Database Driven Speech Synthesis Systems

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Overview

1. Introduction
2. Database building
3. Units
4. Concatenation Synthesis
5. Unit Selection
6. Examples
7. Summary

1 Introduction 1/3

Important criterion for speech synthesis systems:

→ Naturalness

Rule-based systems vs. Concatenation of real speech-based systems

1 Intoduction 2/3

- Reproductive Speech Synthesis

  Replay of pre-recorded words and phrases

  Example: talking toys

- Text-to-Speech Synthesis

  potentially unlimited vocabulary

  subword concatenation

1 Introduction 3/3

Demands on Database-Driven Speech Synthesizers

- Intelligible
- Natural
- Scalable
- Retrainable
- Consistent quality
- Real-time

2 Database Building 1/3

- High quality
- Phonetically rich sentences and words
- Experienced speaker
- Reconstructable environment

2 Database Building 2/3

- Targeted training text
  (news for newspaper reader)

- Recording of additional information
  Laryngograph signal (used for pitchmark extraction for pitch-synchronous resynthesis techniques (LPC, PSOLA)

2 Database Building 3/3

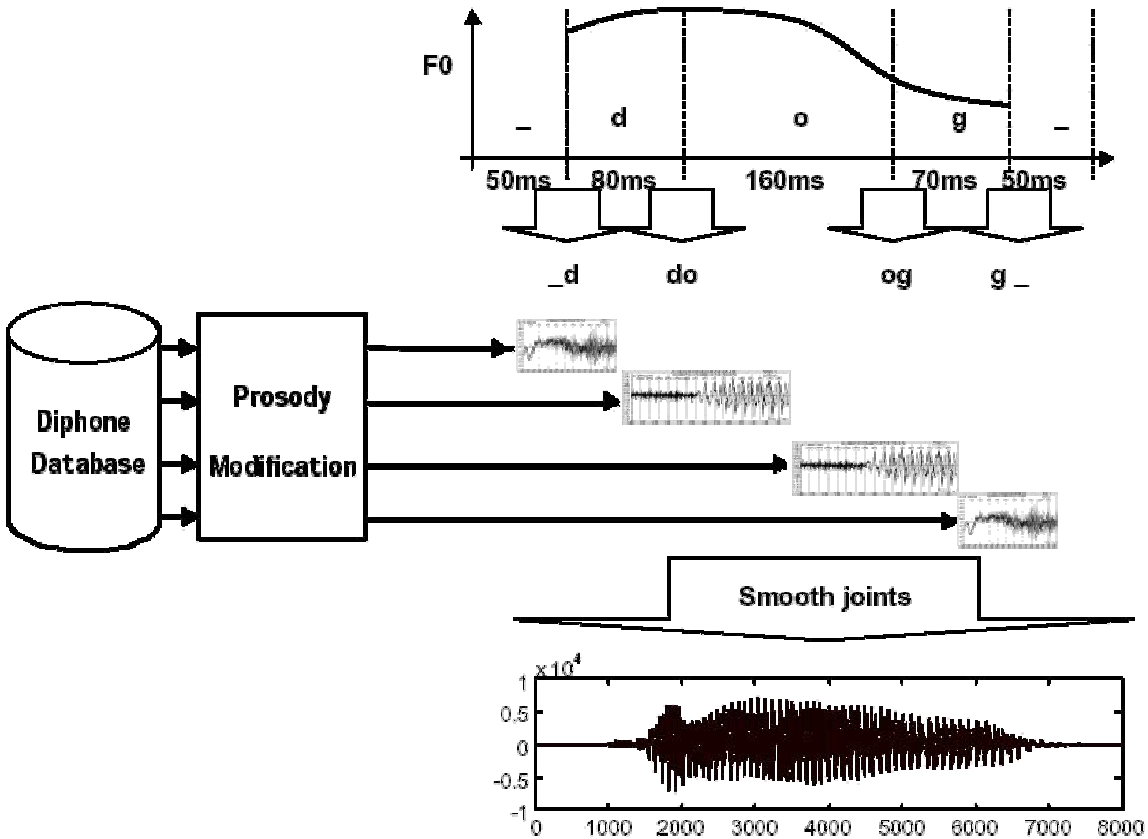
- Time-consuming
- Requires consistent speaker

3 Units

- Phones (40-50)
- Diphones (2.000)
- Triphones (>10.000)
- Demi-syllables (5.500)
- Syllables (11.000)
- (Words)

- Half-phonemes
- Non-uniform units

4 Concatenation Synthesis 1/4



4 Concatenation Synthesis 2/4

Inventory Creation

- Diphone or demi-syllable based
- Units extracted by hand from database

One instance of each unit!

→ Small inventory database

4 Concatenation Synthesis 3/4

Signal Processing

- Prosodic modification
  to match the context
- Smoothing algorithms
  for concatenation points

→ Distortion of the natural waveforms

4 Concatenation Synthesis 4/4

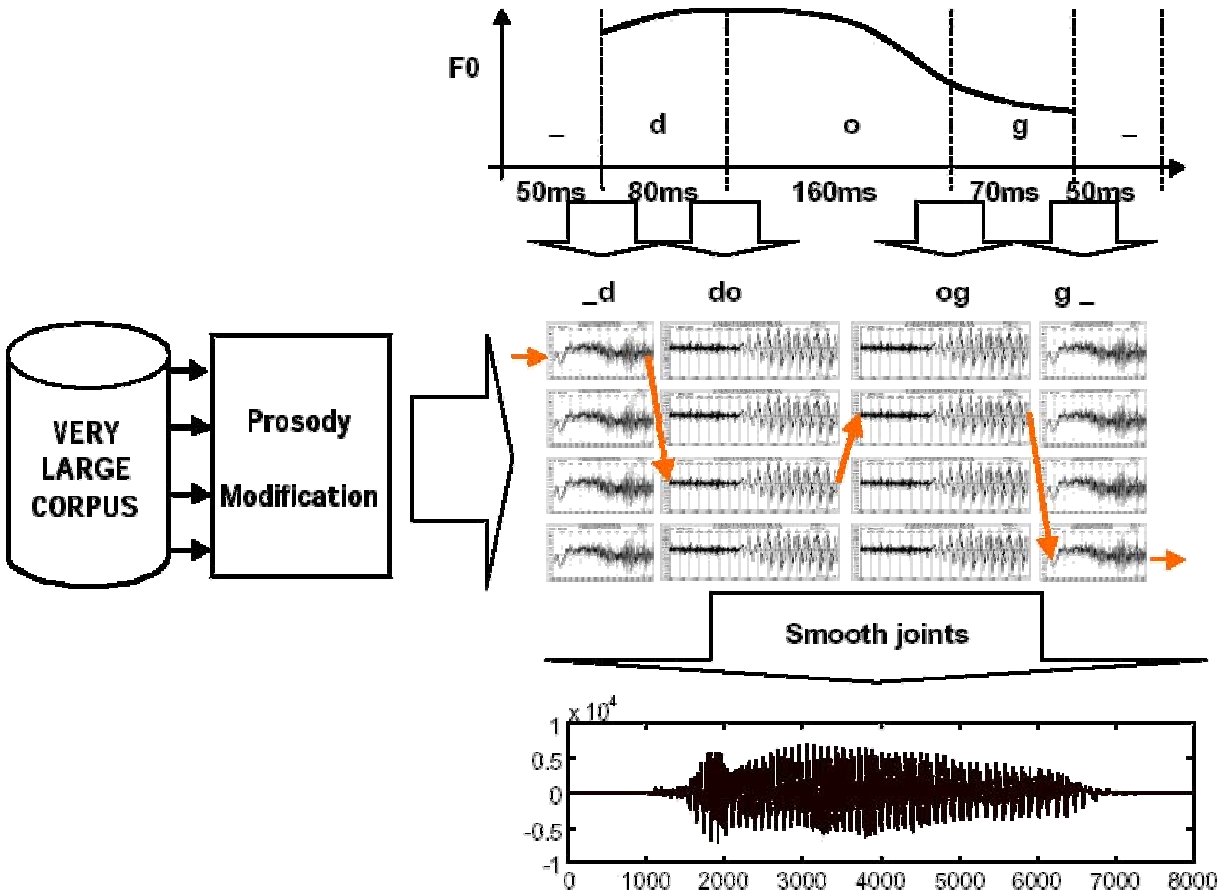
Benefits

- Consistent quality

Demerits

- Lack of naturalness
- Lack of flexibility

5 Unit Selection 1/13



5 Unit Selection 2/13

Inventory Creation

- Phone or sub-phone based
- Units extracted automatically from database

Multiple instances of each unit!

→ Large inventory database

5 Unit Selection 3/13

Signal Processing

- As little as possible!

→ Choice of context-matching and smoothly concatenable units

5 Unit Selection 4/13

Benefits

- Mostly almost natural output

Demerits

- Some very poor examples (inconsistent!)

5 Unit Selection 5/13
CHATR 1/8

CHATR (ATR, Japan)

- Phone-based
- Units represent a fully connected state-transition network
- Choice of units by means of cost-functions

5 Unit Selection 6/13
CHATR 2/8

Database Analysis

Each unit is characterised by a *p*-dimensional feature-vector

- phoneme label
- duration
- power
- F0
- characteristics of neighbouring units
- …

5 Unit Selection 7/13
CHATR 3/8

→ Clustering of similar units

→ Pruning

- Atypical units
- "Equal" units

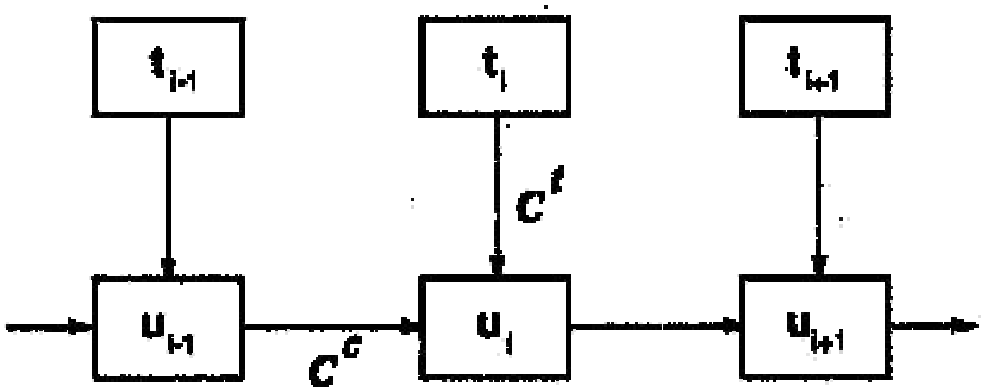
5 Unit Selection 8/13
CHATR 4/8

Synthesis

→ Based on two cost-function

5 Unit Selection 9/13 *CHATR* 5/8

Two Cost-Functions



Target cost $$C^t(t_i, u_i) = \sum_{j=1}^{p} w_j^t C_j^t(t_i, u_i)$$

Concatenation cost $$C^c(u_{i-1}, u_i) = \sum_{j=1}^{q} w_j^c C_j^c(u_{i-1}, u_i)$$

5 Unit Selection 10/13 *CHATR* 6/8

Cost-function of a sequence of n units:

$$C(t_1^n, u_1^n) = \sum_{i=1}^{n} C^t(t_i, u_i) + \sum_{i=2}^{n} C^c(u_{i-1}, u_i) + C^c(S, u_1) + C^c(u_n, S)$$

Including the sub-costs:

$$C(t_1^n, u_1^n) = \sum_{i=1}^{n}\sum_{j=1}^{p} w_j^t C_j^t(t_i, u_i) + \sum_{i=2}^{n}\sum_{j=1}^{q} w_j^c C_j^c(u_{i-1}, u_i) + C^c(S, u_1) + C^c(u_n, S)$$

Goal:

$$\bar{u}_1^n = \min_{u_1,\ldots,u_n} C(t_1^n, u_1^n)$$

5 Unit Selection 11/13 *CHATR 7/8*

Search Algorithm

For each target segment:

- Find units with the same name
- Compute target cost of each unit
- Prune
- Compute concatenation cost
- Prune

- Perform Viterbi-Search (beam-width 10..20)

5 Unit Selection 12/13 *CHATR 8/8*

Training the cost-functions

1. Assume a set of weights
2. Determine best set of units
3. Sythesize waveform
4. Determine distance from the natural waveform

Repeat 1-4 for a range of weight sets and multiple utterances

→ Choose the best(?) weight set

5 Unit Selection 13/13
Whistler

Whistler (Microsoft)

Whisper Highly Intelligent Stochastic TaLkER

- Sub-phonetic units: *senones*
- Probabilistic learning methods
- *Whisper* Speech Recognition System to segment the units from the database corpus
- Part of Windows 2000 and XP

6 Examples

- SVox — diphone concatenation
- CHATR — unit selection
- ≤ Whistler — unit selection

7 Summary 1/2

1. Why database-driven speech synthesizers?
2. How is a speech database recorded?
3. Which types of units can be concatenated?
4. Concatenation Synthesis
   - Inventory creation
   - Prosody modification, smoothing algorithms

7 Summary 1/2

5. Automatic Unit Selection
   - CHATR
     - Database analysis
     - Synthesis by means of cost functions
   - Whistler
6. Examples

References

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