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# 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**

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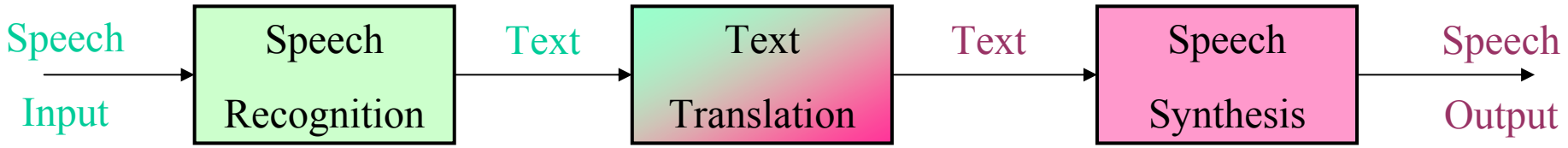
# Speech-To-Speech Translation System




- **Speech Recognition Module:**
  - **Provides text input for translation module**
  - **Can provide additional information:**
    - **Word POS tags**
    - **Word Confidence scores**
    - **Out-of-domain utterance control**

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# Minimum Description Length (MDL) Criterion for Model Selection

$$L_i(\mathbf{x}) = \underbrace{-\log P(\mathbf{x} \mid \hat{\theta}^{(i)})}_{\text{log likelihood}} + \underbrace{\frac{\alpha_i}{2} \log N_T}_{\text{\# of parameters x log \#of samples}} + \log I$$

$\mathbf{x} = \{x_1, \ldots, x_{N_T}\}$ : observation data

$\{1, \ldots, i, \ldots, I\}$ : a set of models

$\alpha_i$ : the number of free parameters of model $i$

$\hat{\theta}^{(i)}$ : the maximum likelihood estimate of model $i$

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# 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 1st term and the 2nd term.

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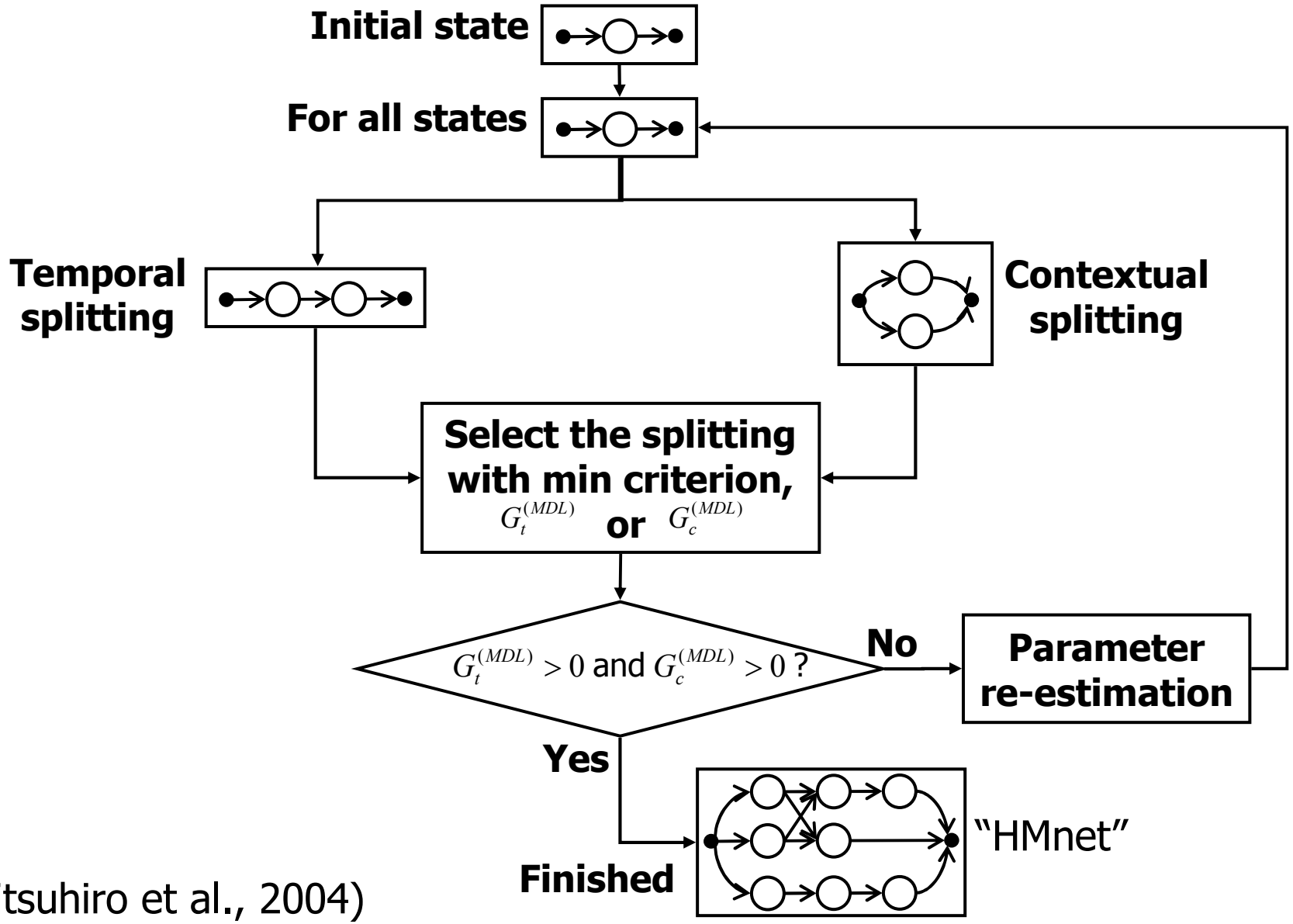
# MDL-SSS Algorithm




(T. Jitsuhiro et al., 2004)

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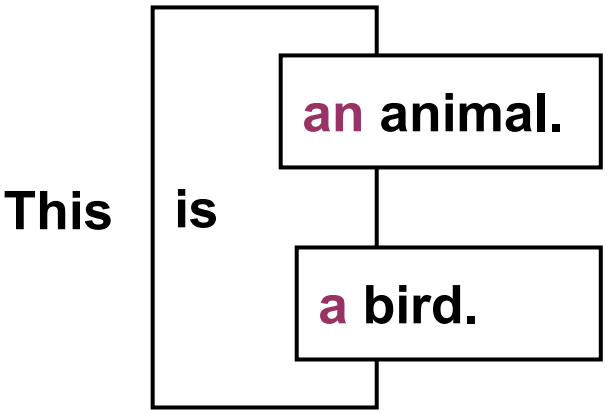
# Multi-Class N-gram LM

**Conventional Class 2-gram**

$$P(w_i \mid w_{i-1}) \approx P(c(w_i) \mid c(w_{i-1}))P(w_i \mid c(w_i))$$




**Class assignment of an and a:**

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

**Multiple class assignment depends on direction:**

$$P(c^{f}(w_i) \mid c^{p}(w_{i-1}))P(w_i \mid c^{f}(w_i))$$

(H. Yamamoto et al., 1999)

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# 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

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# 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

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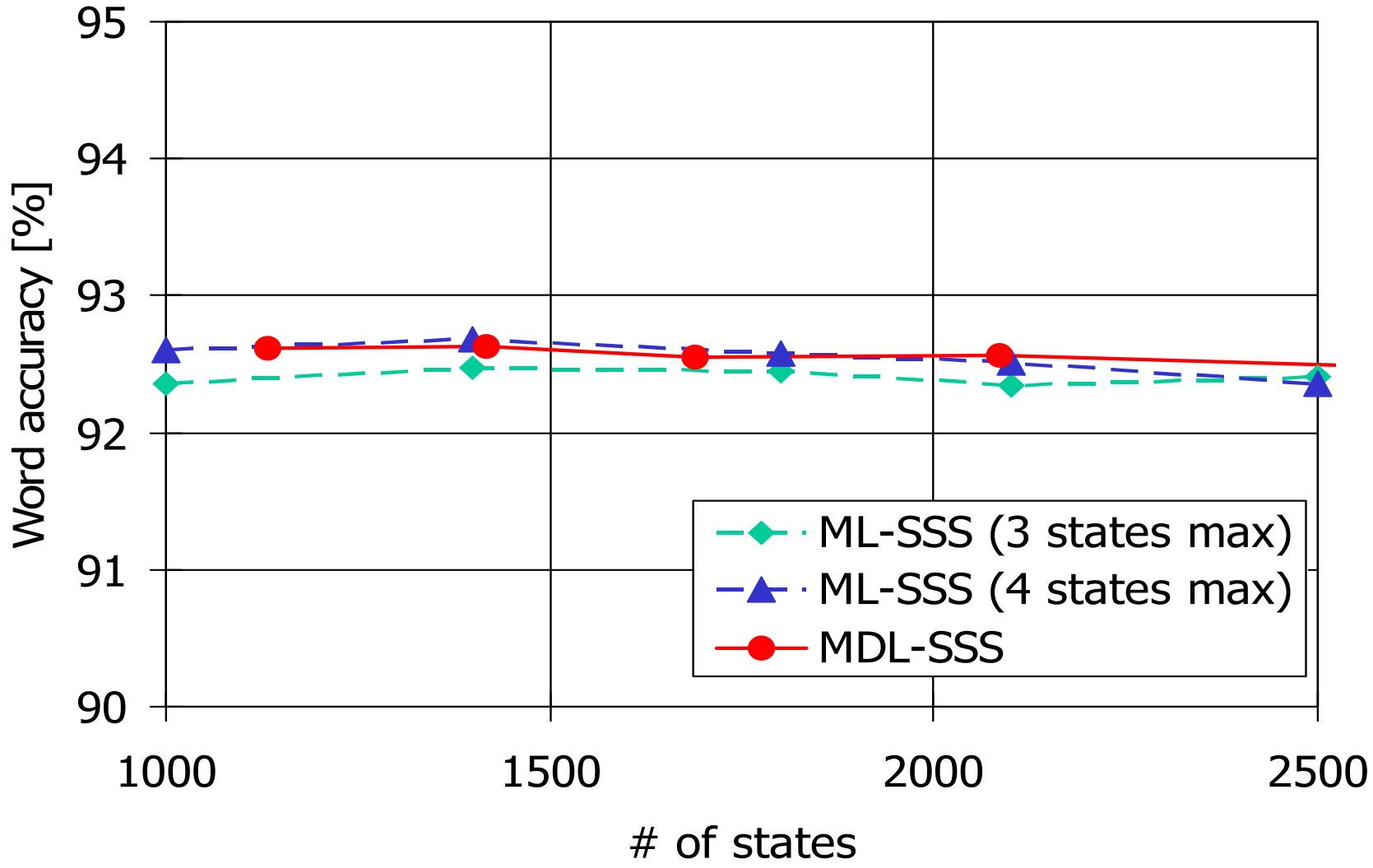
# Japanese ASR - Performance



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# 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

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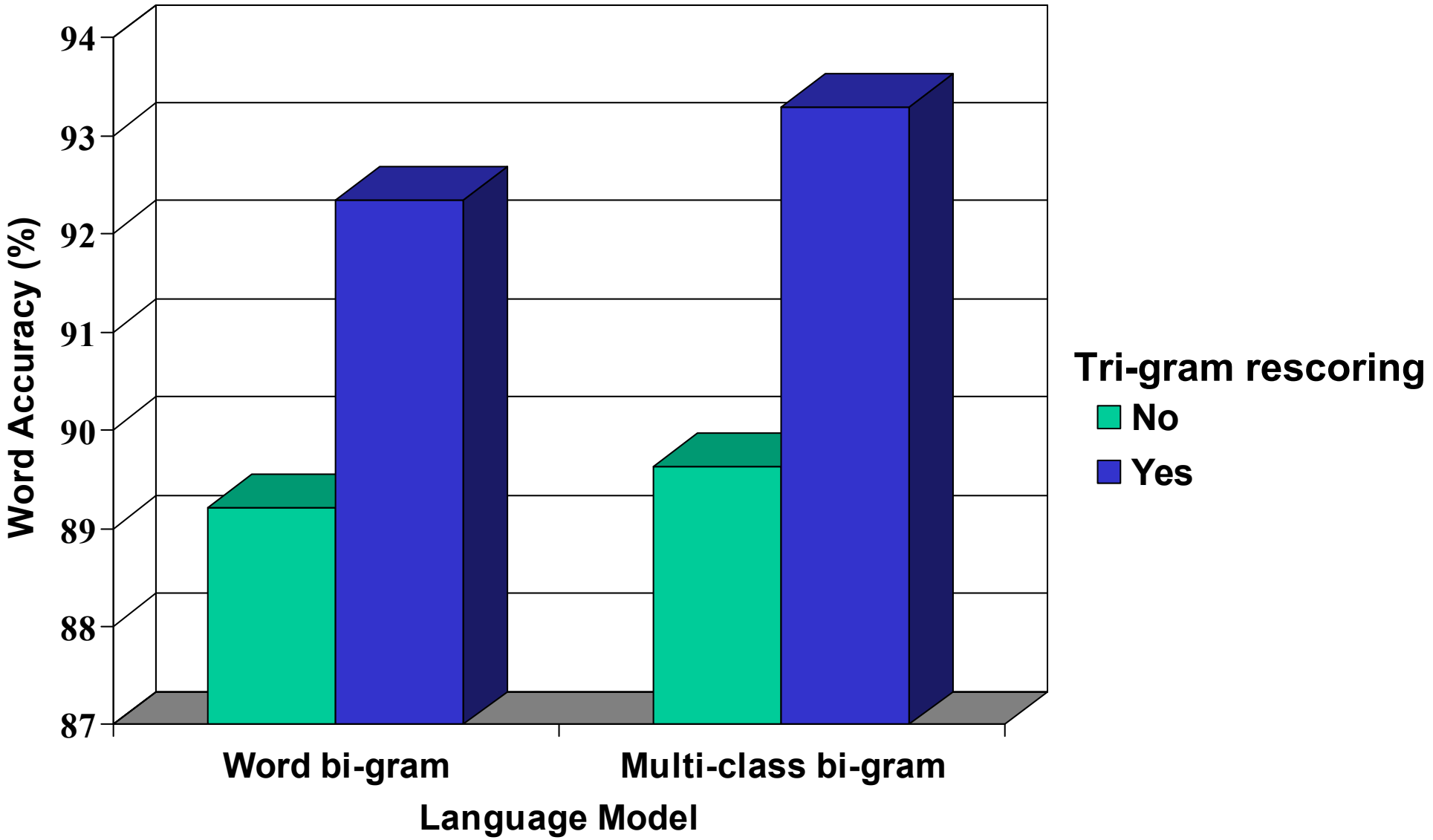
# English ASR - Performance



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# 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

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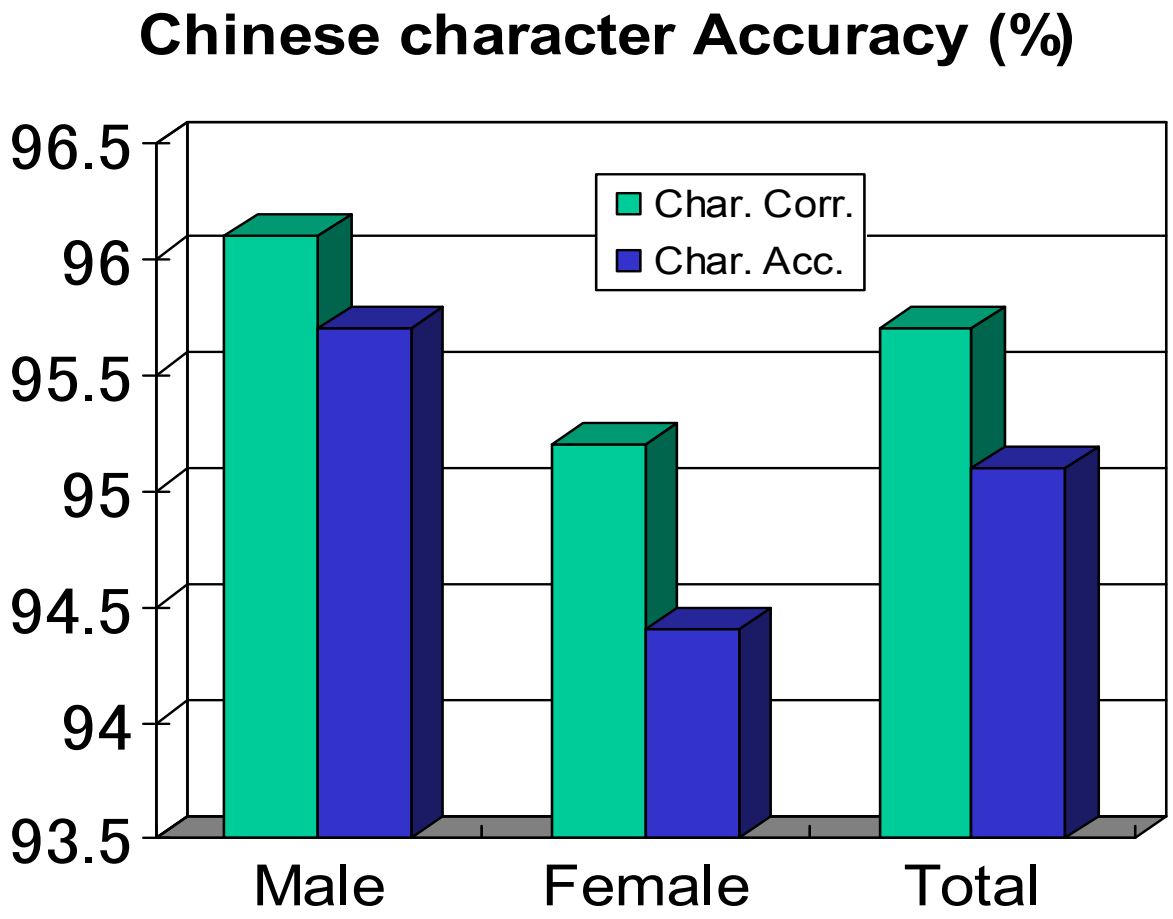
# Chinese ASR - Results

- **Acoustic model**
  - ML-SSS HMnet
  - 1200 states
- **Language model**
  - Multi-class bi-gram
  - Tri-gram



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# 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