CMPT 825
Natural Language Processing

Anoop Sarkar

http://www.cs.sfu.ca/~anoop

Automatic Speech Recognition

- Acoustic observations: signal processing to extract energy levels at each frequency level
- Observation sequence **o** is composed of acoustic features extracted from the waveform at regular (10msec) intervals
- ASR is the task of converting the observation sequence **o** into a transcription **w**

Noisy Channel Model

- Finding the best transcription **w*** given an observation sequence **o**

$$\mathbf{w}^* = \underset{\mathbf{w}}{\arg\max}\, P(\mathbf{w} \mid \mathbf{o}) = \underset{\mathbf{w}}{\arg\max} \frac{P(\mathbf{o} \mid \mathbf{w}) P(\mathbf{w})}{P(\mathbf{o})}$$

$$= \underset{\mathbf{w}}{\arg\max}\, \underbrace{P(\mathbf{o} \mid \mathbf{w})}_{\text{generative model}} \underbrace{P(\mathbf{w})}_{\text{language model}}$$

Generative Models of Speech

- Typical decomposition of P(**w** | **o**) into a cascade of generative models:
  - Acoustic Model:

    P(**o** | **p**) predict observation sequence **o** given phone sequence **p**
  - Pronunciation Model:

    P(**w** | **p**) predict phone sequence **p** given a word sequence **w**
  - Language Model:

    P(**w**) predict word sequence **w**

Generative Models of Speech

- Further decomposition of the acoustic model: P(**o** | **p**)
  - P(**o** | **d**) observation vectors given distribution sequences (quantitative given symbolic)
  - P(**d** | **m**) distribution sequences given model sequences (model dependent phone sequences)
  - P(**m** | **p**) model sequences given phone sequences

Brief History of ASR

- 1920s: Radio Rex
  - 500 Hz of energy in the word “Rex” caused the toy dog to move
- 1950s: Digit Recognition (Bell Labs)
- 1960s: Advances in Signal Processing and Neural Nets (not much progress in ASR)
- 1970s: Despite large ARPA funding, not much success

Brief History of ASR

- 1980s: Discrete ASR, Language Models, corpus collection efforts
  - TIMIT corpus (phonetics)
  - ATIS corpus (Air Travel Information System)
  - Focus on language understanding dialog systems

Brief History of ASR

- 1990s: Large Vocabulary Continuous ASR
  - Dynamic Time Warping (edit distance)
  - Better phonetic models using classifiers (decision trees and neural nets)
  - Better language models using smoothing
  - Larger corpora: 10^7 and 10^9 in size

Brief History of ASR

- Current Work
  - Other languages and dialects
  - Multiple speakers, Speaker adaptation
  - Speaker identification
  - Noise resistant (telephone speech)
  - Open source software: HTK, Sphinx, CMU LM toolkit, SRI LM toolkit