Speech recognition and synthesis

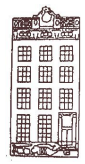
Copyright ©2007 R.J.J.H. van Son, GNU General Public License [FSF(1991)]

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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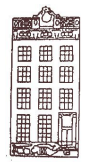

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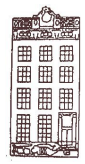
Computer Speech: Generating the sound

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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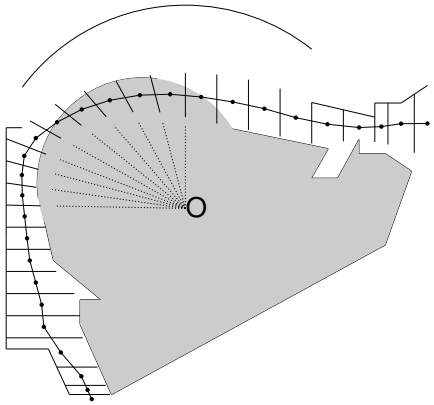

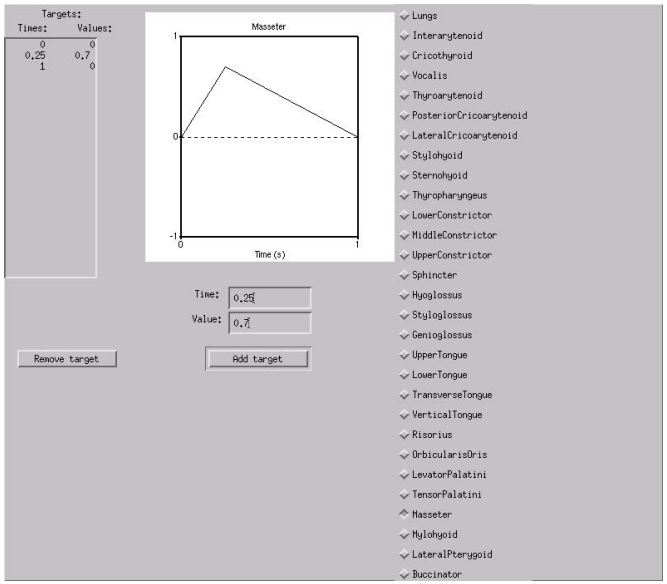

Characteristics (/ɛrə/ from Praat) [Boersma(1998)]

- Quantitative Source-Filter model of vocal tract
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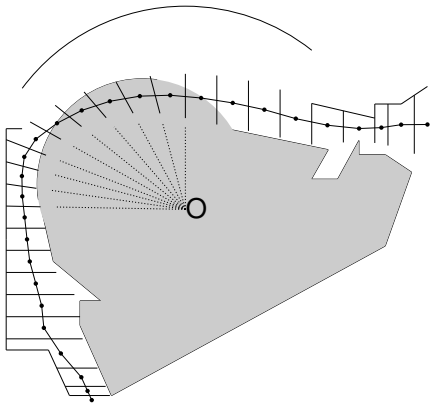

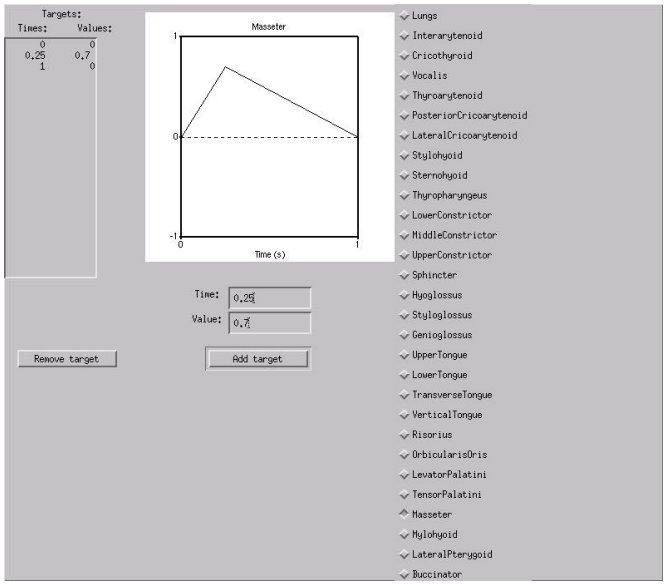

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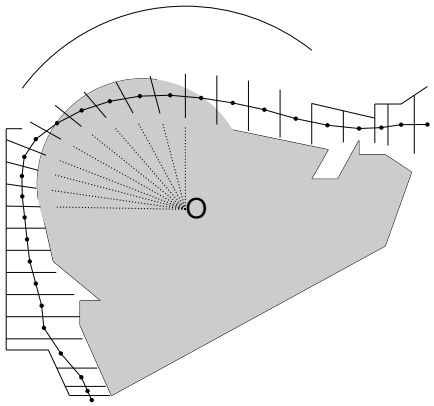

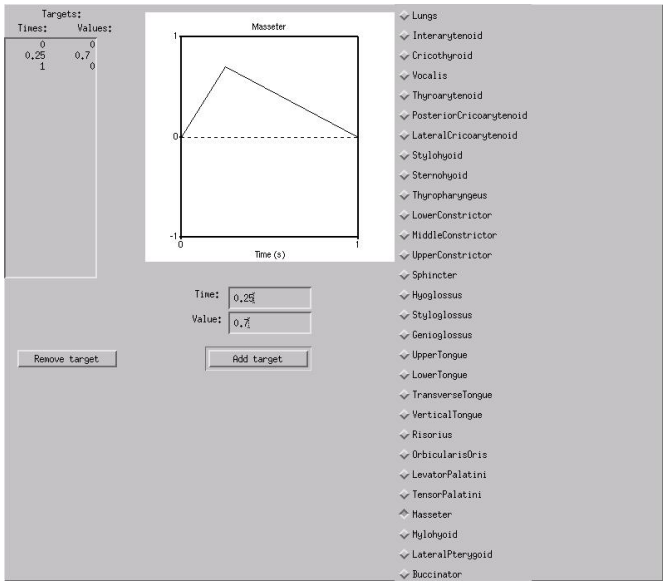

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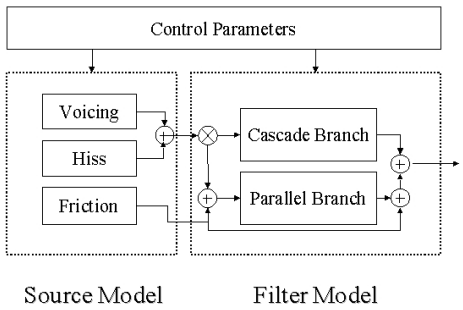

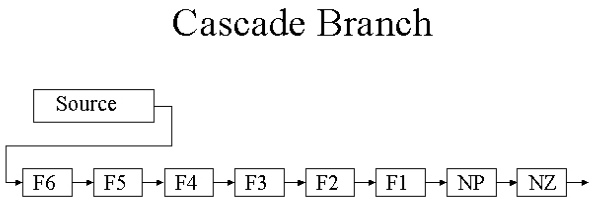

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Characteristics (YorkTalk [Möhler(2005)])

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- Endless tuning, no data driven modelling possible

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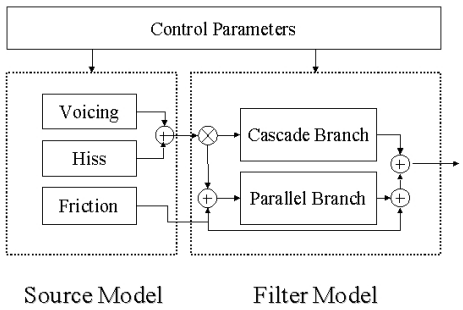

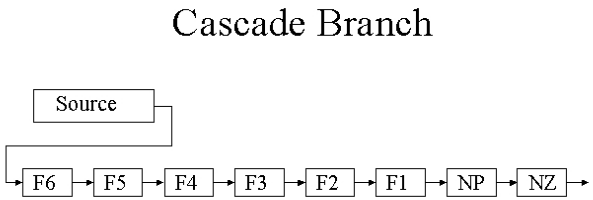

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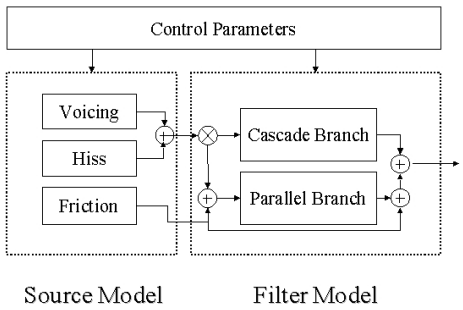

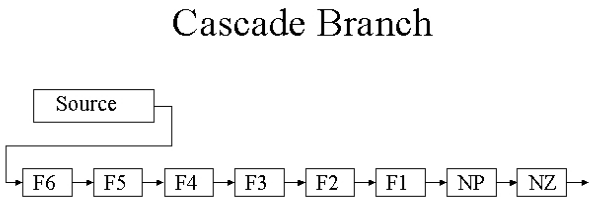

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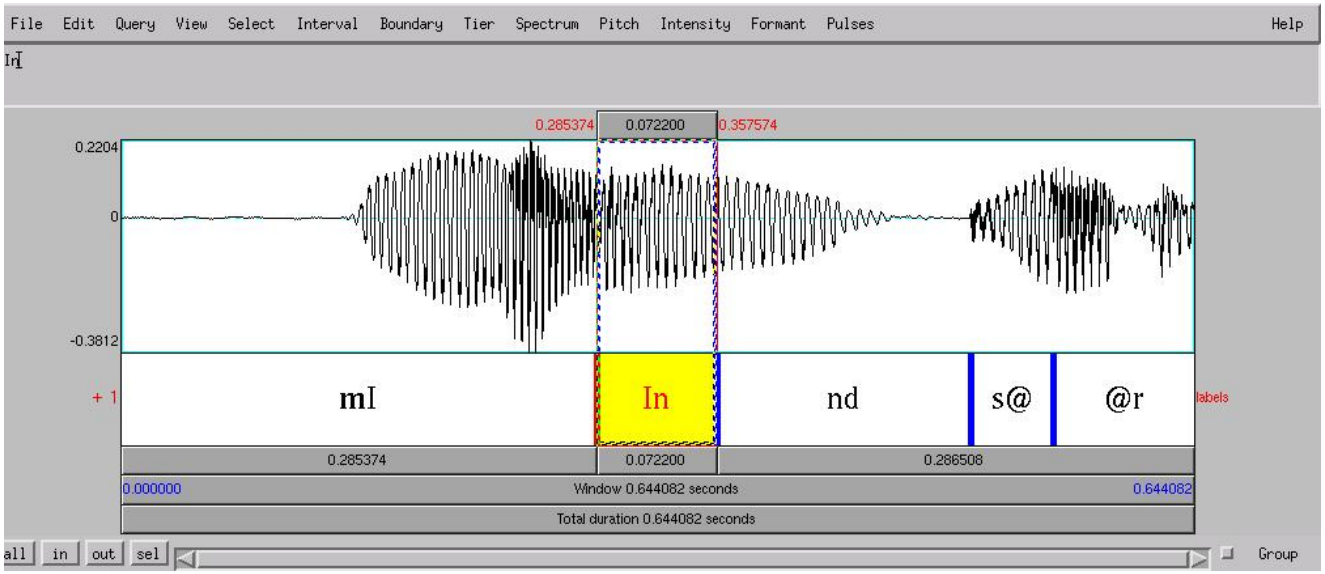

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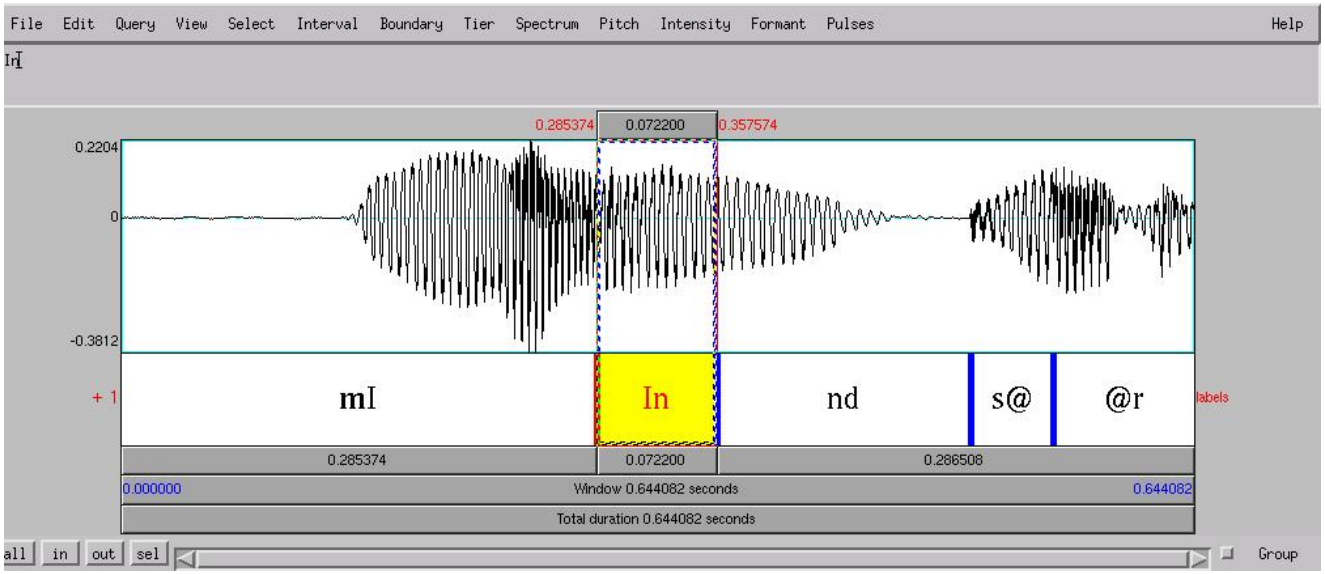

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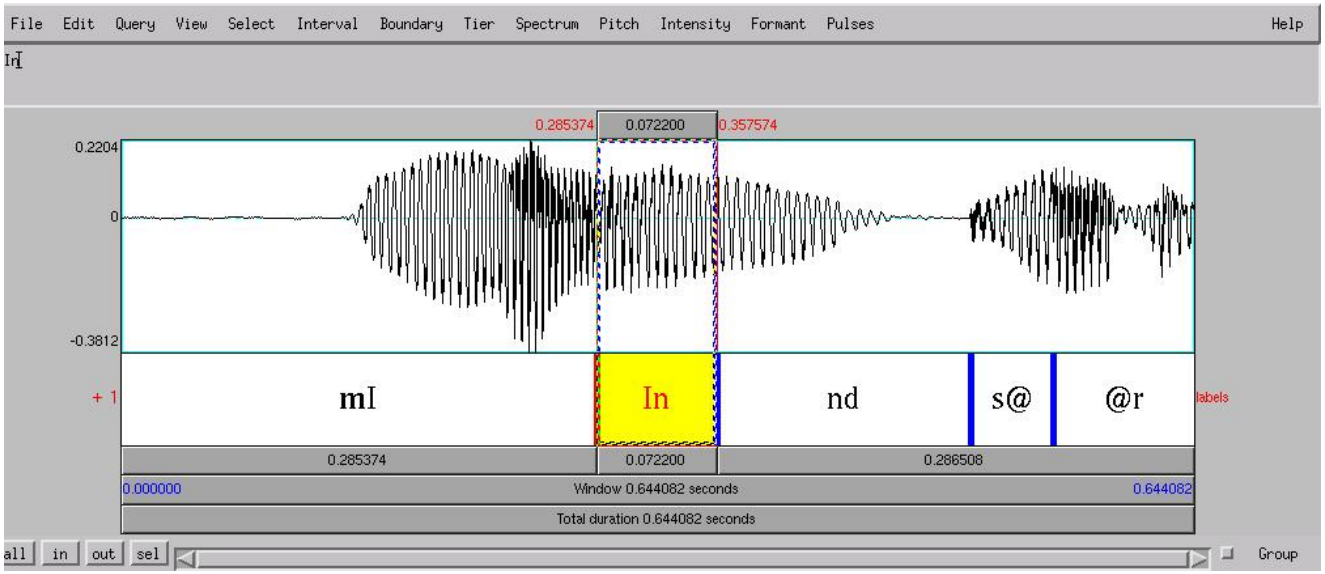

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Generalize diphone synthesis to use larger, non-uniform, units like: diphones, multiphones (clusters), demi-syllables, syllables, words, and short phrases

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- Requires large annotated speech corpora ($\sim$ GByte range)
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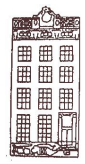

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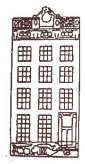

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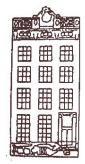

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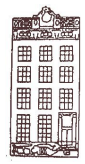

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Text should contain only pronounceable tokens

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

Join Kerry Stratton & his guest chamber orchestra as they bring the music of the Italian Maestro to life on our stage. Tickets $46.00
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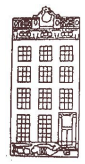

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Grapheme to Phoneme conversion: By dictionary and rules

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 )`
  - `( # [ c h ] r => k )` "ch" word initially in English
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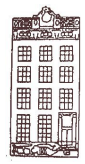
After all words have been converted, there is a second pass to catch changes at word boundaries and general effects of running speech



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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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Morphological decomposition: Out-of-Vocabulary words

Compound words and other words not in the dictionary are common

- Compound words are common in many languages, eg, German, Dutch, Finnish, Turkish
- 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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Morphological decomposition: German examples

Unerfindlichkeitsunterstellung
"allegation of incomprehensibility"

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

German decompositions [Möbius(1998)]

- *gener+ator* "generator"
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Morphological decomposition: Decomposition

noun forming prefixes				
	N	Ftyp	n1	P
*schwind-	1	1	1	1
vor-	104	14	2	0.0192
be-	600	6	1	0.0017
ge-	8125	164	10	0.0012
semi-	12	3	0	0.0000

noun forming suffixes				
	N	Ftyp	n1	P
-chen	1140	255	42	0.0368
-ling	278	20	3	0.0108
-heit	604	7	2	0.0033
-schaft	11109	171	15	0.0014
-ett	51	1	0	0.0000

adjective forming prefixes				
	N	Ftyp	n1	P
*wiss-	1	1	1	1
ur-	108	10	1	0.0093
un-	10010	601	64	0.0064
in-	219	49	1	0.0046
aller-	42	2	0	0.0000

adjective forming suffixes				
	N	Ftyp	n1	P
-haft	1107	102	14	0.0126
-voll	132	6	1	0.0076
-är	502	17	1	0.0020
-lich	32168	569	51	0.0016
-ig	3966	40	3	0.0008

verb forming prefixes				
	N	Ftyp	n1	P
weit-	94	11	3	0.0318
vor-	1401	31	4	0.0029
ent-	13007	200	18	0.0014
ver-	53899	930	71	0.0013
dar-	1071	6	1	0.0009

verb forming suffixes				
	N	Ftyp	n1	P
-er	65	24	5	0.0769
-el	1197	86	11	0.0092
-isier	1019	75	7	0.0069

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

Lexical stress and sentence accent: Prominence

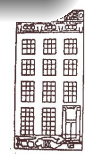
Some words are more prominent than others. They are:

- Accented, i.e. 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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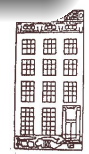

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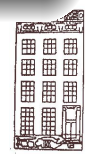

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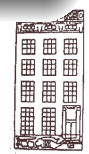

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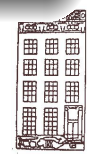

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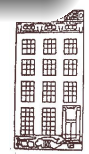

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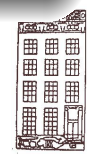

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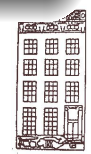

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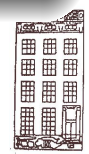

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Mostly, you can get away with either the lexicon, or fixed positions. Syllable stress shifts in compound words. Morphological decomposition gives rules for these shifts

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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

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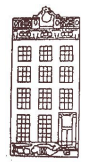
- Guess boundaries on POS tags (HMM style)
- Do a partial syntactic parse and use phrases

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



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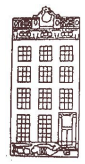

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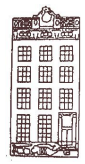

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- Sentence accent/prominence
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- Syllable length and position (Onset, Coda)
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These factors are used to construct statistical models from annotated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

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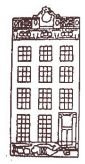

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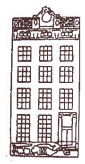

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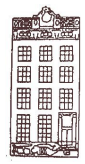

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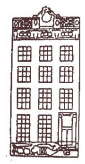

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- Phoneme identity
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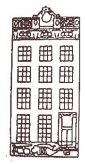

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Intonation

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
- Assign each vowel its target F_0 value
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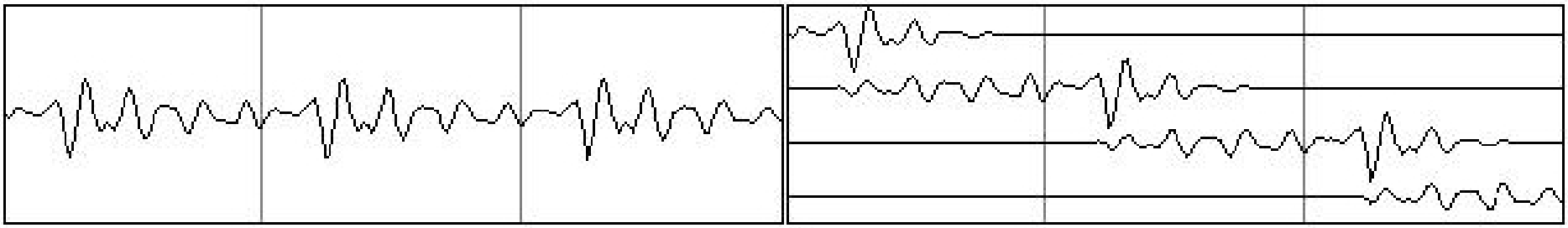

Multi Band Excitation (Time Domain) Pitch Synchronous Overlap Add [MBROLA(2005)]

- 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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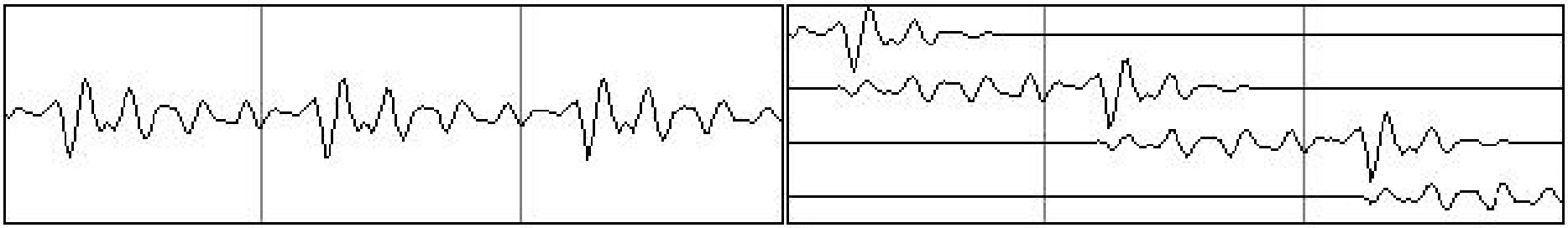

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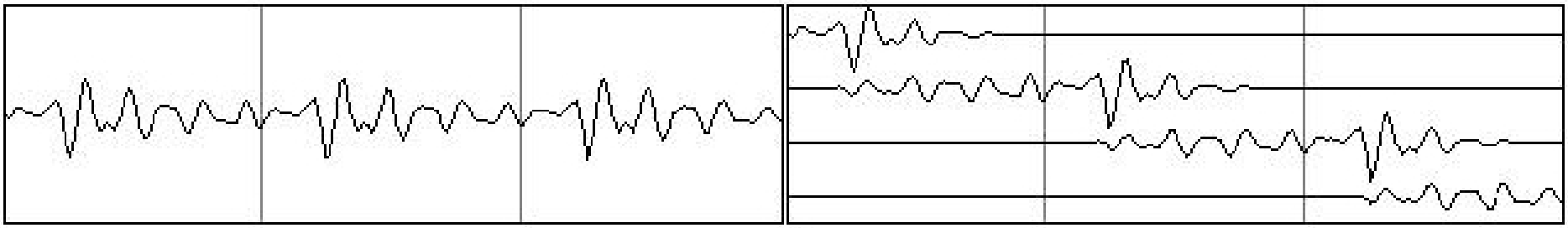

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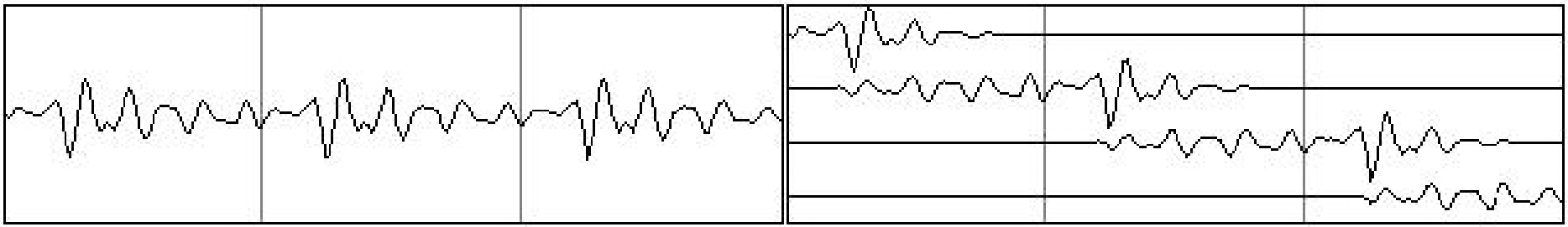

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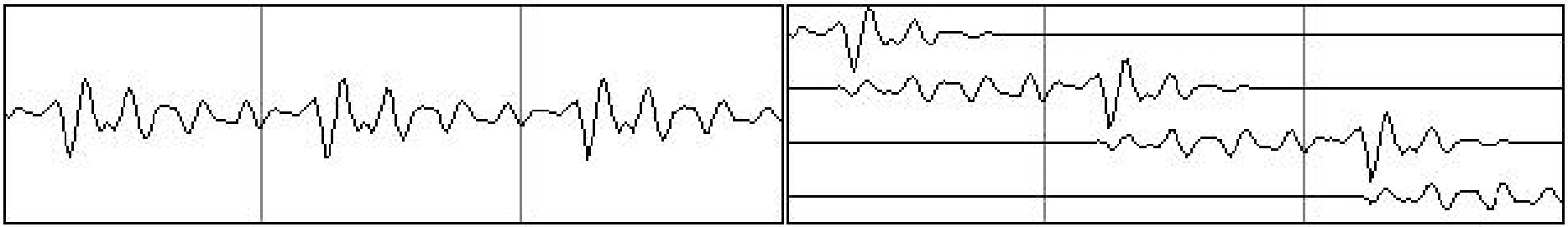

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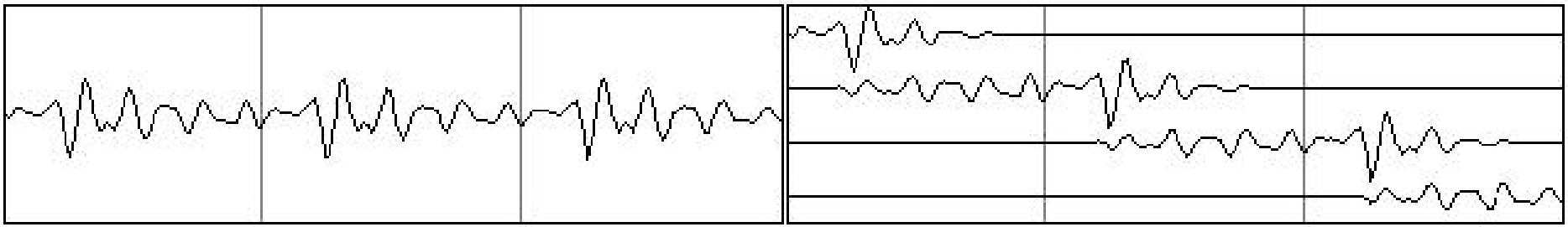

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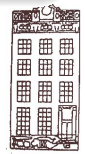

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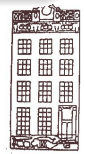

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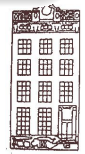

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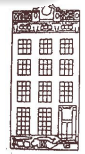
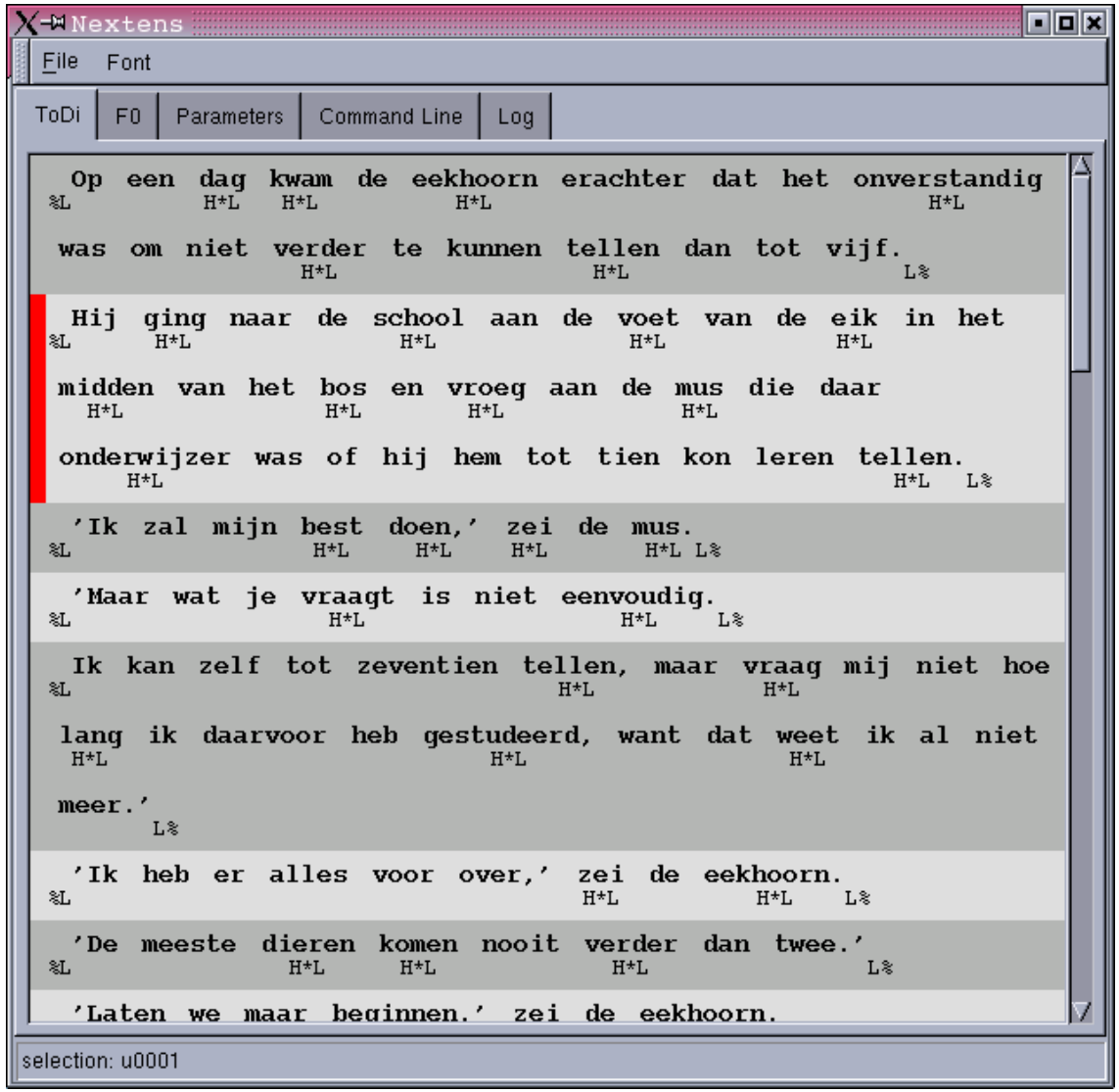
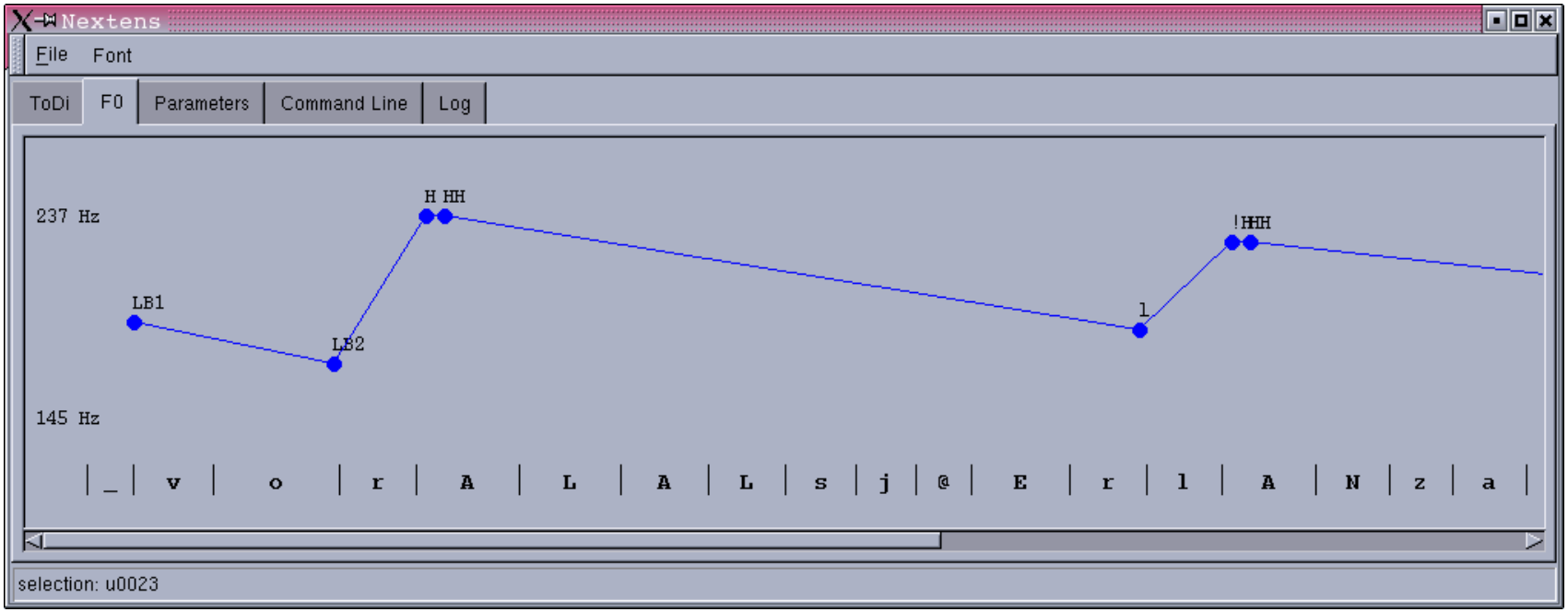
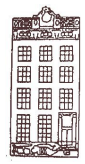


Nextens: Annotation interface

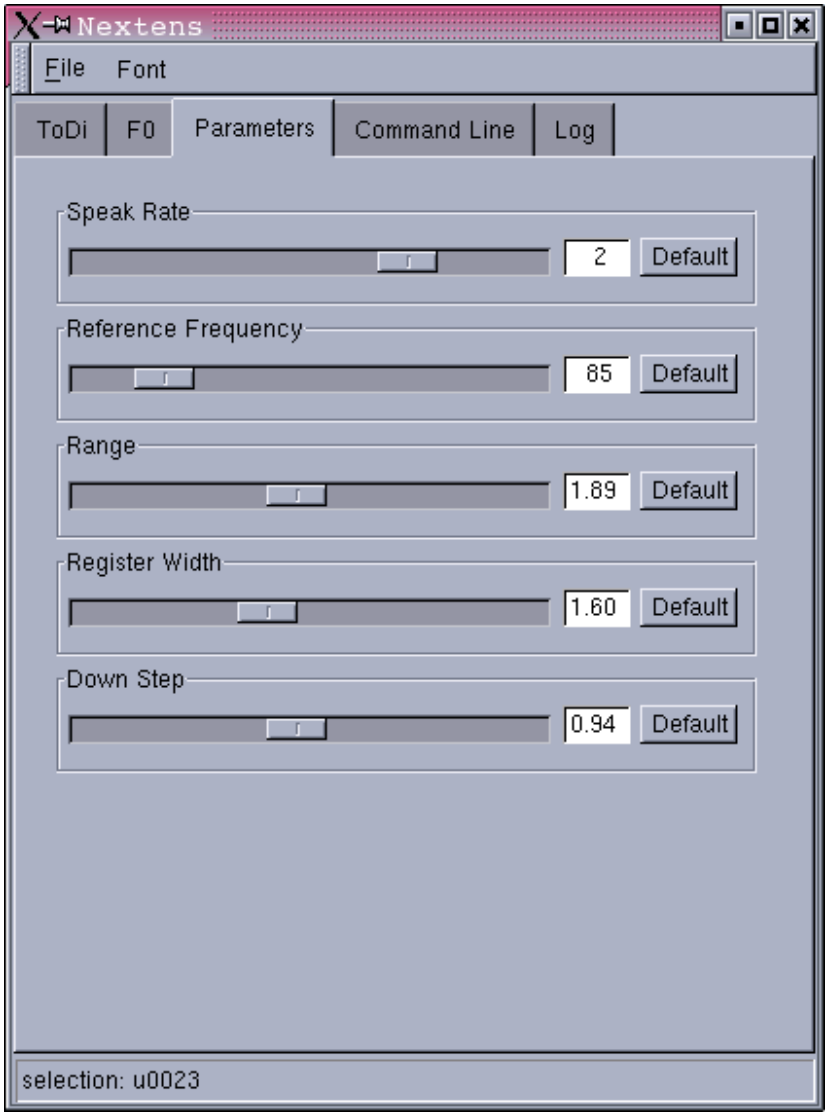


Nextens: F_0 interface

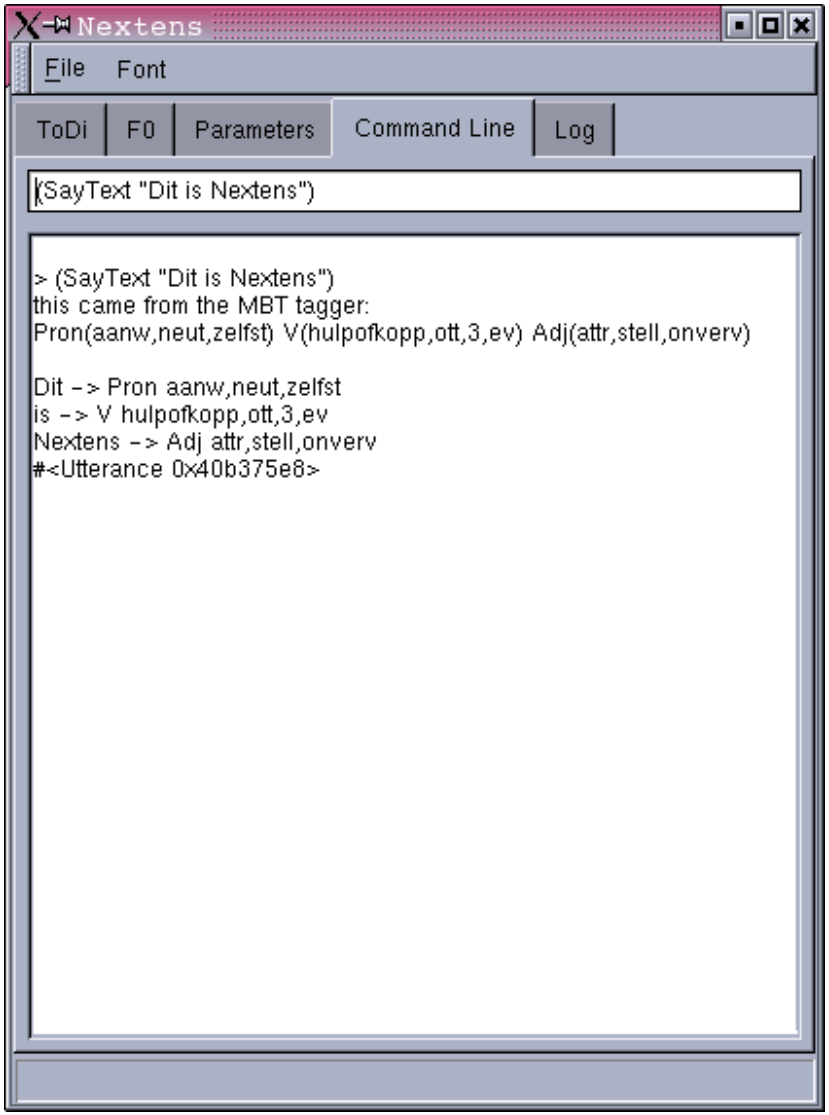




Nextens: Parameters interface



Nextens: Commandline interface



Assignment: Week 5 Using Nextens

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

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- Under file menu, select 'add sentence'
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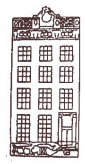

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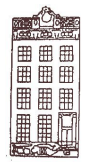

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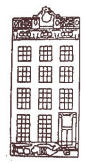

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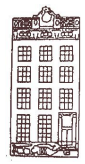
Appendix A



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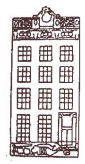

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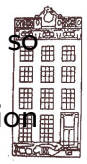

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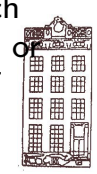

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End of Terms and Conditions

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Appendix: How to Apply These Terms to Your New Programs

If you develop a new program, and you want it to be of the greatest possible use to the public, the best way to achieve this is to make it free software which everyone can redistribute and change under these terms.
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