Providing Sublexical Constraints for Word Spotting within the ANGIE Framework

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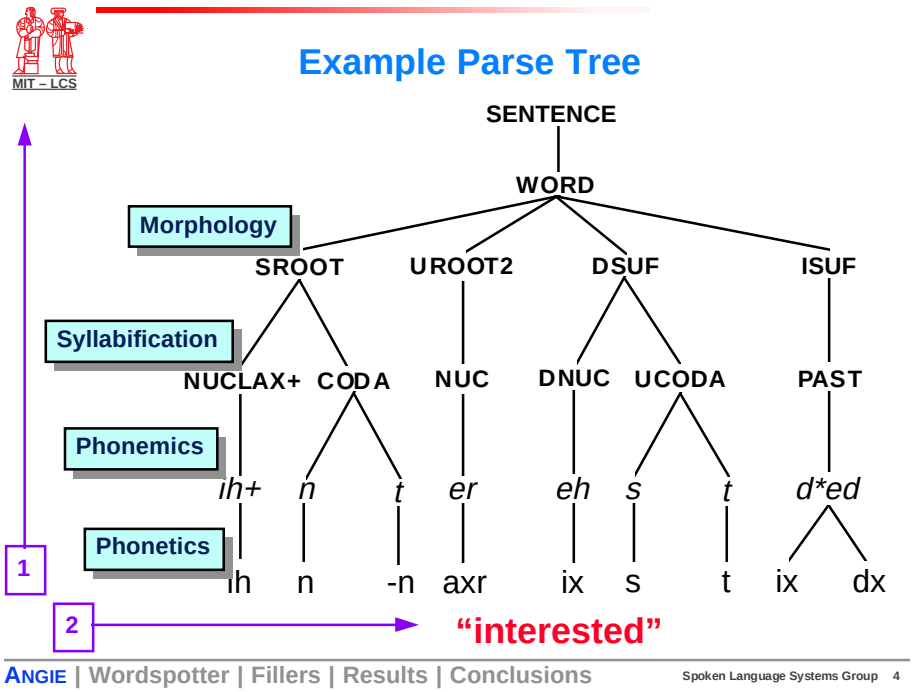
Outline

- ANGIE
- Wordspotter
- Filler models
- Results
- Conclusions

What is ANGIE?

- Flexible, multipurpose system for speech processing
- Framework introduced in Seneff, Lau & Meng (ICSLP '96)
- Word substructures characterized jointly by:
  - Context free grammar
  - Probabilistic model
- Possible applications include:
  - Flexible/extensible speech recognition tasks
  - Bidirectional letter/sound generation
  - Prosodic modeling
- Benefits include:
  - Pooling of data due to hierarchical structure
  - Generalization of knowledge to new words
  - Easy experimentation with subword representations



- Very regular layered structure
- Regular structure imposed by CF rules with lhs and rhs on adjacent layers
- Layers are sentence, word, morphology, syllabification, phonemics, phonetics
- No stress layer -- instead, distributed amongst layers
- Parsing proceeds left-to-right with each column built bottom-up
- Last two layers capture phonological variation
- Context dependencies typical in phonology learned by probability model
- Probabilities:
  - Terminal advancement
  - Bottom up trigram

Current Task: Wordspotting

- Task: Wordspot 39 city names in ATIS
  - Training 5000 utts, testing Dec ’93 test set
  - Similar task to Manos and Zue (ICASSP ’97)
- Objectives:
  - Explore effects of varying subword lexical model
    - * Easy to do within the ANGIE framework
  - Further establish empirically the feasibility of using ANGIE for speech recognition tasks
  - Use as a natural foundation for building a full ANGIE speech recognizer

Wordspotter

- Start with segment based graph as in MIT's SUMMIT
- Use mixture diagonal Gaussian acoustic models for context-independent phones:
  - MFCC means averaged over thirds of segments
  - MFCC derivatives across segment boundaries
- Perform left-to-right search of phone graph
  - Partial ANGIE parses computed for partial theories
    - Well supported by ANGIE's left-to-right bottom-up parsing strategy
  - Best ANGIE parse score used as linguistic score

Search Strategy

- Previous work with ANGIE used best-first strategy
  - Proved inadequate empirically for wordspotting
  - Possible reason: difficulties in normalizing short vs. long theories for comparison
- Current strategy: Variant of *stack decoder*
  - c.f., Jelinek (IEEE ’76), Paul (ICASSP ’91)
  - Extend all paths at the earliest unexplored time boundary based on score
  - Prune based on a maximum number of paths permitted at any boundary

Filler Models

- ANGIE provides subword lexical model for the filler space
- Different ANGIE configurations give us a range of models
- Start with least constraint: phone bigram
- End with most constraint: full ANGIE layered model with 1200 word lexicon
- In all cases, no cross-word constraints (e.g., word *n*-gram) used

Range of Filler Models

- Phones
  - Only phone bigram used
- Pseudo-words (e.g., flid: f l ih dcl d)
  - "Invent" possible pseudo-words bottom-up
- Syllables (e.g., ciscofran: s ih s kcl k uh f axr n)
  - Syllable is highest unit
  - Syllable ordering not enforced
- Morphs (e.g., conflighting: kcl k aa n f l ay tcl t iy ng)
  - Syllables with ordering enforced
- Known words plus pseudo-words
  - 1200 words plus allow "invention" of pseudo-words
- Known words only
  - 1200 words

Results

Filler Model	Figure of Merit	Rel. Time
Phone Bigram	*85.3*	-
Pseudo-words	86.3	1.00
Syllables	87.7	0.56
Morphs	88.4	0.79
Words + Pseudo-words	88.6	0.79
Words	89.3	0.74

- More constraint leads to higher FOM
- Speed increases with constraints
  - Possible explanation: lower branchout
  - Exception: Syllables very fast
- Word bigram gets 93.9 FOM

Other Points

- **Increasing subword lexical constraints on filler model improves performance**
  - **Another example of "full recognition is best"**
  - **Permitting pseudo-words in addition to known words did not help, even if vocabulary lowered to 400 words**
- **Integration of Chung's ANGIE-based duration model improves performance even more (up to 91.6 FOM)**
  - **To be presented: W2C.3 (Wed, 12:30, Delphi)**

- Test set coverage is 92% with vocab size of 400 and 86% with vocab size of 200 (where performance starts to swap relative ordering)

Future Work

- ANGIE is a workable framework for speech processing
  - Especially for research in subword lexical modeling
  - But also can leverage off of parse tree structure for acoustic modeling
- Natural next step is full speech recognition
  - Easy to do dynamic vocabulary updates
- Other tasks
  - Pronunciation server (integrates well with dynamic vocabulary recognizer)