Speech Recognition Using Stochastic DTW

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Background

- Dynamic Time Warping (DTW) and Hidden Markov Model (HMM) algorithms have been applied widely to speech recognition
- HMM has been the dominant technique in speech recognition

Table 1: Performance of HMM and DTW

	HMM	DTW
Training	High	Zero
Complexity	Difficult	Easy
Accuracy	High	Low

- How to get the more higher accuracy by DTW?

New method for Speech recognition using DTW

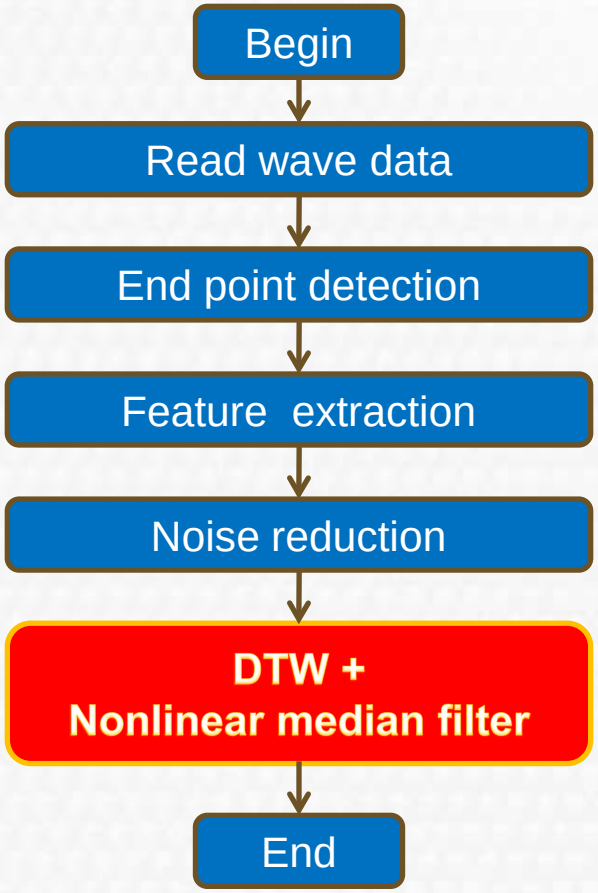


Fig.1 Flowchart of speech recognition using DTW

End point Detection (1)

- Short time energy *E*:

$$E = \sum_{m=-\infty}^{+\infty} [x(m)(m-n)]^2 \qquad (1)$$

- Maximun energy of non-speech τ:
  - n: number of frame (n = 5)
  - α: weight factor (α = 1.5)

$$\tau = \alpha \times \frac{1}{n} \sum_{i=1}^{n} E(i) \qquad (2)$$

- Noise energy level of frame *F(i)*:
  - λ: forgetting factor (0 ≤ λ ≤ 1)

$$F(i) = \lambda F(i-1) + (1-\lambda) E(i) \qquad (3)$$

End point Detection(2)

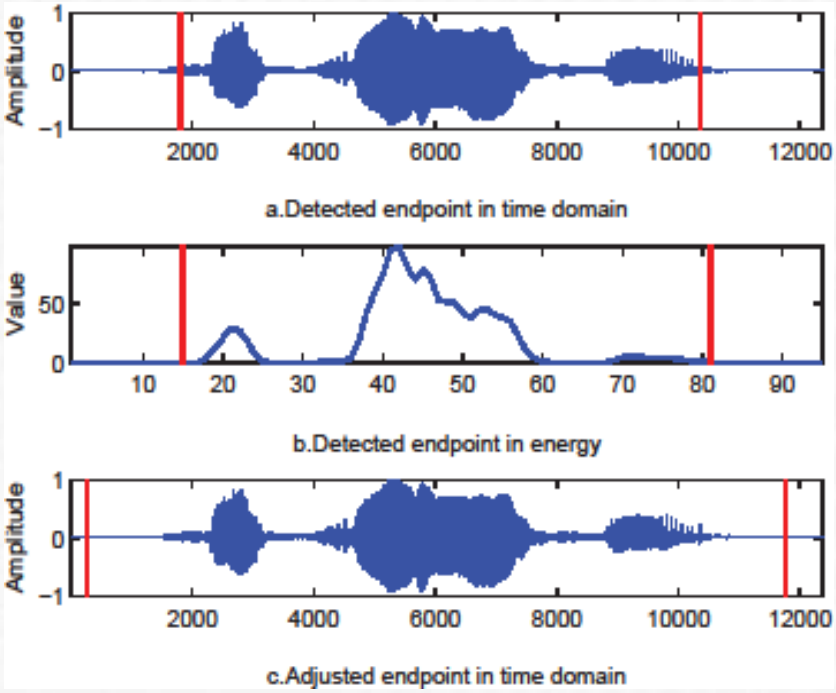


Fig.2 Clean speech data with endpoint detection

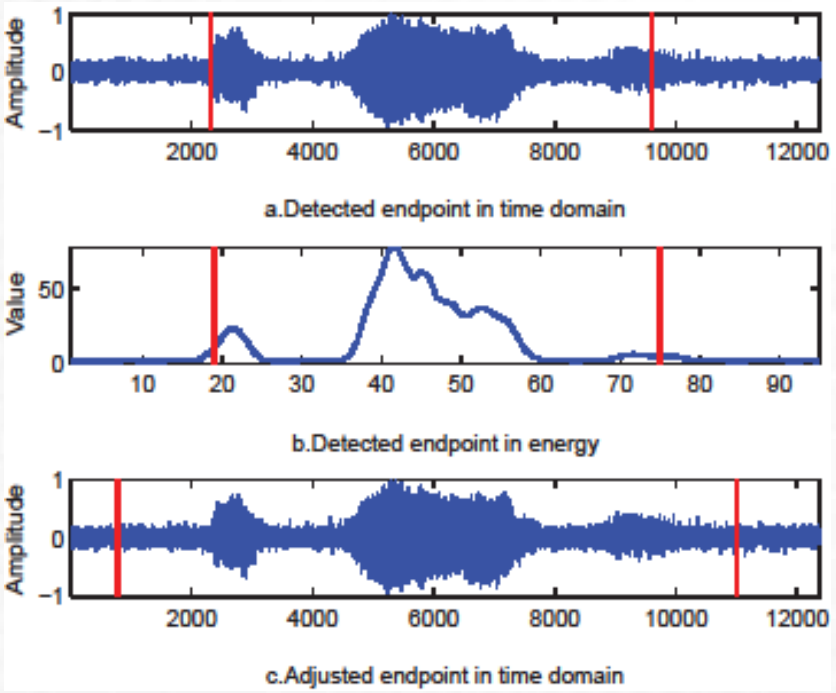


Fig.3 Speech data with endpoint detection at SNR =10 dB

Noise Reduction (RSF+DRA)

- Most of noise spectrum energy concentrates around the direct current (DC) component .
- Some relatively noise of lower energy at high frequency
- Most of the noise energy is comprised in the band [0,1] Hz
- Band [1,16] Hz is important

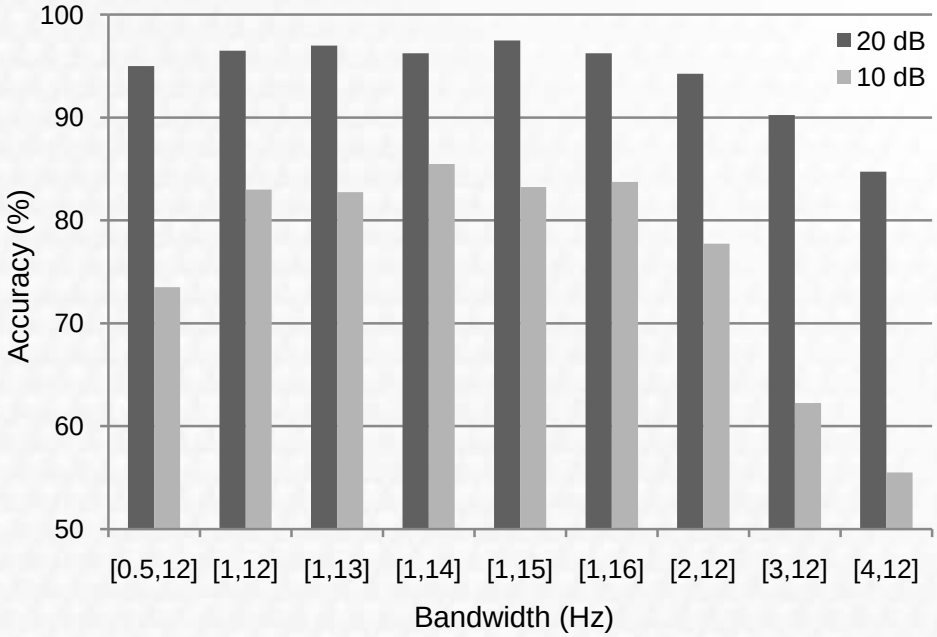
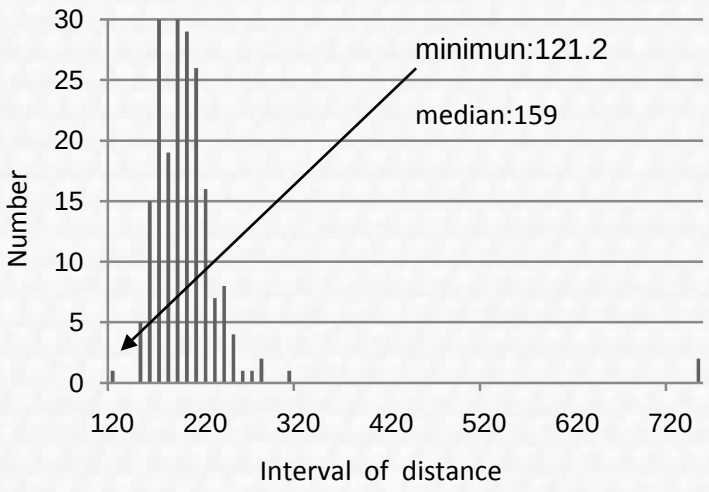


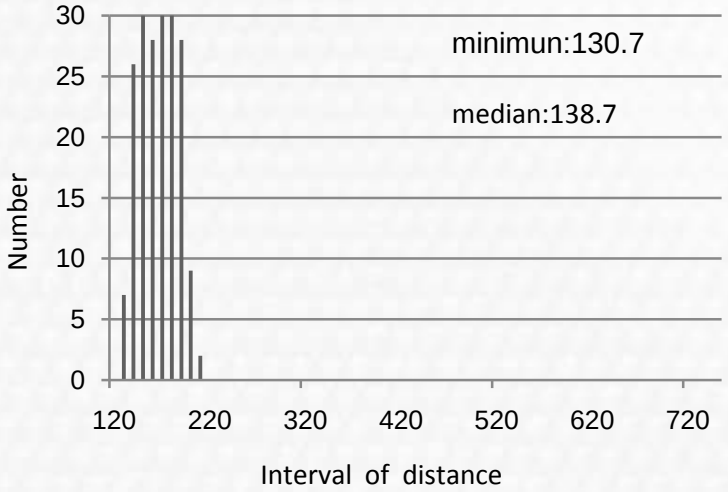
Fig.4 Recognition rate vs. bandwidth for RSF+DRA

DTW with nonlinear median filter

- Accuracy of recognition is not so high if only DTW is used to recognize.
- Nonlinear median filter can improve the accuracy of recognition



a. Distribution of Distance to "Date"



b. Distribution of Distance to "Hatinohe"

Fig.5 Distributions of all distances for which the test word ”Hatinohe” matches ”Date” and ”Hatinohe”.

Experiment parameter

- The test words: 50 Japanese words. Every word has 100 waveforms spoken by 100 persons.
- The reference words: 100 Japanese words and every word has 50 waveforms spoken by 50 persons.

Table 2: Parameter of experiment

Recognition task	Isolated 100 words
Speech data	100 Japanese region names from JEIDA
Sampling	11.025kHz (16 bit)
Window Length	23.2ms (256 points)
Frame Period	11.6ms (128 points)
Bandwidth of bandpass filter	1~16Hz
Feature extraction	38 dimensional MFCC
Noise varieties	White and Babble noise

Experiment Result

Table 3: Recognition rate with end point detection

Experiment methods		Without end-point detection (%)		With end-point detection (%)	
		White 10 dB	White 20 dB	White 10 dB	White 20 dB
A	All data with CMS&DRA	67.68	86.7	78.42	93.58
B	All data with RSF&DRA	70.54	87.38	77.36	92.76
C	All data with DRA	44.76	77.18	53.56	85.1
D	Reference data with RSF&DRA Test data with CMS&DRA	65.1	84.34	73.38	91.76
E	All data without noise reduction	14.7	65.7	19.34	72.12

Table 4: Recognition rate with nonlinear median filter

Methods	Without median filter (%)				With median filter (%)			
	white		Babble		white		Babble	
	10 dB	20 dB	10 dB	20 dB	10 dB	20 dB	10 dB	20 dB
A	78.42	93.58	71.9	90.54	84.18	96.92	77.74	93.28
B	77.36	92.76	70.42	89.16	85.04	97.08	77.38	92.82
C	53.56	85.1	56.52	85.38	58.3	90.14	65.66	89.3
D	73.38	91.76	68.1	88.26	82.4	96.5	76.06	92.48
E	19.34	72.12	22.94	73.84	24.2	77.46	28.94	79.06

Conclution

- The endpoint detection is necessary to the DTW
- RSF/DRA is best among four methods in the white noise.
- The accuracy of DTW is improved by nonlinear median filter
- All recognition rates almost are close to that one using HMM with the same noise reduction in the 10dB and 20dB SNR.

Thank you