MULTI-LINGUAL SPEECH RECOGNITION SYSTEM FOR SPEECH-TO-SPEECH TRANSLATION


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OUTLINE

- S2ST and Speech Recognition
- Overview of the ATR ASR System
  - MDL-SSS Acoustic Model
  - Multi-Dimensional Class N-gram LM
- BTEC Corpus Description
- Evaluation:
  - Japanese ASR
  - English ASR
  - Chinese ASR
- Conclusion
Speech-To-Speech Translation System

- **Speech Recognition Module:**
  - Provides text input for translation module
  - Can provide additional information:
    - Word POS tags
    - Word Confidence scores
    - Out-of-domain utterance control
Minimum Description Length (MDL) Criterion for Model Selection

\[ L_i(x) = -\log P(x | \hat{\theta}^{(i)}) + \frac{\alpha_i}{2} \log N_T + \log I \]

- \( L_i(x) \): log likelihood
- \( \alpha_i \): number of free parameters of model \( i \)
- \( \hat{\theta}^{(i)} \): maximum likelihood estimate of model \( i \)
- \( x \): observation data
- \( \{1, \ldots, i, \ldots, I\} \): set of models
- \( \log \): log likelihood
- \( \log \): log of samples
- \( \log \): log of samples
Gain Function of MDL-SSS

A gain function can be derived from the difference of the MDL criteria between before splitting and after splitting.

For contextual splitting:

\[
G_c^{(MDL)}(S_i) = -G_c^{(ML)}(S_i) + C_c \frac{\alpha'_c - \alpha_c}{2} \log N_{all}
\]

For temporal splitting:

\[
G_t^{(MDL)}(S_i) = -G_t^{(ML)}(S_i) + C_t \left\{ \frac{\alpha'_t}{2} \log N'_{all} - \frac{\alpha_t}{2} \log N_{all} \right\}
\]

\[C_c, C_t:\] adjust differences between the 1\textsuperscript{st} term and the 2\textsuperscript{nd} term.
MDL-SSS Algorithm

- **Initial state**
  - For all states
    - Temporal splitting
    - Contextual splitting
      - Select the splitting with min criterion,
        - $G_t^{(MDL)}$ or $G_c^{(MDL)}$
      - $G_t^{(MDL)} > 0$ and $G_c^{(MDL)} > 0$?
        - No: Parameter re-estimation
        - Yes: Finished

(T. Jitsuhiro et al., 2004)
Multi-Class N-gram LM

Conventional Class 2-gram

\[ P(w_i | w_{i-1}) \approx P(c(w_i) | c(w_{i-1}))P(w_i | c(w_i)) \]

Class assignment of \textit{an} and \textit{a}:

- Same class -> less accurate
- Different class -> less reliable

Multiple class assignment depends on direction:

\[ P(c^{\text{f}}(w_i) | c^{\text{p}}(w_{i-1}))P(w_i | c^{\text{f}}(w_i)) \]

(H. Yamamoto et al., 1999)
Basic Travel Expression Corpus (BTEC)

- Covers utterances in the travel domain:
  - Sentences extracted from bi-lingual phrase-books.
  - Revised to reduce context dependence.
  - Out of domain and special sentences removed.
- Divided into 4 parts – BTEC 1,2,3 and 4:
  - In total: ~600 000 sentences
- Available in 3 languages:
  - Japanese
  - English
  - Chinese
Japanese ASR - Experiment

- **Training data for acoustic models:**
  - Pseudo-dialogs: Travel Arrangement (TRA)
  - Phonetic balanced sentences (BLA)
  - Total 30 hours
  - 407 speakers

- **Training data for language models:**
  - BTEC: 160k sentences with 1.2 M words
  - 37K word dictionary

- **Evaluation data**
  - BTEC test set 01: 510 sentences
  - 20 males and 20 females
English ASR - Experiment

- **Training data for acoustic models:**
  - Wall Street Journal (WSJ) corpus
  - 284 speakers (WSJ-284)
  - Total ~60 hours

- **Training data for language models:**
  - BTEC: 160k sentences with 1.2 M words
  - 22K word dictionary

- **Evaluation data**
  - BTEC test set 01: 200 sentences
  - 10 males and 10 females
English ASR - Performance

Word Accuracy (%)

Tri-gram rescoring
- No
- Yes

Language Model
- Word bi-gram
- Multi-class bi-gram
Chinese ASR - Experiment

- Basic subword units: 21 Initials and 37 Finals
- **Training data for acoustic models:**
  - ATR phonetically rich Putonghua (General domain)
  - 140 speakers with a total of 54 hours of speech.
- **Training data for language models:**
  - 200k BTEC Chinese sentences
  - 16.5k word dictionary
- **Evaluation data:**
  - BTEC: 12 000 sentences
  - 20 males and 20 females
Chinese ASR - Results

Chinese character Accuracy (%)

- **Acoustic model**
  - ML-SSS HMnet
  - 1200 states

- **Language model**
  - Multi-class bi-gram
  - Tri-gram
Conclusions

- **ATR multi-lingual ASR system:**
  - Uses advanced modeling technologies – MDL-SSS, Multi-class N-gram, etc.
  - Achieves high performance (about 8% WER) in all languages: Japanese, English and Chinese

- **Ongoing development work:**
  - Implementation of noise and channel robust techniques
  - Adaptation to various accents of Japanese, English and Chinese
  - Field trial in real environment