A STUDY ON MODIFIED MEMBERSHIP FUNCTION BASED ON FREQUENCY VARIATION OF LPC

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ABSTRACT

To solve the frequency variation of speech patterns which consist of LPC sequences, a new membership function made by the relation between order of LPC and spectrum is proposed in this paper. To reduce errors, fuzzy inference is executed using the proposed membership function.

The computer simulation shows the effectiveness of the proposed method for the word recognition.

I. INTRODUCTION

Linear prediction method is used widely in speech analysis, and several speech recognition studies have used linear prediction coefficient(LPC)[1-3]. In particular, a lot of studies on word recognition using fuzzy inference concepts have been recently continued[4-7]. However, these studies have the handicaps which cannot deal with the pattern changes adaptively, because they need not only the preexperiments for the decision of variation width of membership function, but the data processing with the fixed variation width in each parameters. Therefore, for the pattern recognition of speech signals, the acoustical characteristics of speech must be considered[8-9].

In this paper we introduce the fuzzy theory for the solution of the frequency variation. Especially, we study the relation between LPC and spectrum from the idea that LPC includes the components of all frequencies. We also propose the membership function with a new variation width based on power difference rate(PDR) to decide the variation width of membership function.

Ⅱ. LPC AND MEMBERSHIP FUNCTION

2.1 LPC and Frequency Variation

Consider the relation between LPC and frequency variation from the shape of spectrum envelope. Fig.1 displays the envelope for 23th frame of 'ə' in the word 'Seoul'. The envelope shows that the main component of vowels is the low frequency because the 1st formant frequency is 495[Hz]. Therefore, Fig.1 shows the fact that the spectrum is estimated exactly from LPC.

The changes of spectrum envelope according to the change of LPC order are displayed in Fig.2. The used LPC value according to each order in the 23th frame of 'seoul' is presented in Table 1. Fig.2 shows that the spectrum envelope is affected by the magnitude of LPC. Especially, we could learn that the formant frequency of envelope equals each other in spite of the difference of coefficients in case of (i),(j),(m) of Fig.2. This means that the use of formant frequency can become a major cause of false recognition. Therefore, it can be seen that it is better to compare all frequencies than each formant frequency for the solution of false recognition, because the coefficient is not equivalent to the frequency,but the magnitudes of each coefficient have the components of all frequencies.

2.2 Power Difference Rate(PDR) and Membership Function

1. Power Difference Rate

To consider the envelope affected by the coefficient change, the power difference rate(PDR) of envelope is defined as follows.

$$PDR = \frac{\text{original power} - \text{varied power}}{\text{original power}} \times 100\ [\%] \qquad (1)$$

For example, Fig.3 shows the change of spectrum envelopes according to the variation of coefficients in the 42th frame of 'ə' in the word 'Incheon'.

Fig.4 shows the mean of PDR according to the variation of coefficients on selected randomly 50 frames from 6 city names. This shows that the variation of coefficient locates between upper 0.5[%] and lower 1[%] in case of less than 1[%] of PDR, and that these envelopes are similar to the original envelope. These results show that the coefficients of each order is not equivalent to the envelope, because the envelope is affected by the coefficients. Therefore, we could learn that the coefficients organizing a frame are not related with the order, but they have the all frequency components inclusively. Finally, it can be seen that the absorption of frequency variations according to individual variations is equal to the absorption of coefficient variations. So, we introduce the coefficient with fuzzy theory to solve the frequency variation by fuzzy inference, and propose the new membership function using the results of PDR.

2. Membership Function

In this paper we propose the modified membership function made by applying of PDR, and a triangle membership function which has the center value and the variation width as the mean and the variance of reference pattern, respectively. The proposed triangle menbership function $\mu_T(X)$ and the modified membership function $\mu_M(X)$ is defined as follows.

$$\mu_T(X) = \begin{cases} (X-M)/4D + 1, & M-4D<X<M \\ 1, & X=M \\ (X-M)/4D + 1, & M<X<X+4D \\ 0, & X\leq M-4D, X\geq M+4D \end{cases} \qquad (2)$$

$$\mu_M(X) = \begin{cases} (X-M)/4D + 1, & M-4D<X<M-\beta \\ 1, & X-\beta\leq X\leq M+\alpha \\ (X-M)/4D + 1, & M+\alpha<X<X+4D \\ 0, & X\leq M-4D, X\geq M+4D \end{cases} \qquad (3)$$

where M and D is the mean and the variance of reference pattern, α and β is the upper 0.5[%} and lower value 1[%] of the mean, respectively.

III. EXPERIMENTAL RESULTS

For the simulation we use 280 speech data uttered by two adult males, who pronounced each word 5 times on 28 DDD local area names. The reference pattern is made by 2 male speakers, uttered 3 times and the unknown pattern is made by the rest of speakers, uttered twice. To verify the validity of the proposed membership function, the recognition experiments against 28 DDD local area name data have been accomplished. The simulation results show that the proposed membership function has been improved 1~2[%] more than in case of using the triangle membership function as Table 2.

IV. CONCLUSION

In this paper we proposed the modified triangle membership function made from power difference rate according to variation of coefficients, and cosidered the affect between the coefficient and the spectrum to absorb the frequency variation. To verify the validity, recognition experiments by fuzzy inference considering 3 candidates have been accomplished. As the results, we confirmed that the absorption of coefficient variation could absorb the frequency variation effectively.

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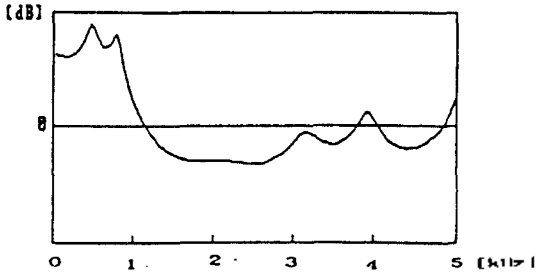

Fig.1. Spectrum envelope for the 23th frame of 'Seoul'

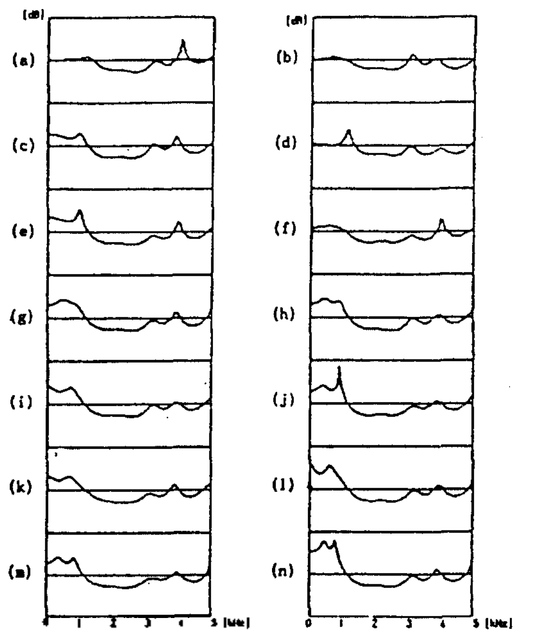

Fig.2. Spectrum envelope in case of replacing coefficient of each order with 'zero'

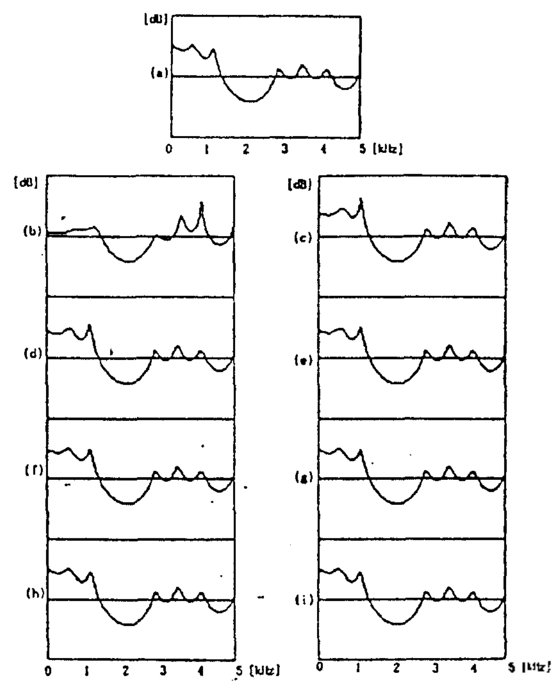

Fig.3. spectrum envelope according to the variation of coefficient.

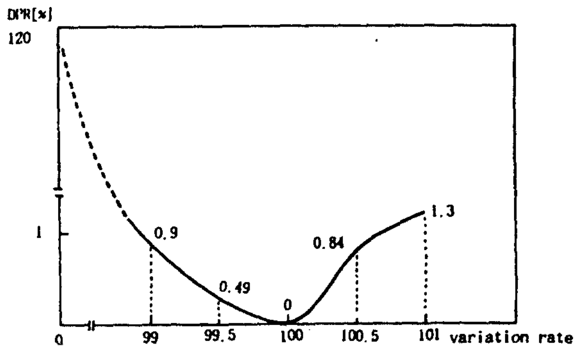

Fig.4. Mean of the PDR according to the variation of coefficient.

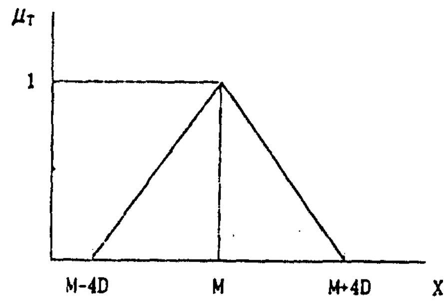

Fig.5. Triangle membership function (M=Mean, D=Variance)

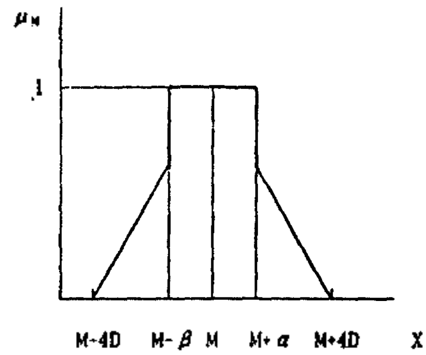

Fig.6. Modified triangle membership function

Table 1. The LPC for the 23th frame of 'Seoul'

order	coefficient
A_0	1.00000
A_1	- 0.98094
A_2	- 0.92206
A_3	0.42604
A_4	0.97262
A_5	0.30376
A_6	- 0.62164
A_7	- 0.17825
A_8	- 0.18155
A_9	0.24053
A_{10}	- 0.20902
A_{11}	0.32190
A_{12}	0.150554
A_{13}	- 0.22693
A_{14}	- 0.01223

Table 2. Recognition rates by candidates.

unit : %

	Triangle membership function	Modified membership function
1st candidate	83.9	84.8
2nd candidate	87.5	89.3
3rd candidate	92.9	93.8