

Speech recognition and synthesis

1 Basics of TTS and ASR: Mandarin tones

- Introduction
- SpeakGoodChinese
- Tone models
- Tone synthesis
- Tone recognition
- Evaluation
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- Bibliography

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Introduction: The problem

Both Text-To-Speech (TTS) and Automatic Speech Recognition (ASR) are based on collecting and manipulating speech corpora

- ASR and TTS can be seen as clever speech databases
- Both compare the target, *input* or *output*, utterance to a speech model
- Select the speech model that best fits the target utterance
- The model speech is constructed from stored examples
- Two questions:
 - How to create a model of the target utterance?
 - How to compare a model to the target utterance?



Introduction: Basic problem

How to build TTS and ASR

- Store speech data in an (abstract) model description
- Create model utterances
- Compare these models to the target utterance
- Select the best fitting model utterance
- Example: Mandarin tones for student practise



Introduction

Problems Teaching Madarin

- Mandarin Chinese is a tone language
- Every syllable in a word has one of 4 (5) tones which determines the meaning of the word
- Using the wrong tone makes a word incomprehensible (cf, English *bad* and *bat*, Dutch *boot* and *bot*)
- Mastering the production and recognition of tones is a major stumbling block in learning Mandarin Chinese
- Direct interaction with a highly proficient speaker, usually the teacher, is needed to practise tone pronunciation



Introduction

A consequence of the difficulty of learning tones

- Classes must be kept small to allow for ample student-teacher interaction
- Speaking and listening proficiency improves very slowly
- High drop-out rates of demotivated students
- Speaking is neglected in favor of writing



Introduction

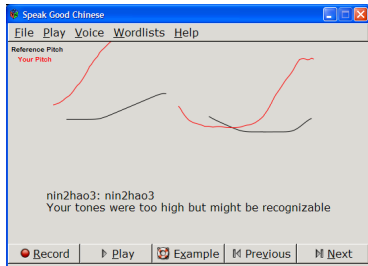
Computer Assisted Language Learning (CALL)

- Language learning requires practise
- Teachers are scarce and expensive
- Use computer technology to help students practise
- Reading and Writing: texts, spelling and grammar checkers
- TTS: Read aloud texts, generate examples
- ASR: Judge student pronunciations and give feedback



SpeakGoodChinese

An aid for practising Mandarin tones.



<http://www.SpeakGoodChinese.org/>

- All mono- and bisyllabic words
- Automatic Tone Recognition
- Graphical Tone Presentation
- A written analysis of tone pronunciation.
- Hummed (TTS) or pre-recorded examples
- Replaying recorded student pronunciation
- Automatic student evaluation (hidden)



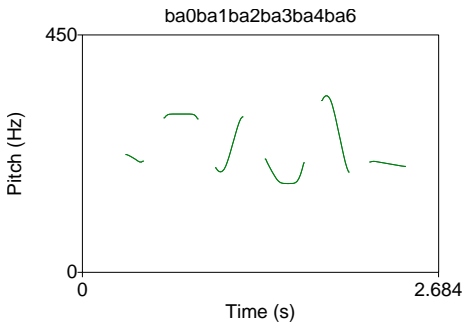
SpeakGoodChinese

Pinyin to Tone synthesis as TTS

- Pinyin phonetic transcription system (eg, *ni3hao3*)
- Each syllable has a number 1-4 or the neutral tone 0
- Split pinyin word into syllables (on tone number)
- Split pinyin syllable into Unvoiced initial and voiced final
- Tone contour is realized on voiced part only



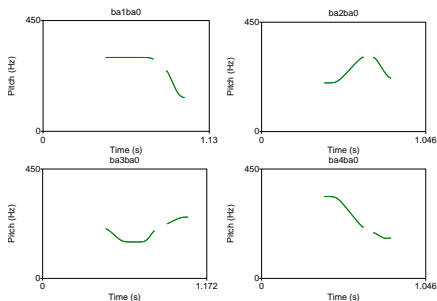
Tone models: All tones



SpeakGoodChinese tone models

- Neutral tone, 0, tones 1-4, and garbage model 6
- Tones change in “context”

Tone models: Assimilation of neutral tone



Examples

- Neutral tone continues from previous tone
- Returns to “neutral” position
- Fourth tone seems exception

Tone synthesis: Pinyin to syllables and tones

Mandarin syllables, eg, *zhong1*

- Syllable: Optional Initial (*zh*) + Obligatory Final (*ong*)
- Initial is always a single phoneme (*zh* = /dʒ/)
- Initial can be voiced and voiceless
- Final is always voiced
- Final is a vowel and an optional nasal /nmŋ/
(rarely an /r/)
- Vowel can be a monophthong, /e/, diphthong, /ei/, or triphthong, /iau/
- Tones are realized on the voiced part of the syllable



Tone synthesis: Initials and finals

	a	ei	ong	ia	iong	uan
b	ba	bei				
d	da	dei	dong			
zh	zha		zhong			zhuan
r						
j				jia	jiong	
g	ga	gei	gong			guan

Durational model

- Estimate durations of Initial and Final
- Crude model: Fixed duration + $\delta \cdot$ number of symbols (iao=3)
- Adapt duration to tone: $3 > 1 > 2 \approx 4 \gg 0$



Tone recognition

Tone recognition: Was student correct?

- Extract utterance pitch contour (F_0)
- Pinyin-to-Tone synthesis for all tones (correct and *incorrect*)
- Compare student utterance to all possible tone contours using Dynamic Time Warping
- Pick best matching model \Rightarrow Recognition
- Construct possible countours from theoretical tone model
- Limited to two syllables (combinatorial explosion)
- Student pitch register must be known



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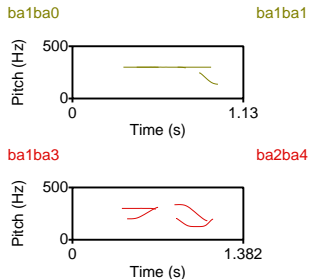
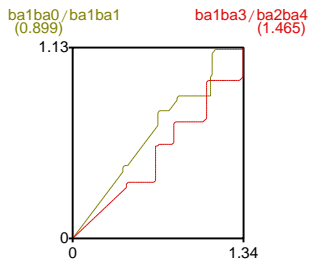
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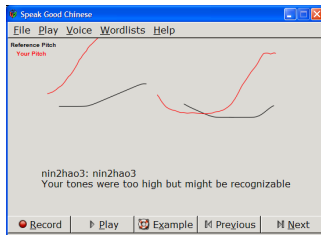
Tone recognition: Dynamic Time Warping



Align time points and “sum” distances \Rightarrow shortest path

- *ba1ba0* and *ba1ba1* very much alike (0.899)
- *ba1ba3* and *ba2ba4* more different (1.465)
- Do this for all combinations, effective for bisyllabic words

Tone recognition: Pitch height and movements



A good tone has correct pitch height and movements

- If *top pitch* deviates from model, flag an error
- If *pitch range* deviates from model, flag an error
- Students will exaggerate tones, punish exaggerations less
- Flag error if 3 semitones too low or too narrow
- Flag exaggeration if 6 semitones too high or too wide

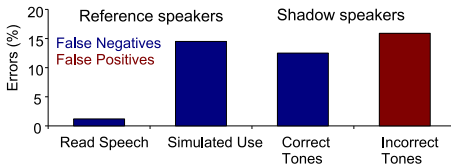
Tone recognition: Heuristic rules

Model tones do not model enough variation

- Duration rules currently very bad
- Current tone models do not capture variation
- Use “heuristic” rules to capture common confusions
- Eg, tones 2 and 3 merge before another tone 2 or 3
- Eg, tones 2 and 4 often misidentified as tone 0 in DTW but tone 0 would have been flagged by tone height and movement



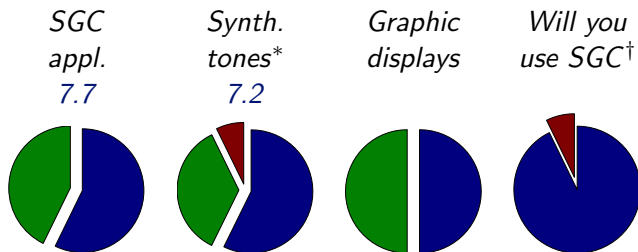
Evaluation: Recognizer False *rejects* and *accepts*



Reference speakers and Students

- Correct Tones
 - Read Speech: **R** read aloud 6 words: *cha2, dian4hua4, duo1shao3, gong1zuo4, jie2hun1, shi2jian1*, 83 tokens.
 - Simulated Use: **R** free word choice, 358 tokens
 - Shadowed Correct Speech: **R** and **S** shadowed 6 words, 160 tokens
- Incorrect tones
 - Shadowed Incorrect Speech: **R** and **S** shadowed 6 words, 320 tokens

Evaluation: Usefulness and grade 1-10



Legend: **Not useful/No** - **Useful** - **Very useful/Yes**

* One subject couldn't hear the tones clearly

† One subject preferred to practice with family members

Questionnaire to 14 students

- Tested RAD Tcl/Tk GUI with functional recognition
- Responses used to design User Interface

Evaluation: Usage data

Does SpeakGoodChinese improve tone pronunciation?

- Single Female student (13)
- Tried out SpeakGoodChinese in 7 session of a few hours
- In total she uttered 1531 words
- Each session started and ended with test runs without audio feedback
- Pretest and Posttest \approx 30 words
- Practise \approx 83-389 words
- Automatically determined error rate ($*p < 0.002, X^2$)
 - Overall: 28% (including practise)
 - Pretest: 39% *
 - Posttest: 24% *
- Real progress awaits human judgment



Assignment: Week 4 Dynamic Programming

```
function MIN-EDIT-DISTANCE(target, source) returns min-distance
```

```
n ← LENGTH(target)
```

```
m ← LENGTH(source)
```

```
Create a distance matrix distance[n+1,m+1]
```

```
distance[0,0] ← 0
```

```
for each column i from 0 to n do
```

```
  for each row j from 0 to m do
```

```
    distance[i,j] ← MIN(distance[i-1,j] + ins-cost(target[i]),  
                       distance[i-1,j-1] + subst-cost(source[j], target[i]),  
                       distance[i,j-1] + del-cost(source[j]))
```

- Implement the Minimal Edit Distance (see figure)
- See 5.6, pages 153-156 + figure 5.6, of Jurafsky & Martin
- Use your favorite programming/scripting language
- Include back-pointers to allow tracing the best alignment
- NOTE: there are (initialization) errors in the pseudo-code
- Test it on several character strings

See blackboard for more information.



Further Reading I



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Ty Coon, President of Vice*

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