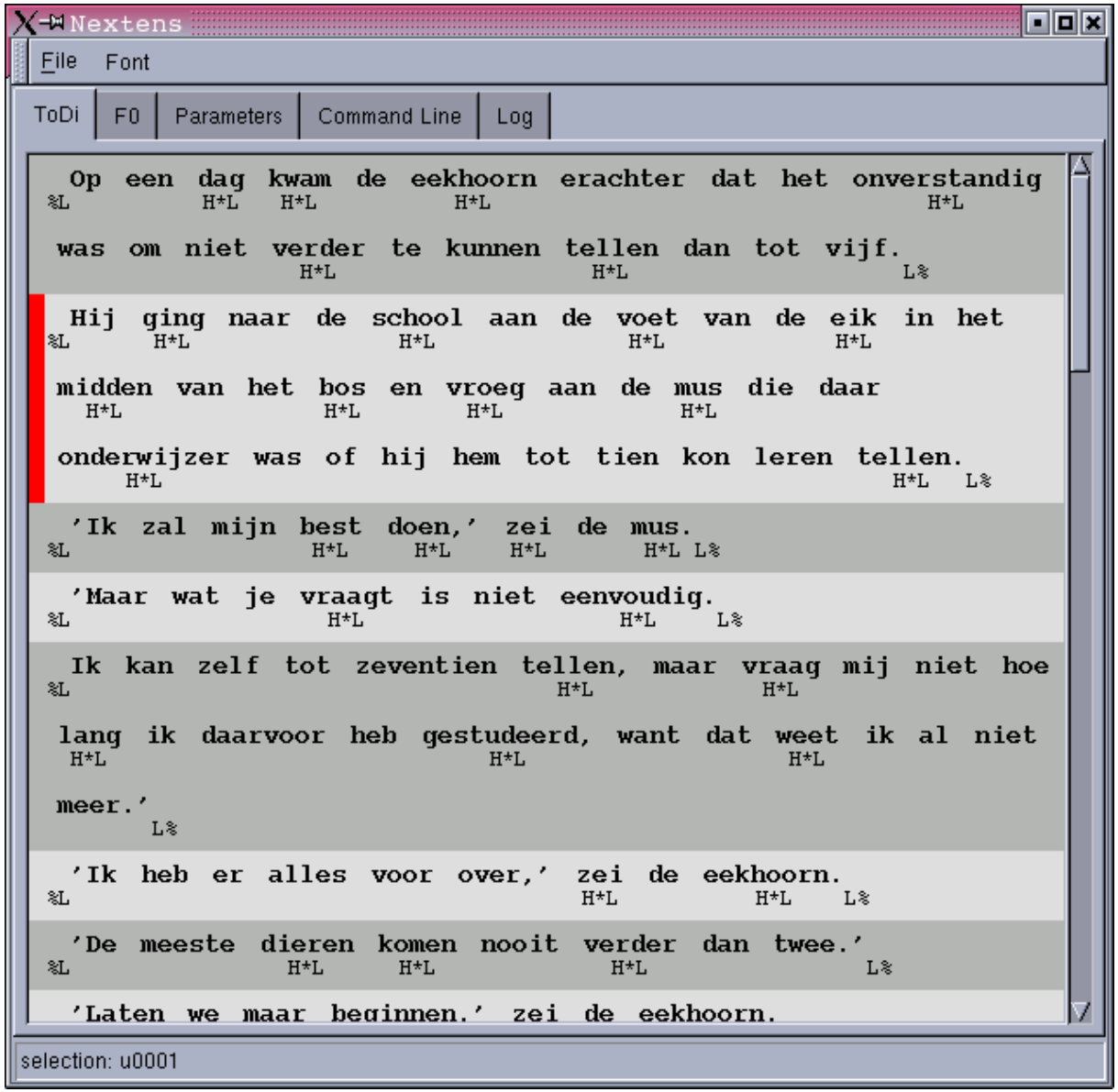
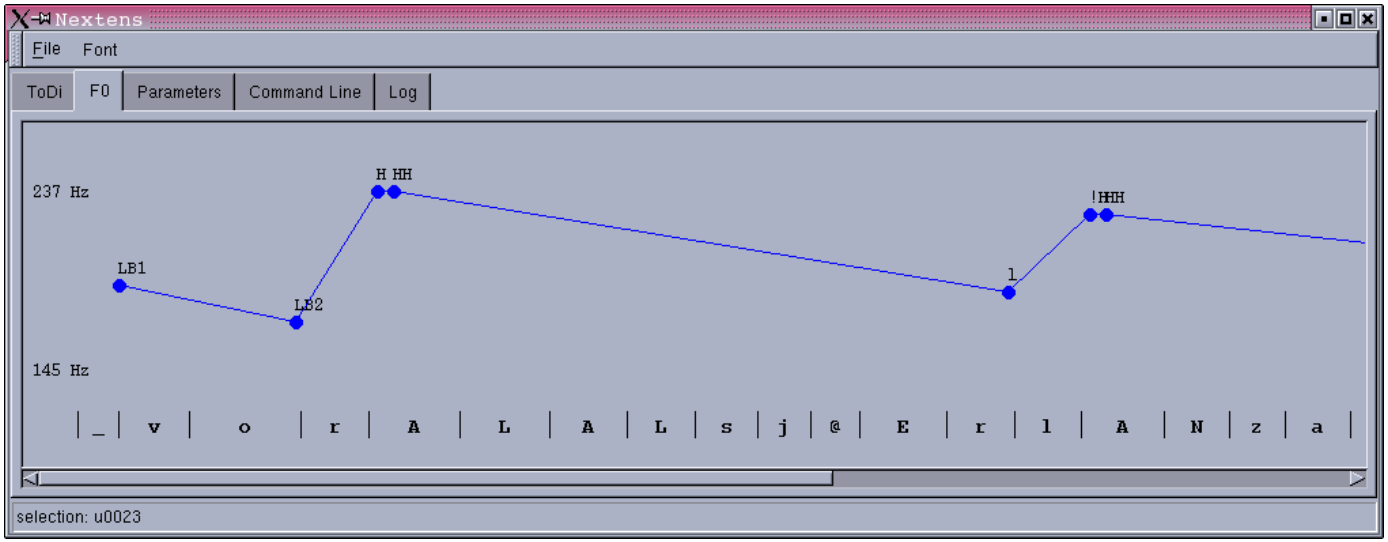
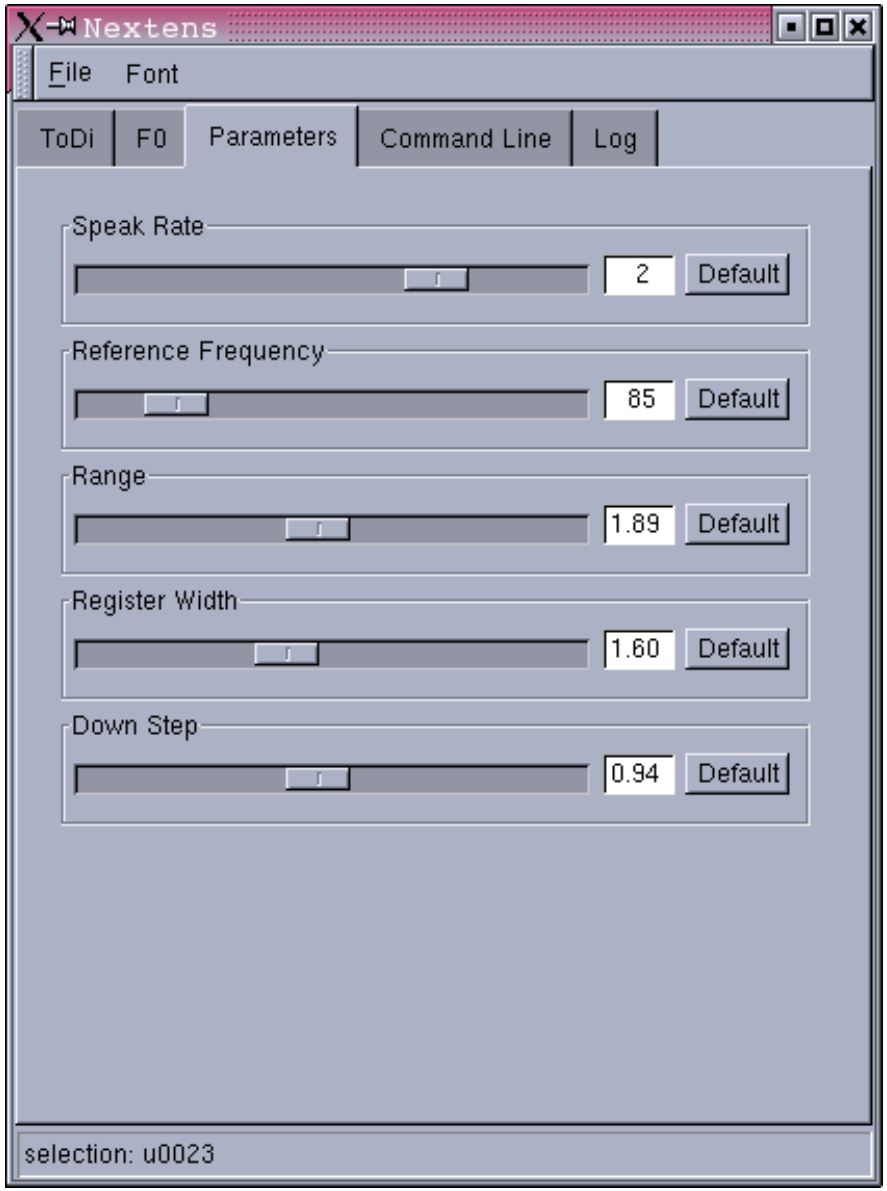


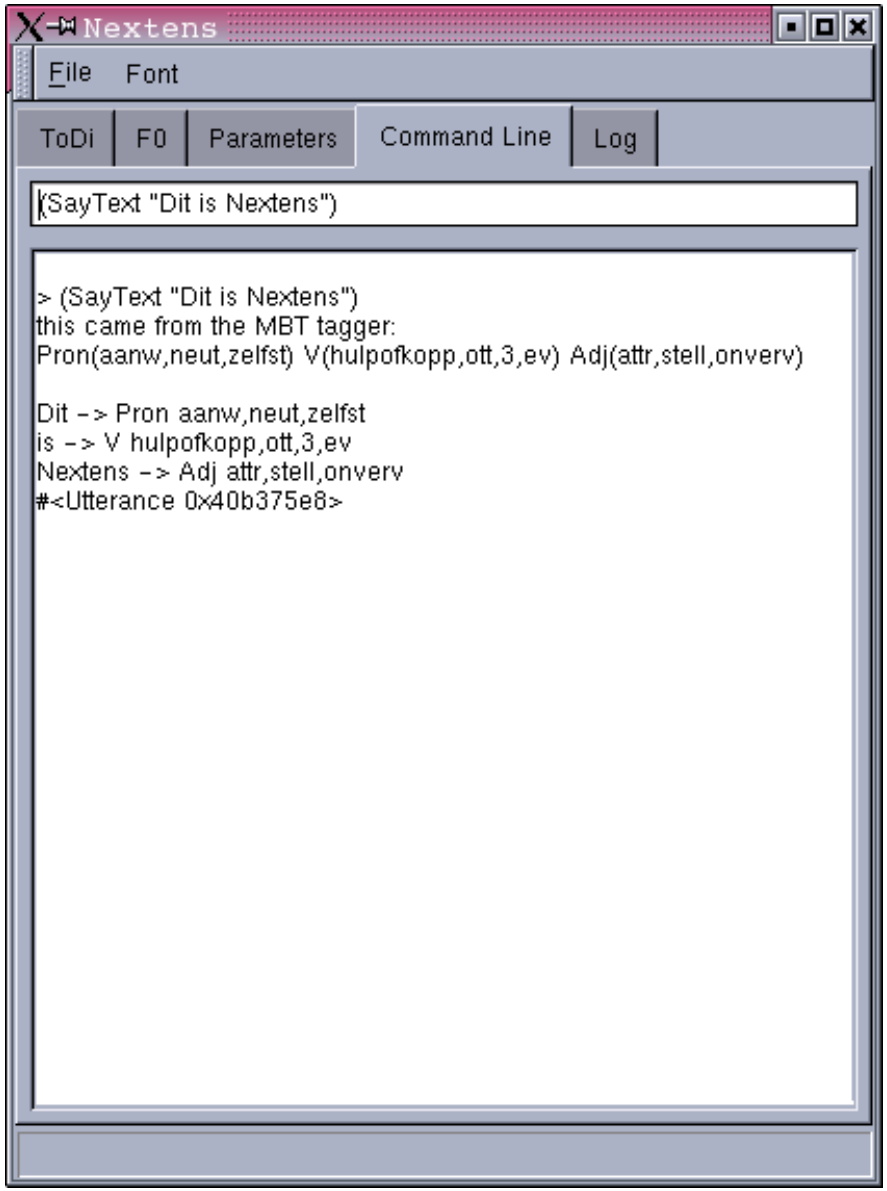
Nextens: F_0 interface



Nextens: Parameters interface



Nextens: Commandline interface



Assignment: Week 5 Using Nextens

See CD or Nextens web-site for information [Nextens(2003)]

- Install Nextens (see info)
- Start Nintens
- Under file menu, select 'add sentence'
- Generate a sentence
- Inspect tabs, especially the ToDI tab

Assignment: Week 5 Using Nextens

See CD or Nextens web-site for information [Nextens(2003)]

- Install Nextens (see info)
- Start Nintens
- Under file menu, select 'add sentence'
- Generate a sentence
- Inspect tabs, especially the ToDI tab

Assignment: Week 5 Using Nextens

See CD or Nextens web-site for information [Nextens(2003)]

- Install Nextens (see info)
- Start Nintens
- Under file menu, select 'add sentence'
- Generate a sentence
- Inspect tabs, especially the ToDI tab

Assignment: Week 5 Using Nextens

See CD or Nextens web-site for information [Nextens(2003)]

- Install Nextens (see info)
- Start Nintens
- Under file menu, select 'add sentence'
- Generate a sentence
- Inspect tabs, especially the ToDI tab

Assignment: Week 5 Using Nextens

See CD or Nextens web-site for information [Nextens(2003)]

- Install Nextens (see info)
- Start Nintens
- Under file menu, select 'add sentence'
- Generate a sentence
- Inspect tabs, especially the ToDI tab

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Appendix A

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Version 2, June 1991

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