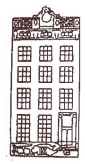
Speech recognition and synthesis



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Speech technology for "disadvantaged" languages

- Language barriers limit access to digital resources
- Speech technology needed for access to services, eg, phone services
- Language often part of national, cultural, and political identity
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- All tools available on the internet for free
- Basic systems for a new language take around 3-6 person months
- Systems and work are modular
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Example 1: A basic Frisian TTS

Master's thesis

- No speech technology available for Frisian
- Language community is organized scientifically
- There is "political" demand for Frisian Language Technology
- Student is a native speaker
- 4 Month thesis project
- Dutch diphones (no time to create Frisian set)
- Aim: "bootstrap" the development of a TTS system

[Dijkstra et al.(2005)Dijkstra, Pols, and van Son]

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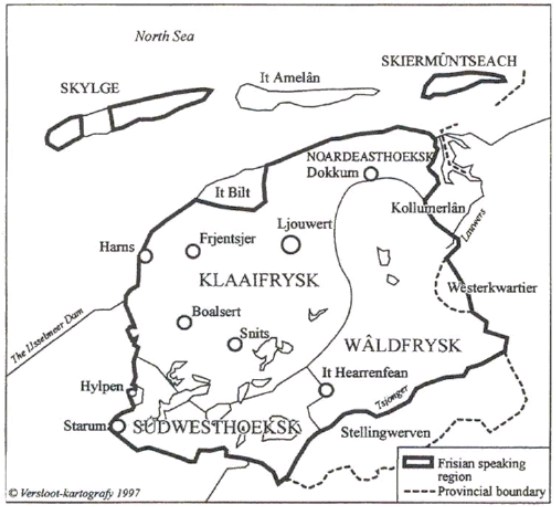

Map 1: Dialect map of Fryslân (Versloot cartography 1997, in: Visser, 1997)

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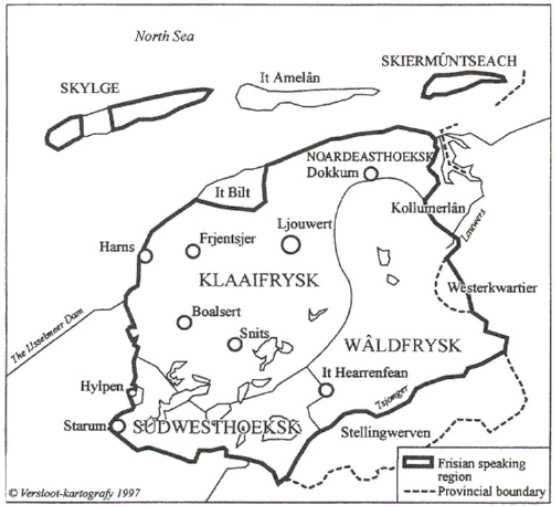

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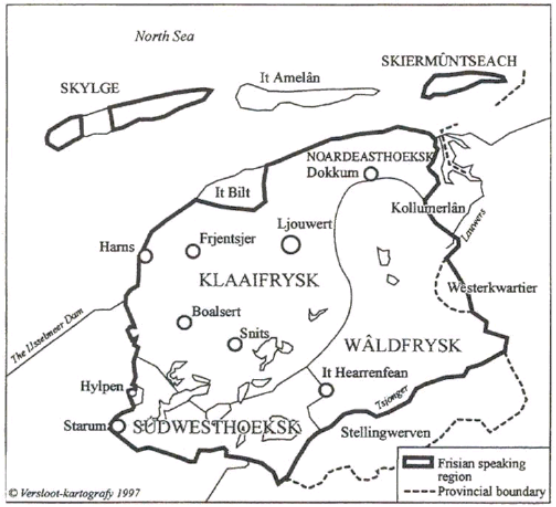

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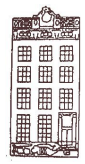

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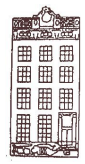

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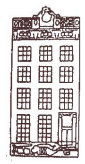

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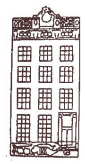

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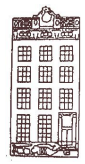

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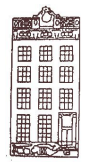

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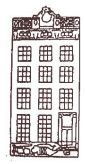

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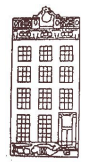

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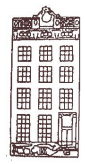

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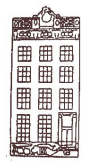

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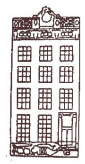

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The architecture of NeXTeNS (Festival):

- **Token Module**: Tokenization
- **POS Module**: Part-Of-Speech tagging
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- Construct Frisian Worldbet phonetic alphabet [Hieronymus(1994)]
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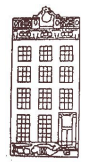
- Map complex sounds, eg, nasalized vowels and triphthongs



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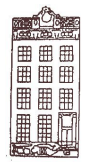

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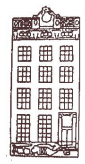

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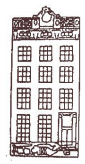

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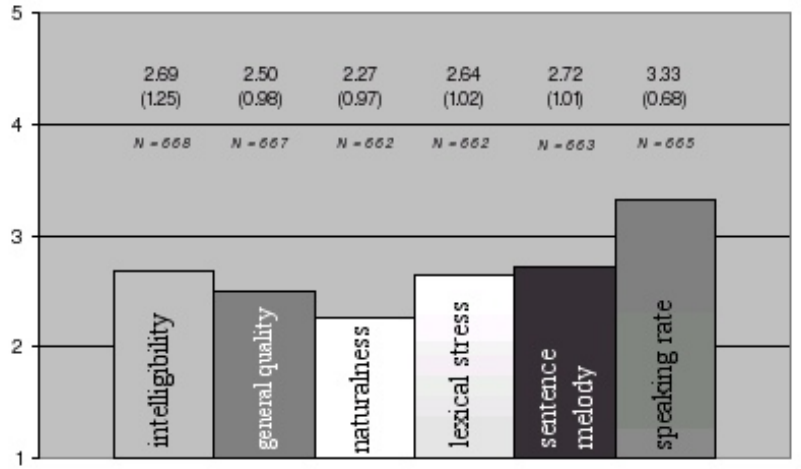

Mean judgments for 20 test sentences

- End evaluation over WWW with 32 native subjects
- 10 short (< 13 words) 10 long (≥ 13 words)
- Example of short and long sentence
- 6 qualities on a 5 point scale (higher is better/more rapid)

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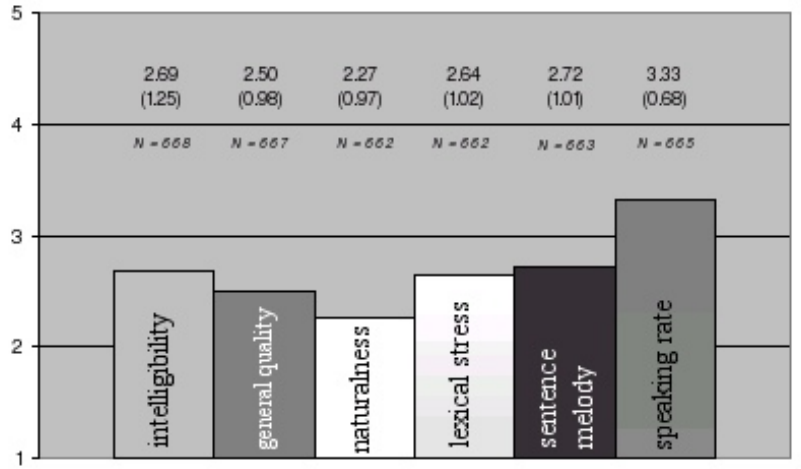

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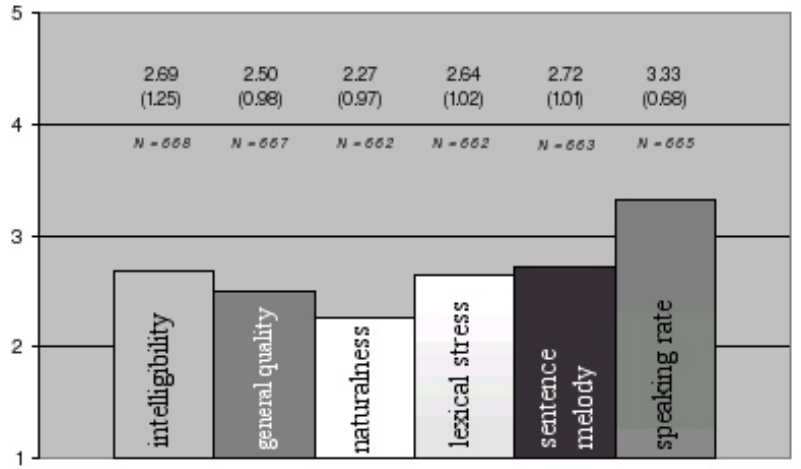

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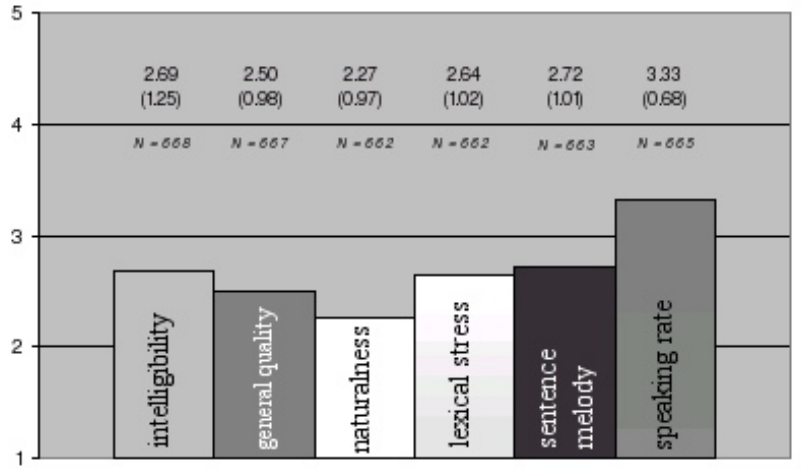

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	short $N \approx 331$	long $N \approx 331$	total $N \approx 662$
intelligibility	2.57 (1.25)	2.80 (1.24)	2.69 (1.25)
quality	2.51 (0.99)	2.50 (0.97)	2.50 (0.98)
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lexical stress	2.67 (1.05)	2.58 (0.99)	2.64 (1.02)
sentence melody	2.79 (0.99)	2.64 (1.02)	2.72 (1.01)
speaking rate	3.30 (0.65)	3.35 (0.71)	3.33 (0.68)

Mean judgments (standard deviation)

- Mean ratings below 3 (mid-point)
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- Sentence length did not change ratings
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3. Recording the data.
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2. Constructing a dictionary for the models
3. Recording the data.
4. Creating transcription files for training data
5. Encoding the data (feature processing)
6. (Re-) training the acoustic models
7. Evaluating the recognizers against the test data
8. Reporting recognition results

Building a basic ASR system

```
# Kinyarwanda
$digit=RIMWE | KABIRI | GATATU | KANE | GATANU | GATANDATU | KARINDWI | UMUNANI
| ICYENDA | ZERO;
(SENT-START [ $digit ] SENT-END)

# Dutch
$digit = EEN | TWEE | DRIE | VIER | VIJF | ZES | ZEVEN | ACHT | NEGEN | NUL;
$name = [ ROB ] (VAN SON) | [ FRANS ] ADRIAANS | [ TOM ] LENTZ | [ MARIJN |
MARINUS ] KOOLEN | [ ORK ] (DE ROOIJ) | [ MARKUS ] HEUKELOM | [ DAAN ]
VREESWIJK;
( SENT-START ( DRAAI <$digit> | BEL $name) SENT-END )
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Task Grammars

- Define digits and names
- Define grammar on vocabular
- Square brackets enclose optional items

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Construct pronunciation dictionary

- Make a word list of all words in the training corpus or a suitable text corpus
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Generate prompts and record utterances

- Use task grammar to generate random prompts
- Record as many users as possible reading the prompts
- Better, subjects repeat synthesized (TTS) prompts
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Training

- Transcribe and (feature) encode utterances
- Feed as much speech as possible to the HTK training
- Kinyarwanda uses 3 male and 3 female speakers, 150 sentences
- Words were hand-labeled
- Dutch uses 1000 labeled sentences from the IFAcorpus (4 male, 4 female speakers)
- Dutch recorded 150 task sentences from 4 male speakers (total 600)
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- Put all files in correct format and fire up HTK training [HTK(2002)]

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ASR evaluation: Kinyarwanda

Subject	Words correct	Substitution errors	Percentage
Subject 1	9	1	90%
Subject 2	8	2	80%
Subject 3	8	2	80%
Subject 4	8	2	80%

Live data recognition results

- 4 New subjects
- Read out all 10 numbers
- HTK self-test results (*not* live):
- Sentence Recognition Rate: 92.00% (N=50)
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TRAINED ON	TESTED ON
IFA + Domain	Domain, training speakers
IFA + Domain	Domain, 'unknown' speaker
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Testing procedures

- Two corpora: IFA corpus and Domain corpus
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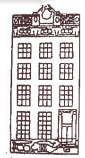
Left Out %	WORD RECOGNITION (%)	SENTENCE RECOGNITION (%)
10	99.71	91.38
20	99.46	92.31
50	99.67	89.93
80	99.66	89.18

Testing on random sentences

- Leave out random sentences and train
- Test randomly selected sentences
- Smaller training set affects Sentence Recognition most



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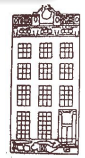

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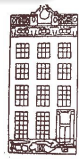

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Ork	99.43	89.13
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12	99.41	92.86
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Top: Testing on a new speaker, Bottom: Testing on new sentences

New speakers are worse than new sentences

- More speakers needed for independence
- Sentence recognition drops sharply
- New speaker *and* new sentences
  Recognition: Word - 99.57%, Sent - 84.35%

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Simple TTS and ASR can be done in a few months

- Free tools are available
- People like it when their language is used
- Recording speech is the most laborous step
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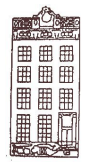

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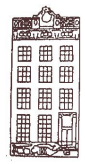

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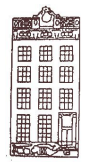

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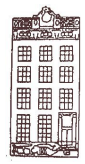
Appendix A



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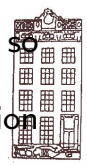

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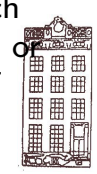

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Appendix: How to Apply These Terms to Your New Programs

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To do so, attach the following notices to the program. It is safest to attach them to the start of each source file to most effectively convey the exclusion of warranty; and each file should have at least the "copyright" line and a pointer to where the full notice is found.

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