Speech Signal Processing

語音信號處理

Berlin Chen 2003

Course Contents

- Both the theoretical and practical issues for spoken language processing will be considered
- Technology for **Automatic Speech Recognition** (ASR) will be further emphasized
- Topics to be covered
  - Statistical Modeling Paradigm
    - Spoken Language Structure
    - Hidden Markov Models
    - Speech Signal Analysis and Feature Extraction
    - Acoustic and Language Modeling
    - Search/Decoding Algorithms
  - Systems and Applications
    - Keyword Spotting, Dictation, Speaker Recognition, Spoken Dialogue, Speech Information Retrieval etc.

Textbook and References

- Textbook:
  - X. Huang, A. Acero, H. Hon, “Spoken Language Processing,” Prentice Hall, 2001
- References:
  - T. F. Quatieri,“Discrete-Time Speech Signal Processing - Principles and Practice,” Prentice Hall, 2002
  - J. R. Deller, J. H. L. Hansen, J. G. Proakis, “Discrete-Time Processing of Speech Signals,” IEEE Press, 2000
  - F. Jelinek, "Statistical Methods for Speech Recognition," The MIT Press, 1999
  - S. Young et al., “The HTK Book”, Version 3.0, 2000 "http://htk.eng.cam.ac.uk"
  - L. Rabiner, B.H. Juang, “Fundamentals of Speech Recognition”, Prentice Hall, 1993

Grading

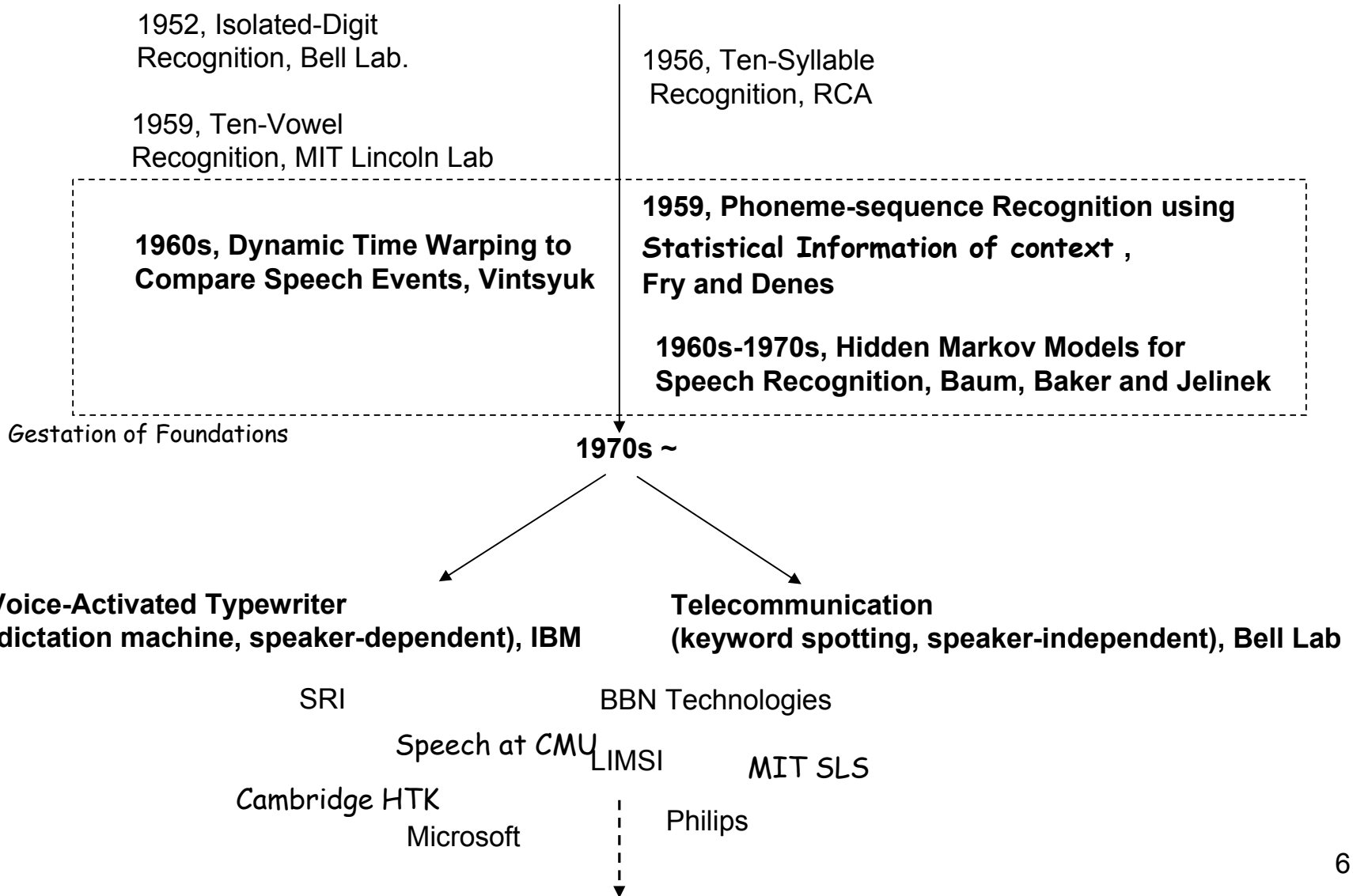
- Midterm or Final: 30%
- Exercises: 30%
- Project: 15%
- Attendance/Presentation/Report: 20%
- Others: 5%

Introduction

References:

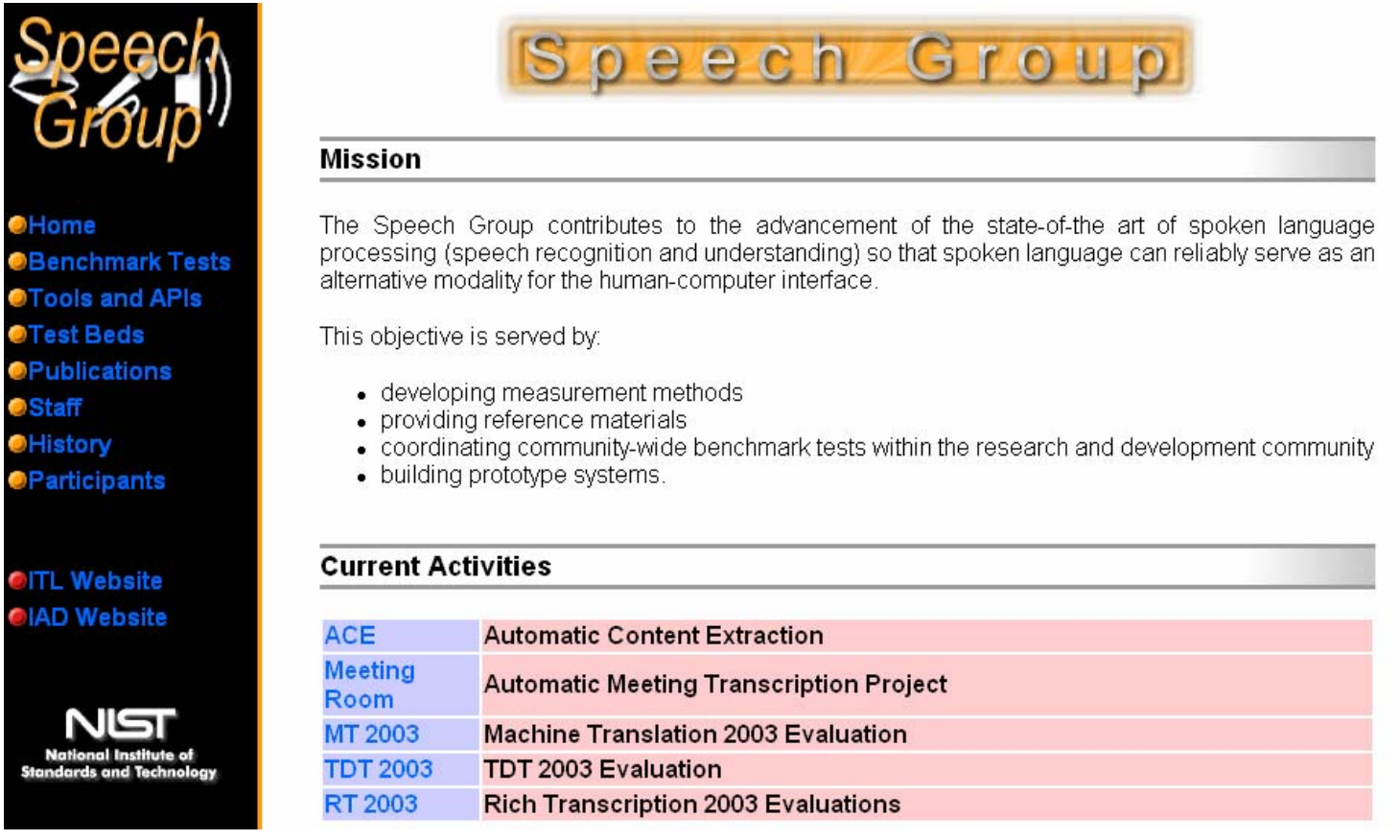
1. B-H Juang and S. Furui, "Automatic Recognition and Understanding of Spoken Language - A First Step Toward Natural Human-Machine Communication," Proceedings of IEEE, August, 2000
2. I. Marsic, Member, A. Medl, And J. Flanagan, "Natural Communication with Information Systems," Proceedings of IEEE, August, 2000

Historical Review



Progress of Technology

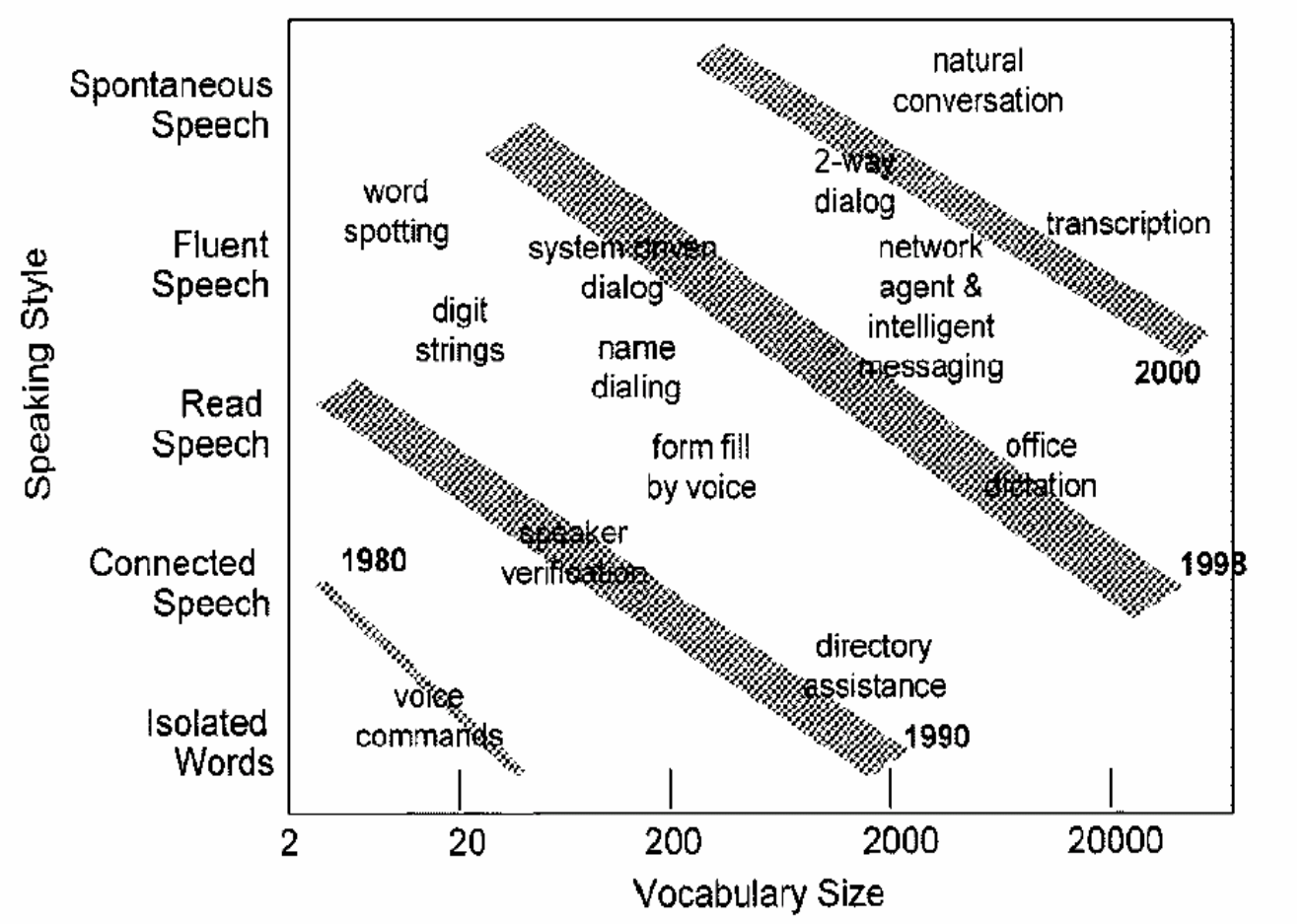
- US. National Institute of Standards and Technology (NIST)



http://www.nist.gov/speech/

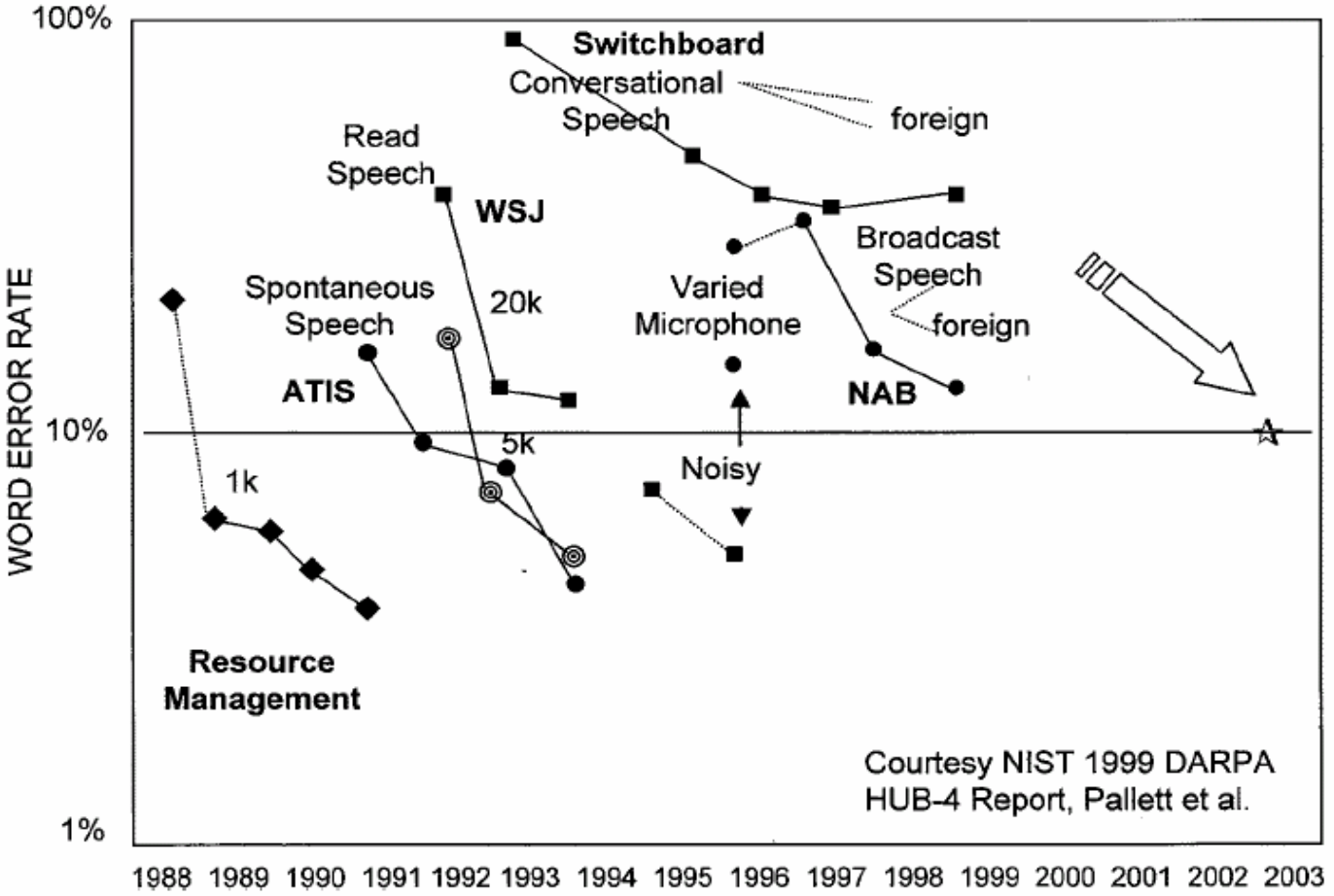
Progress of Technology

- Generic Application Areas (vocabulary vs. speaking style)



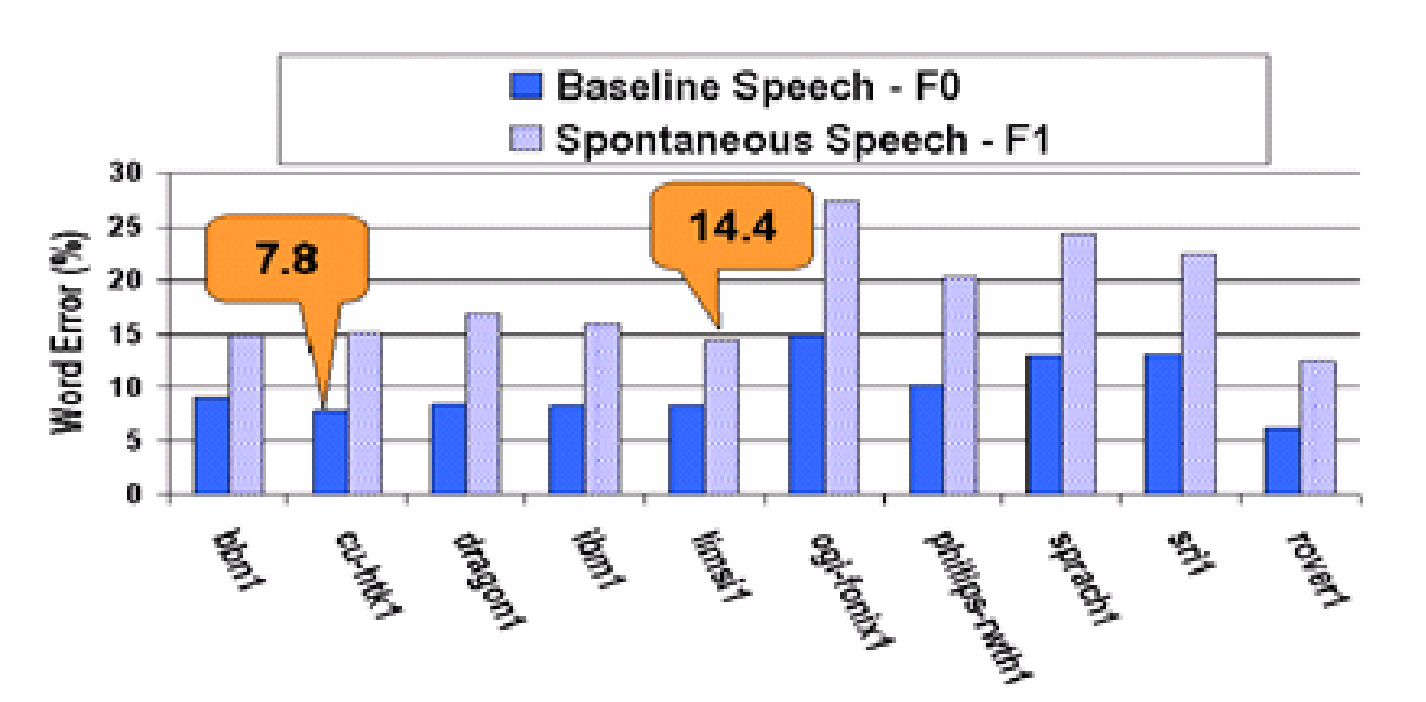
Progress of Technology

- Benchmarks of ASR performance: Overview



Progress of Technology

- Benchmarks of ASR performance: Broadcast News Speech



Progress of Technology

- Benchmarks of ASR performance: Conversational Speech

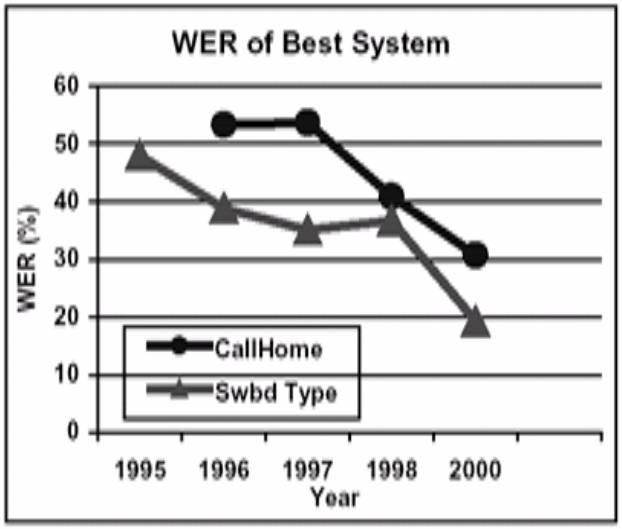


Figure 4 History of lowest word error rates (WER) obtained in NIST conversational speech evaluations on Switchboad and CallHome type conversations in English [26].

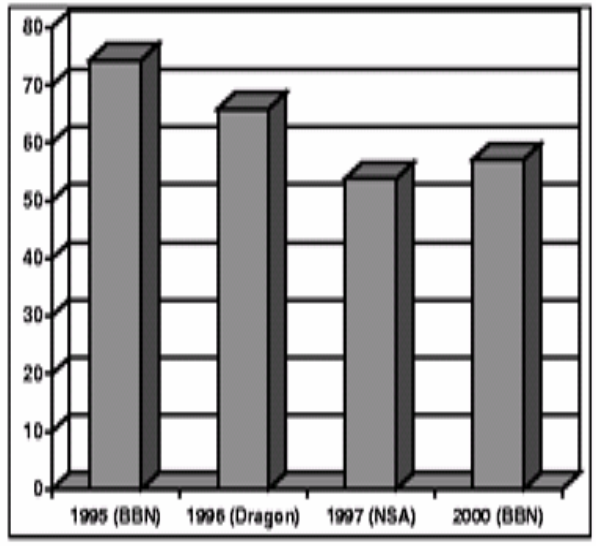
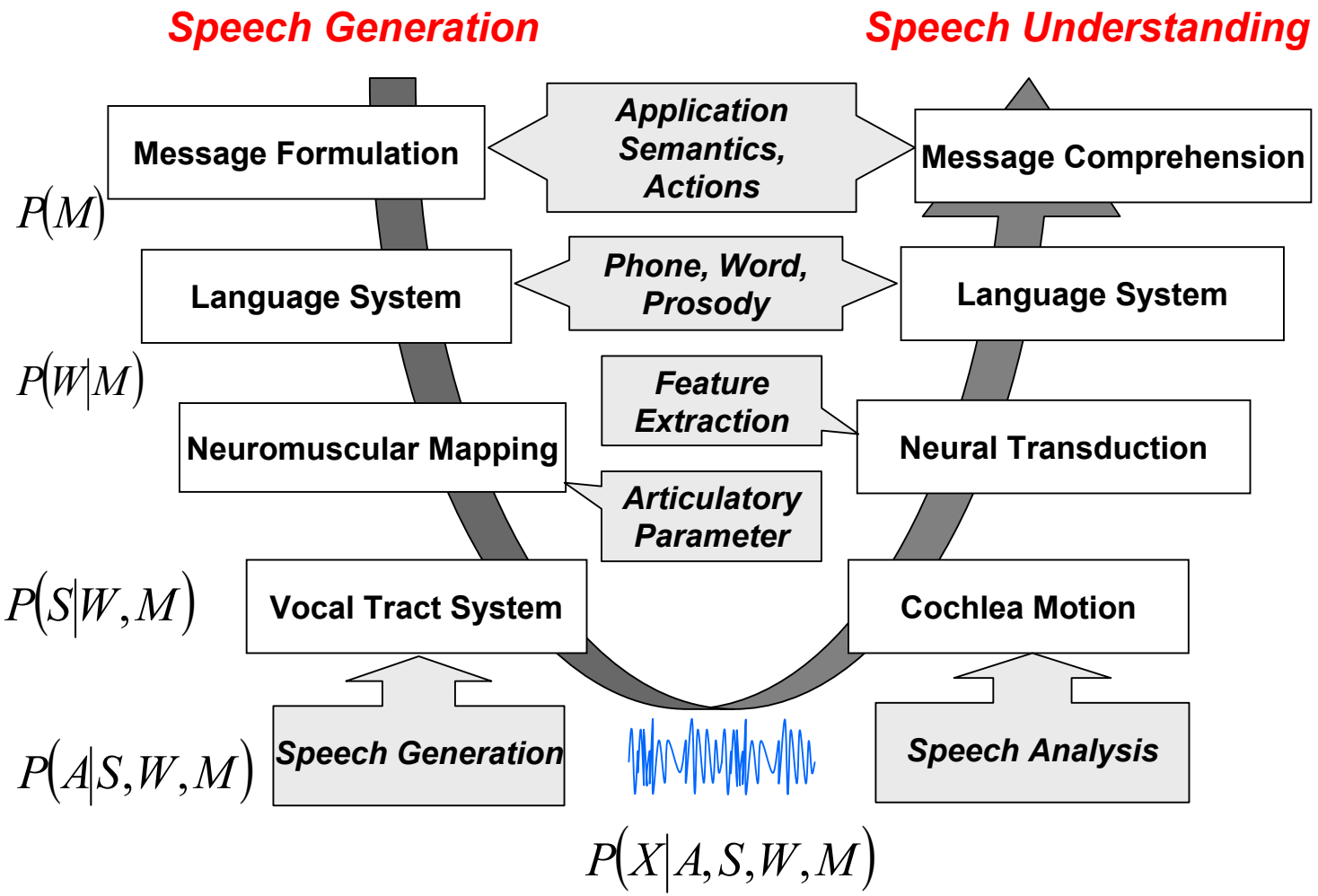


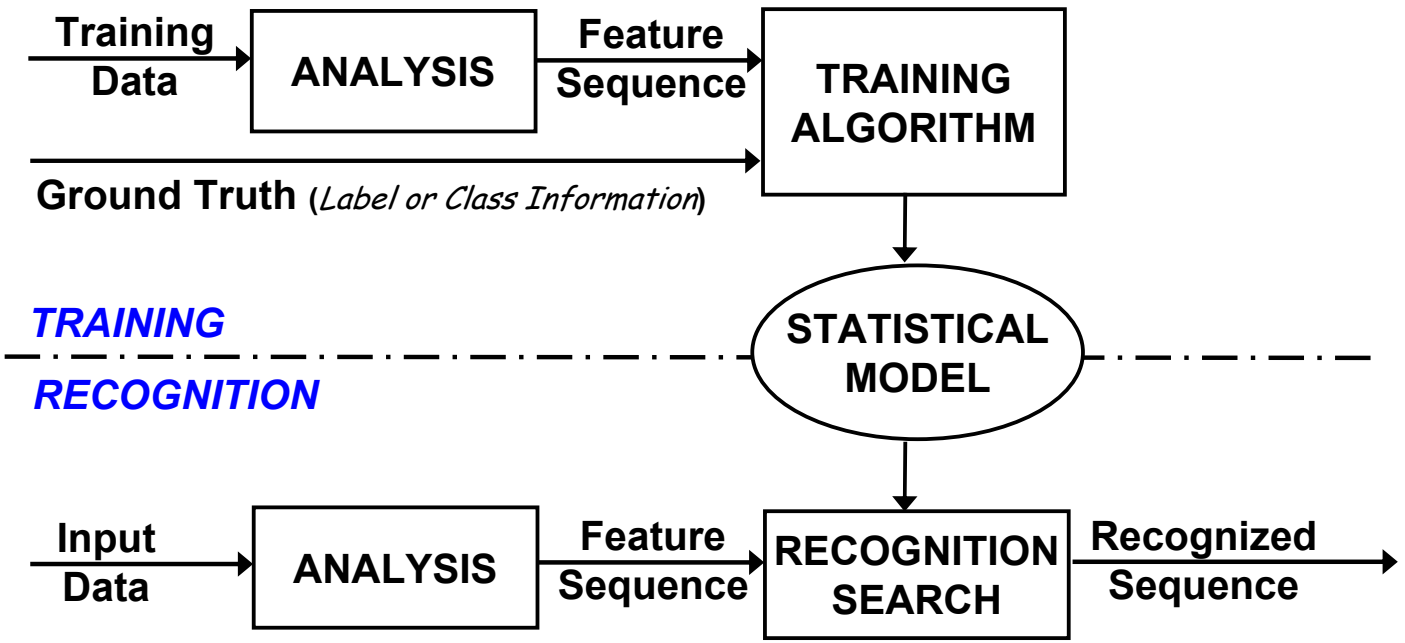
Figure 5 Chinese Character error rates of the best performing evaluation system in NIST Mandarin conversational speech evaluations 1995-2000 [26].

Determinants of Speech Communication



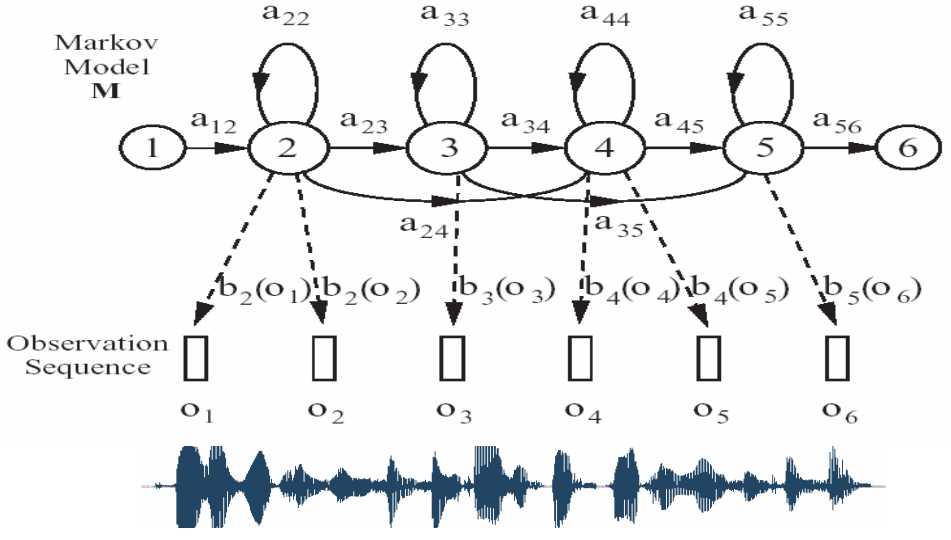
Statistical Modeling Paradigm

- The statistical modeling paradigm used in speech and language processing

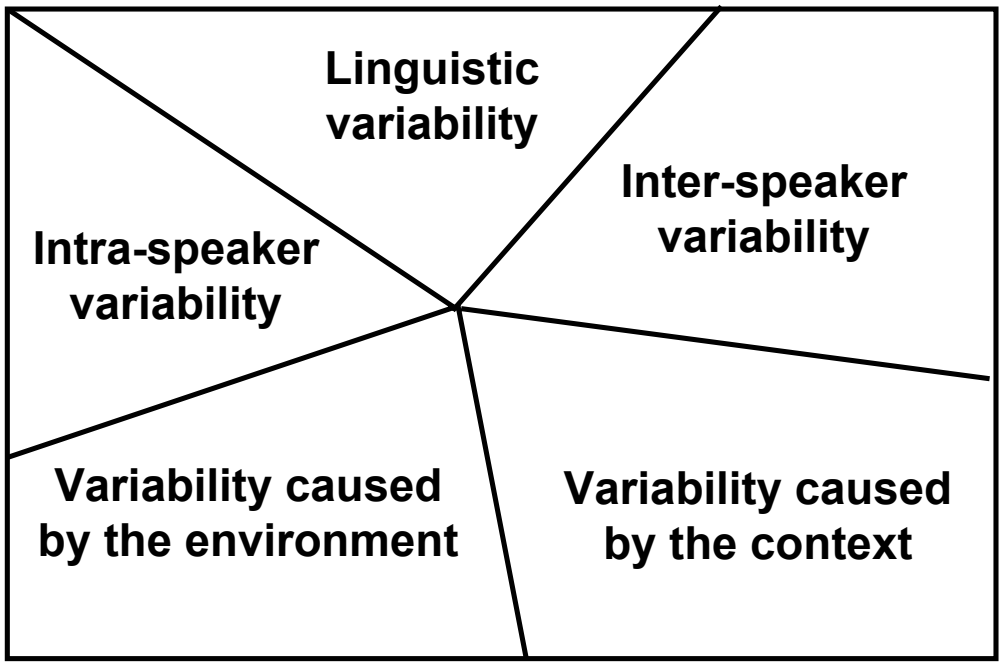


Statistical Modeling Paradigm

- Approaches based on Hidden Markov Models (HMMs) dominate the area of speech recognition
  - HMMs are based on rigorous mathematical theory built on several decades of mathematical results developed in other fields
  - HMMs are generated by the process of training on a large corpus of real speech data



Difficulties: Speech Variability



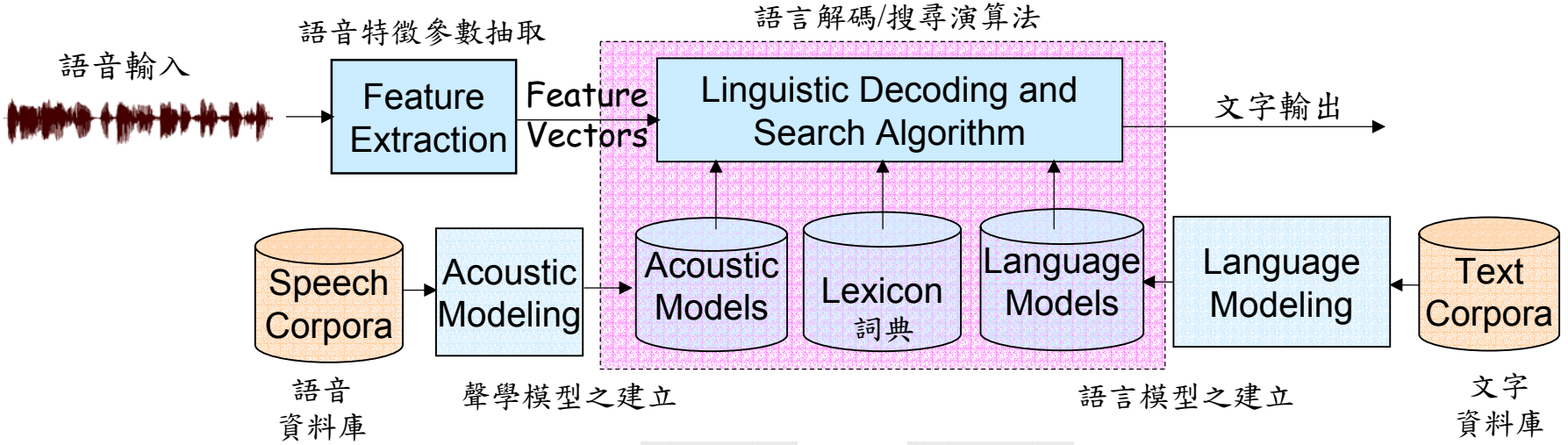
Pronunciation Variation

Speaker-independency
Speaker-adaptation
Speaker-dependency

Robustness Enhancement

Context-Dependent Acoustic Modeling

Large Vocabulary Continuous Speech Recognition



可能詞句　　語音輸入

$$\hat{\mathbf{W}} = \arg\max_{\mathbf{w}} P(\mathbf{W}|\mathbf{X})$$

貝氏定理

$$= \arg\max_{\mathbf{w}} \frac{P(\mathbf{X}|\mathbf{W})P(\mathbf{W})}{P(\mathbf{X})}$$

$$= \arg\max_{\mathbf{w}} P(\mathbf{X}|\mathbf{W})P(\mathbf{W})$$

詞彙網路搜尋

聲學模型機率　　語言模型機率

Large Vocabulary Continuous Speech Recognition

- Transcription of Broadcast News Speech

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 0 SIL 71695 -1 35 1280.422 1.00000 1.00000
 1 行政院 55302 35 80 720.973 1.00000 0.75715
 2 秘書長 50877 80 118 459.867 0.56604 0.18618
 3 劉 2406 118 137 371.101 0.26549 0.50987
 4 世 6603 137 157 610.122 1.00000 1.00000
 5 芳 1111 157 177 545.281 0.22222 1.00000
 6 和 3407 177 196 374.724 0.15385 0.00000
 7 蒙藏 66970 196 237 844.522 1.00000 0.53602
 8 委員會 58282 237 281 776.631 1.00000 1.00000
 9 委員長 58283 281 332 955.699 1.00000 0.83401
10 徐 5422 332 356 561.555 0.36598 0.54206
11 志 5919 356 372 420.553 0.40000 0.54860
12 修 5075 372 416 988.773 0.31579 0.84565
13 上午 40289 416 449 681.523 1.00000 0.75001
14 到 1302 449 463 337.270 0.33333 1.00000
15 立法院 52750 463 509 1077.581 1.00000 0.85865
16 報告 9234 509 550 1061.472 1.00000 1.00000
17 預算 49933 550 587 738.046 1.00000 0.82290
18 編列 9691 587 616 576.571 1.00000 0.60458
19 情況 31054 616 666 1020.239 0.75000 0.81394
20 SIL 71695 666 703 1341.544 1.00000 1.00000
21 好幾 24960 703 729 326.342 0.00760 0.73112
22 位 8111 729 741 273.841 0.18748 1.00000
23 在野 42491 741 767 605.460 0.99551 1.00000
24 立委 21015 767 792 518.366 0.98152 0.75214
25 認為 41950 792 842 957.432 0.96371 0.57802
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26 SIL 71695 842 872 1138.477 1.00000 1.00000
27 行政院 55302 872 934 1120.105 0.86107 0.87346
28 既然 29583 934 971 804.259 0.86107 0.95910
29 不 369 971 988 288.728 0.69917 1.00000
30 承認 38027 988 1043 931.888 0.46961 0.40323
31 外蒙 47896 1043 1084 786.448 1.00000 1.00000
32 為 8063 1084 1100 316.677 0.30057 1.00000
33 我國 47848 1100 1135 804.705 1.00000 1.00000
34 領土 20696 1135 1186 778.006 0.76186 0.96218
35 主張 36487 1186 1237 1003.320 0.07122 1.00000
36 全數 31649 1237 1304 1427.742 0.06937 1.00000
37 刪除 39728 1304 1349 818.702 1.00000 0.65401
38 蒙藏 66970 1349 1392 790.226 0.00928 0.51333
39 委員會 58282 1392 1432 870.207 1.00000 1.00000
40 的 1269 1432 1441 165.007 0.16667 1.00000
41 預算 49933 1441 1490 1304.056 0.23077 1.00000
42 SIL 71695 1490 1522 1101.760 1.00000 1.00000
43 從事 43981 1522 1566 1100.780 0.05556 0.76556
44 過 3023 1566 1580 279.248 0.07692 1.00000
45 院長 49392 1580 1613 632.123 0.10656 0.80456
46 許 3809 1613 1634 526.977 0.08333 1.00000
47 志 5919 1634 1650 222.692 0.05263 1.00000
48 雄 5420 1650 1685 762.830 0.33333 0.56287
49 也 7545 1685 1706 484.241 0.18462 1.00000
50 該 2847 1706 1721 403.345 0.18182 1.00000
51 下台 32060 1721 1781 1458.783 0.06522 1.00000
52 SIL 71695 1781 1843 2489.860 1.00000 1.00000
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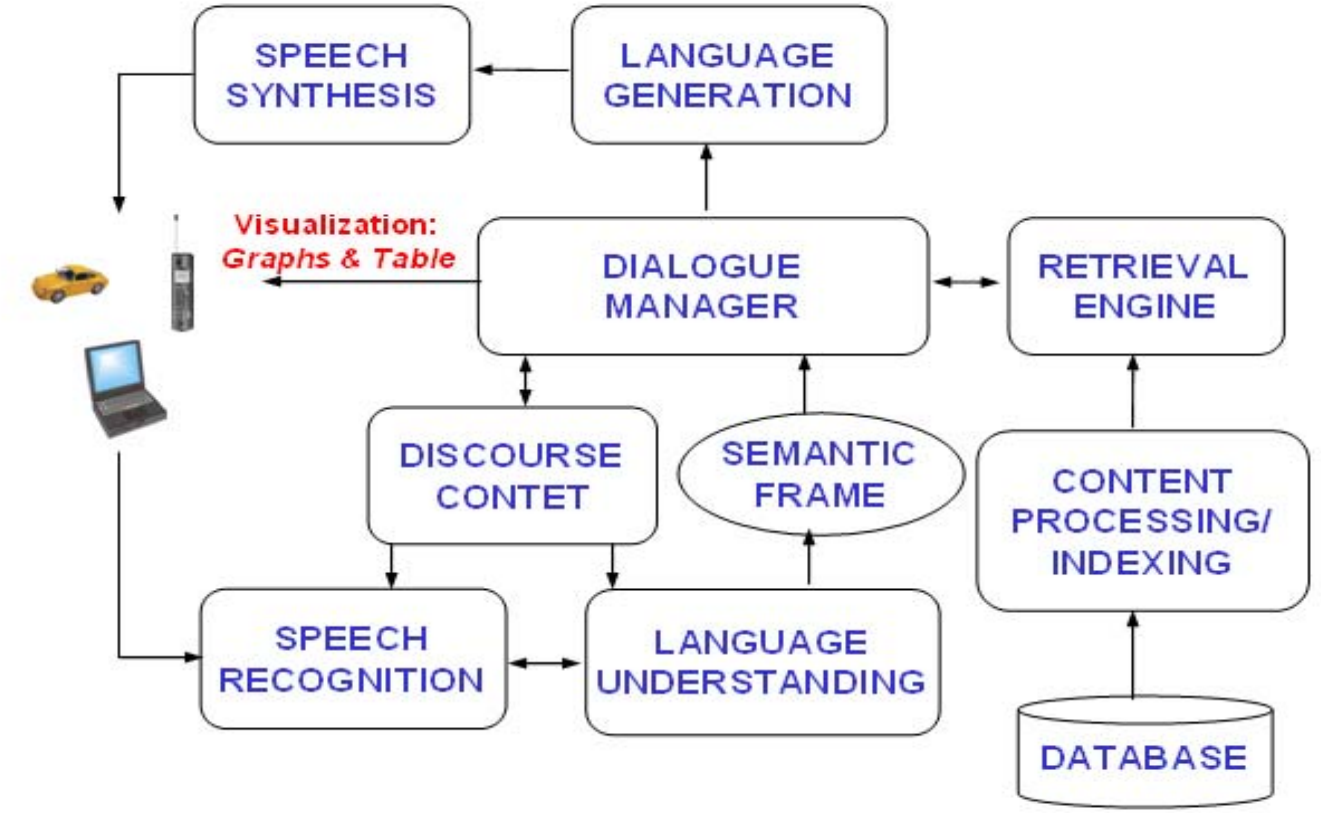
Spoken Dialogue

- Spoken language is attractive because it is the most natural, convenient and inexpensive means of exchanging information for humans
- In mobilizing situations, using keystrokes and mouse clicks could be impractical for rapid information access through small handheld devices like PDAs, cellular phones, etc.

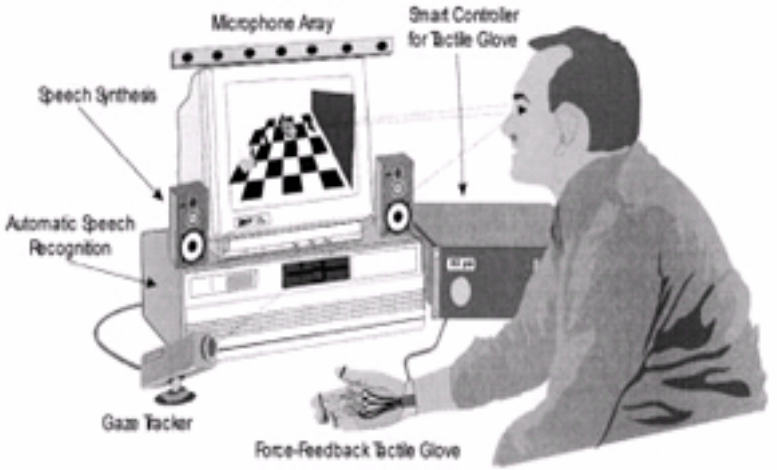
Spoken Dialogue

- Flowchart



Spoken Dialogue

- Multimodality of Input and Output



Experimental client workstation incorporating sight, sound, and touch modalities for human/machine communication. The eye tracker provides a gaze-controlled cursor for indicating objects in the display. The tactile force-feedback glove allows displayed objects to be grasped, "felt," and moved. Hands-free speech recognition and synthesis provides natural conversational interaction [7].

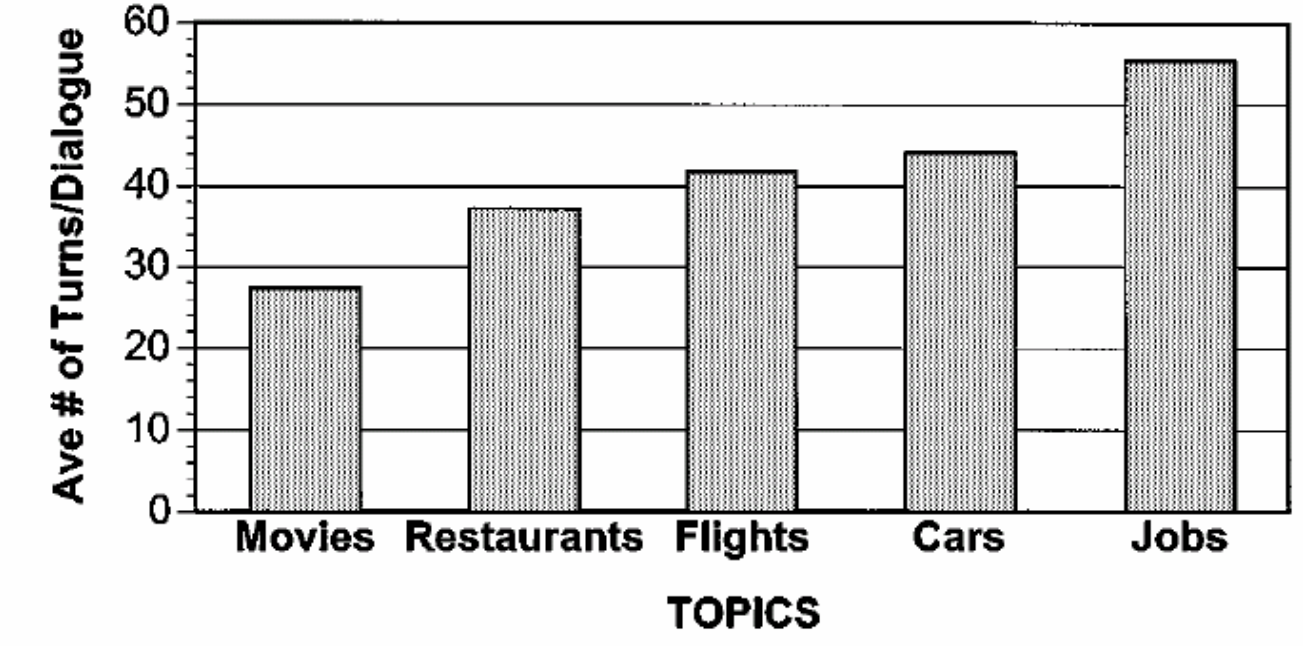
Spoken Dialogue

- Deployed Dialogue Systems

Domain	Language	Vocabulary Size	Average Words/Utt	Average Utts/Dialogue
CSELT Train Timetable Info	Italian	760	1.6	6.6
SpeechWorks Air Travel Reservation	English	1000	1.9	10.6
Philips Train Timetable Info	German	1850	2.7	7.0
CMU Movie Information	English	757	3.5	9.2
CMU Air Travel Reservation	English	2851	3.6	12.0
LIMSI Train Timetable Info	French	1800	4.4	14.6
MIT Weather Information	English	1963	5.2	5.6
MIT Air Travel Reservation	English	1100	5.3	14.1
AT&T Operator Assistance	English	4000	7.0	3.0
Air Travel Reservations (human)	English	?	8.0	27.5

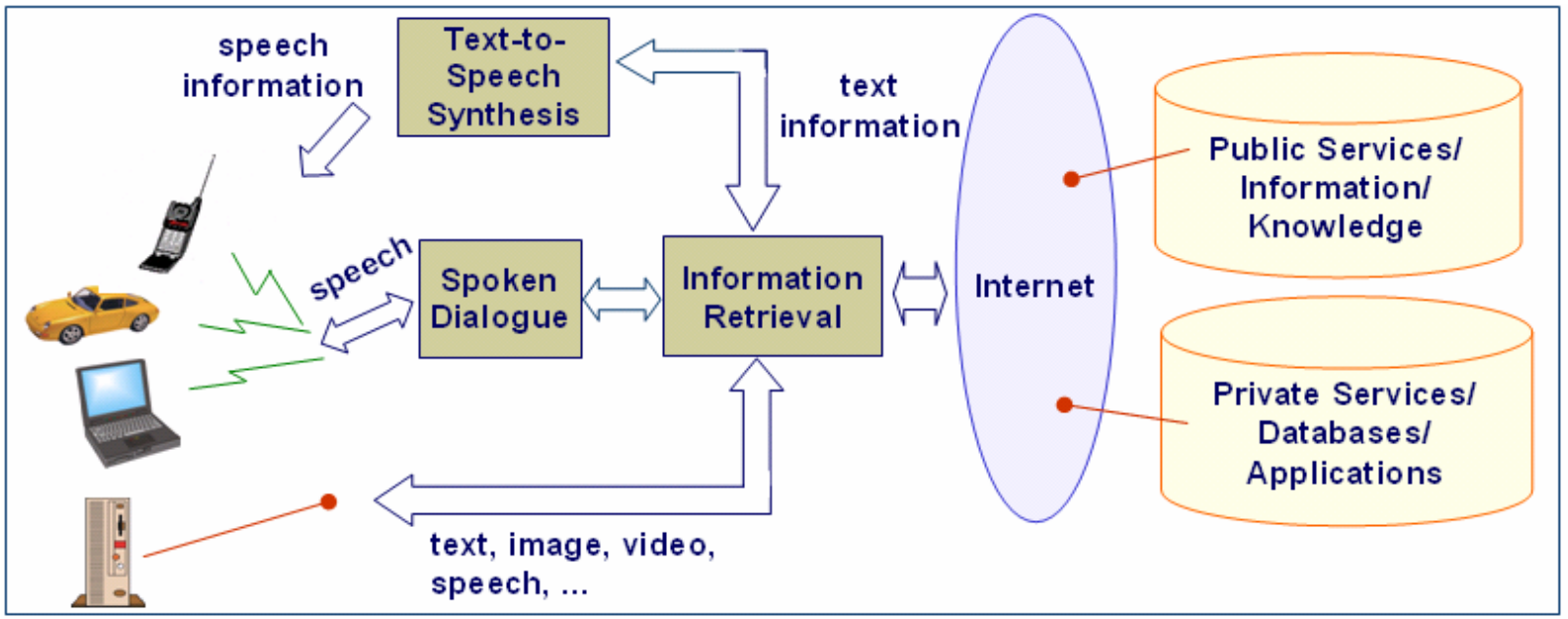
Spoken Dialogue

- Topics vs. Dialogue Terms

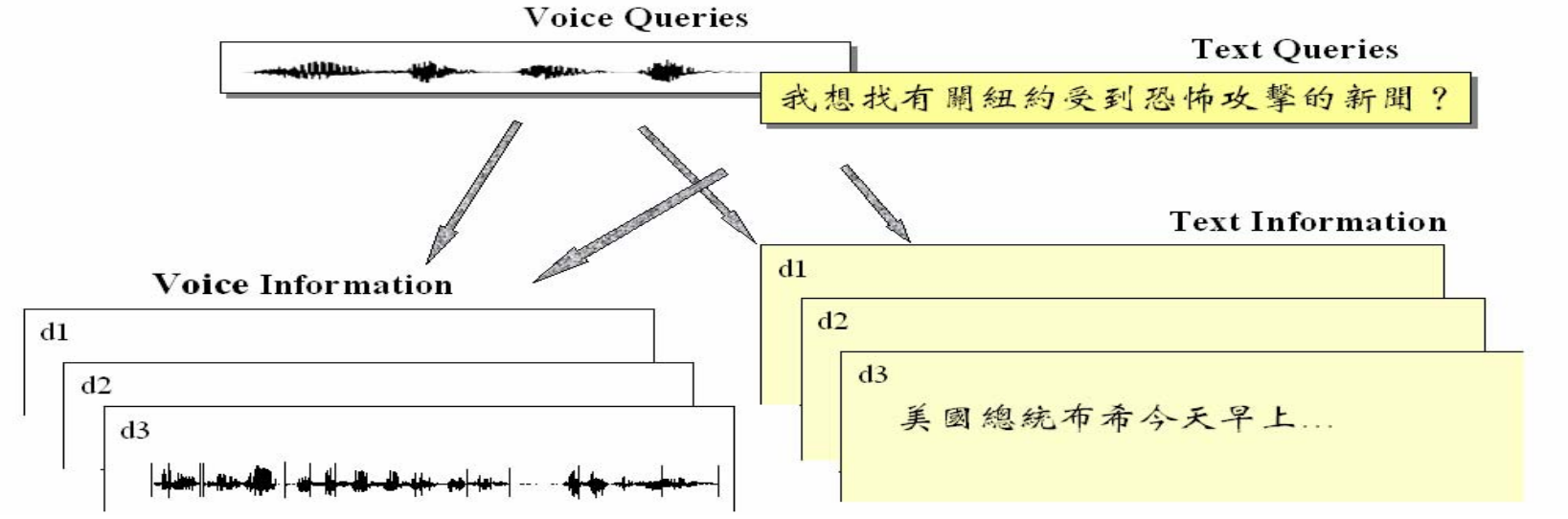


Speech-based Information Retrieval

- Task :
  - Automatically indexing a collection of spoken documents with speech recognition techniques
  - Retrieving relevant documents in response to a text/speech query



Speech-based Information Retrieval (cont.)



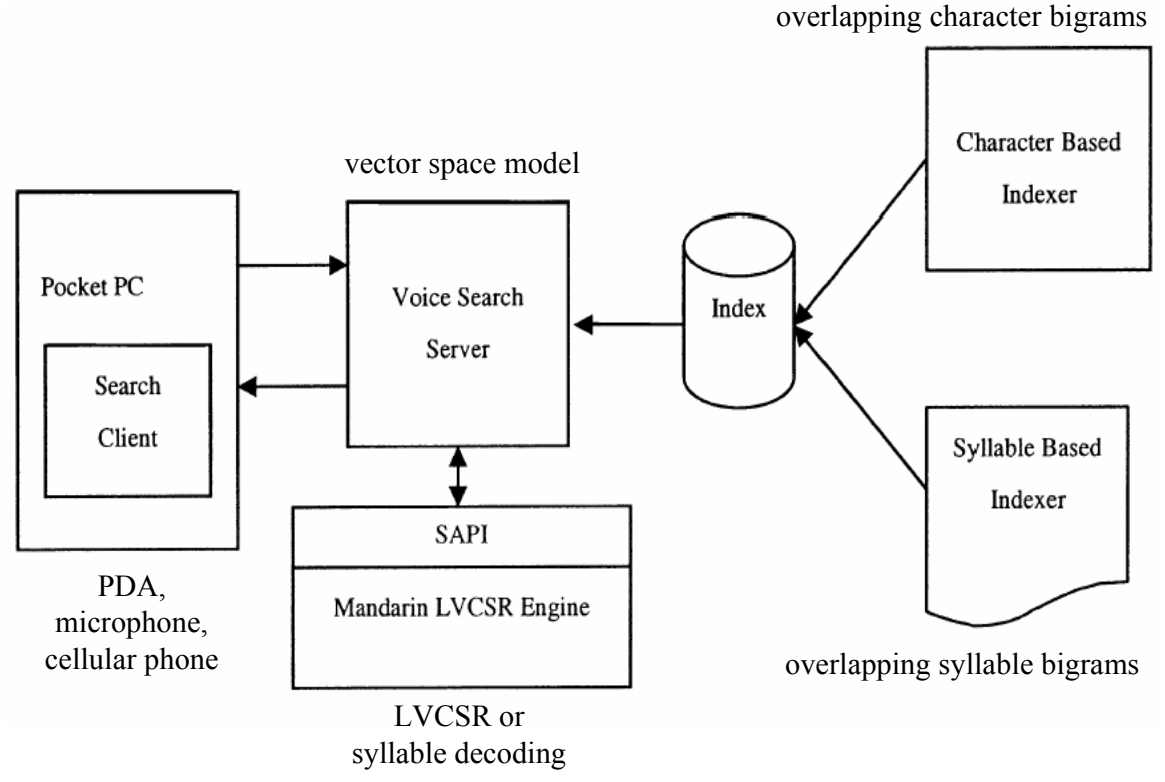
在四種不同時機下的資訊檢索過程。使用聲音問句(VQ，Voice Queries)或文字問句(TQ，Text Queries)去檢索聲音資訊(VI，Voice Information)或者是傳統的文字資訊(TI，Text Information)。

Speech-based Information Retrieval (cont.)

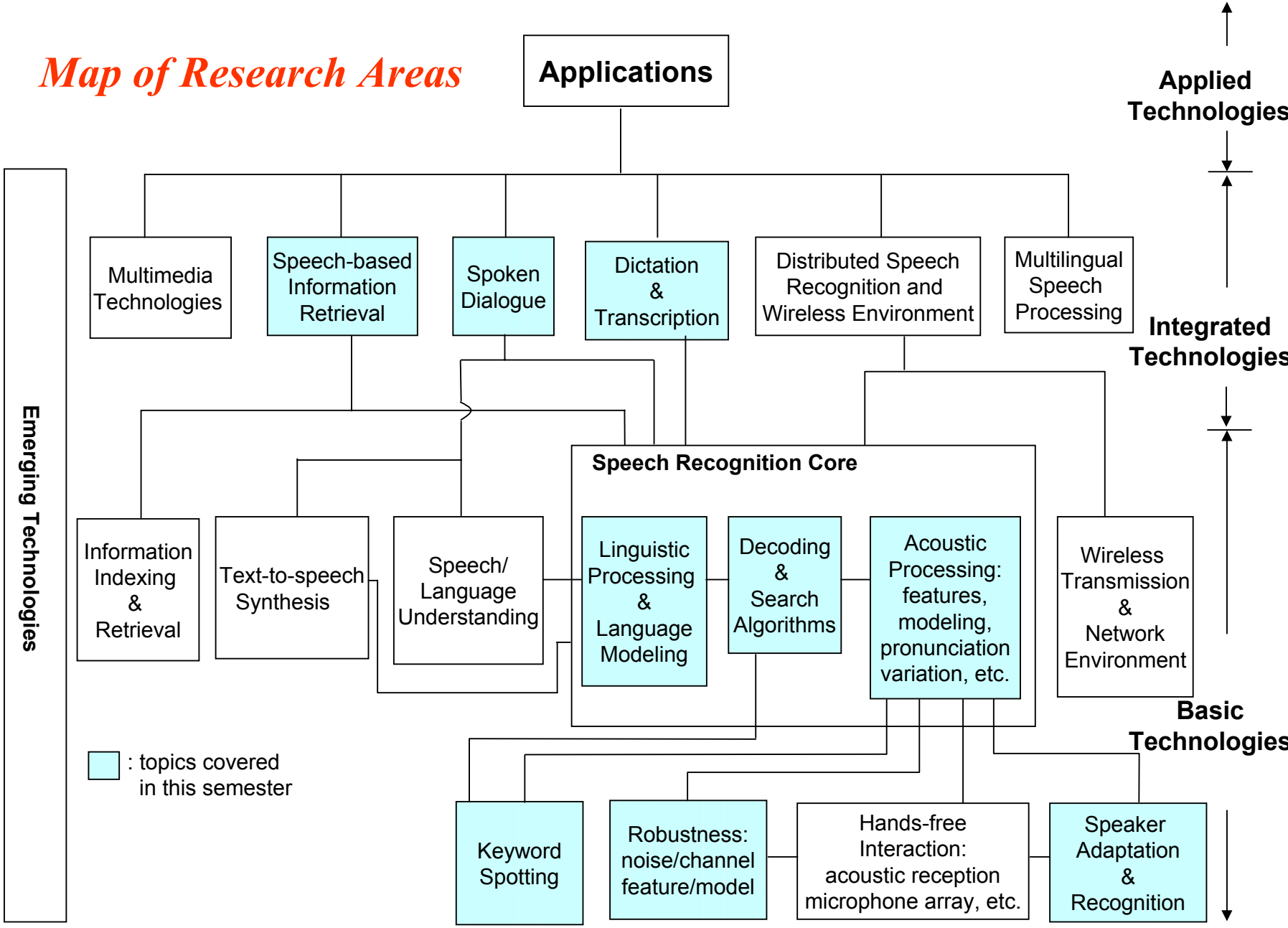
輸入聲音問句："請幫我查總統府升旗典禮"

中文語音資訊檢索雛形展示系統。

Speech-based Information Retrieval (cont.)



Map of Research Areas



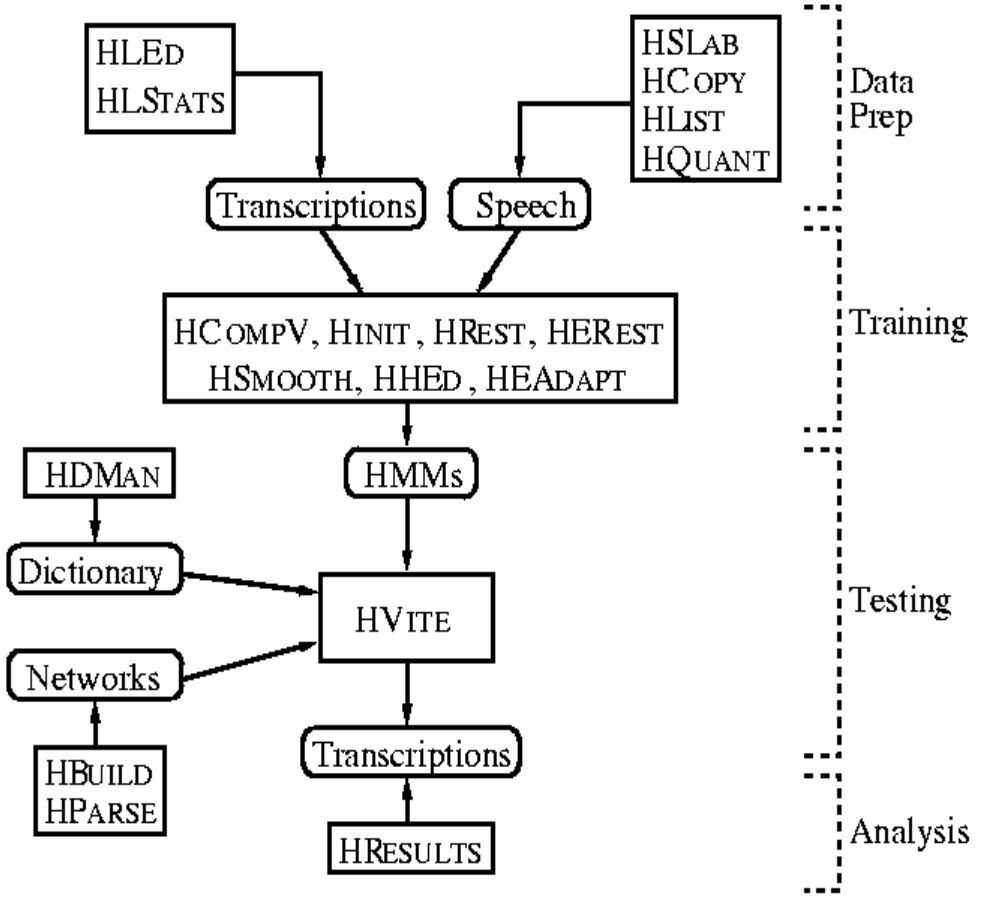
Adopted from Prof. Lin-shan Lee

Speech Processing Toolkit

- HTK (**H**idden Markov Model **T**ool**K**it)
  - A toolkit for building Hidden Markov Models (HMMs)
  - The HMM can be used to model any time series and the core of HTK is similarly general-purpose
  - In particular, for the acoustic feature extraction, HMM-based acoustic model training and HMM network decoding

Speech Processing Toolkit

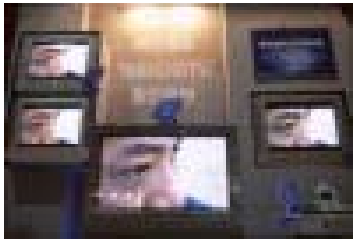
- HTK (**H**idden Markov Model **T**ool**K**it)



Speech Industry

- Telecommunication
- Information Appliance
- Interactive Voice Response
- Voice Portal
- Multimedia Database
- Education
- …..



2003 Speech Workshop

- Date: 19 September, 2003
- Place: National Tsing Hua Univ., Hsinchu
- Webpage: http://140.114.75.26/rocling/

日期	時間	會議內容
9/19	13:30~14:20	演講：當前語音技術研究之趨勢與展望
	14:30~15:20	演講：車內環境之對話系統
	15:40~16:20	座談會：電信學門語音處理領域發展與國際合作
	註：13:30~17:00國科會研究計畫成果發表(壁報)	