Preliminary Classification of Consonants Using Fuzzy Inference

Masahide Yoneyama ,Akihiro Yamamoto ,Fumihiro Yato* and Shogo Nakamura#
Dept. of Information & Computer Science, Toyo University
2100 Kujirai, Kawagoe, Saitama 350-0815 JAPAN
Phone: +81-492-39-1436,Fax: +81-492-33-9788
email: yoneyama@cs.toyo.ac.jp
*Teikyo University of Science & Technology
2525 yatsuzawa, uenohara, kitatsuru yamanashi 409-0193 JAPAN
Phone: +81-554-63-4411,Fax:+81-554-63-4431
email: yato@ntu.ac.jp
#Dept. of Engineering, Tokyo Dennki University
2-2, Kanda Nishiki-cho, Chiyoda-ku, Tokyo 101-8457 JAPAN
Phone: +81-3-5280-3349
email: nakamura@d.dendai.ac.jp

ABSTRACT:A new method for the preliminary classification of consonants in the continuous speech signals using fuzzy inference has been proposed. In this method, all consonants of the voie signal continuously uttered by a specific speeker are classified into 8 groups arranged in advance. The 4 kinds of feature parameters of phoneme were used as the variables for fuzzy inference. The fuzzy inference was performed on the basis of 8 fuzzy rules. As the result of the classification experiment, the good result for the 6 groups of consonants has been obtained, but it is necessary to improve the classification ability for the remained 2 groups. In those 2 groups, one group consists of /f/ and /h/, and the other group consists of /j/ and /z/.

KEYWORDS:preliminary classification,consonants,continuous speech,fuzzy inference, feature parameters of phoneme,fuzzy rule,continuous speech recognition, membership function,matching factor,voice singnal

INTRODUCTION

For the continuous speech recognition, it is effective to preliminarily classify phonemes of input voice signal into several groups before word recognition. In this research, the preliminary classification method of consonants for continuous speech recognition for a specific speeker was studied. In this method, all consonants of input voie signal are classified into 8 groups arranged in advance by means of the fuzzy inference concerning 4 kinds of feature parameters. In this paper, it is reported both of the classification theory and the experimental result of a specific speeker.

FEATURE PARAMETERS

For the preliminary classification of consonants, we used 4 kinds of feature parameters as follows ; (1) rate of amplitude component Φ below 1000 Hz against the total freqency spectrum of its phoneme, (2) rate of amplitude component Γ below 750 Hz against the total freqency spectrum of its phoneme, (3) differential coefficient Δ of voice power of its phoneme, (4) time duration T of the phoneme. The featur parameter Δ described above can be estimated by Equation 1.

$$\Delta(t) = \frac{\sum_{k=-N}^{N} k\Delta(t+k)}{\sum_{k=-N}^{N} k^2} \tag{1}$$

PREVIOUS ARRANGED 8 GROUPS OF CONSONANTS

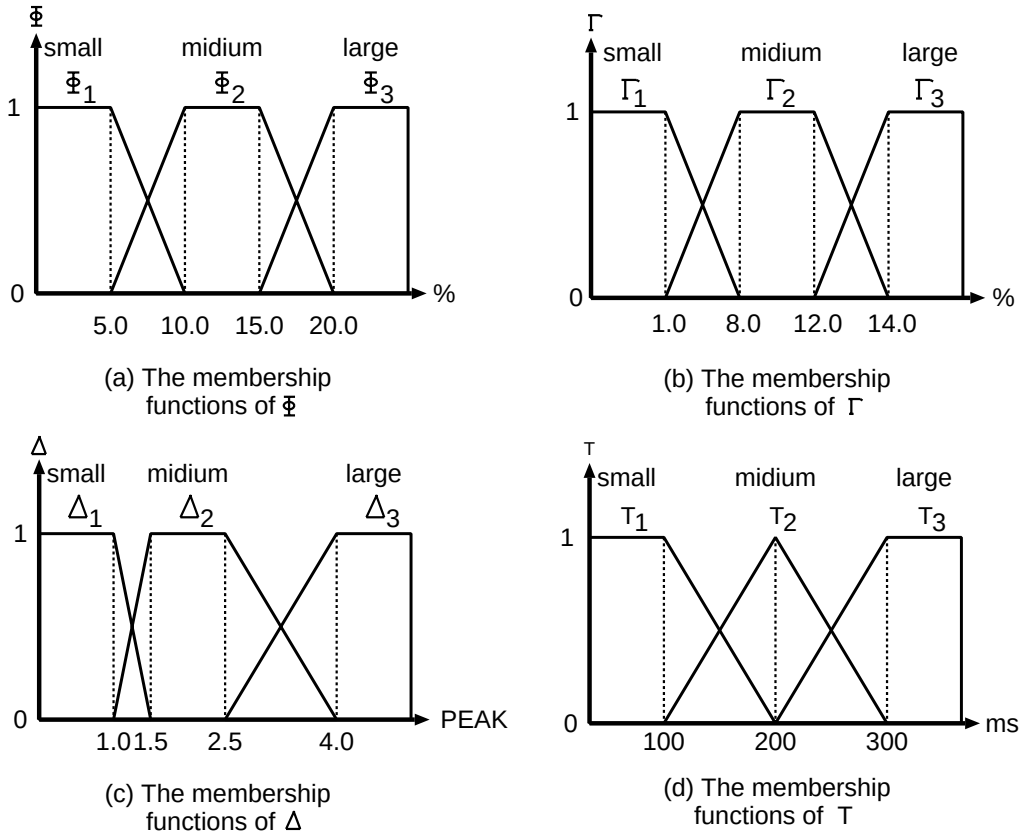
The classification groups of consonants were arranged as shown by Figure 1. Those groups have been determined as the result of several preliminary experiments.

group 1	group 2	group 3	group 4	group 5	group 6	group 7	group 8
/p/ /t/ /k/	/ts/ /ch/	/s/ /sh/	/g/ /m/ /n/ /w/ /y/ /r/	/j/ /z/	/b/ /d/	/f/ /h/	/N/

Figure 1: The classification groups of consonants

THE MEMBERSHIP FUNCTIONS OF 4 KINDS OF FEATURE PARAMETERS

We used plural data samples for each consonant to analyze 4 kinds of feature parameters Φ , Γ , Δ , T about its consonant. As the result, the stochastic distribution of 4 kinds of feature parameters Φ , Γ , Δ , T concerning all consonants were obtained. On the baisis of those stochastic distribution of Φ , Γ , Δ , T , the membership functions for Φ , Γ , Δ , T to perform the fuzzy inference have been dicided as shown by Figure 2 (a)!A!Jd)



(a) The membership functions of Φ

(b) The membership functions of Γ

(c) The membership functions of Δ

(d) The membership functions of T

Figure 2: The membership functions of feature parameters

The shape of those membership functions for Φ , Γ , Δ , T were refined the preliminary heuristic experiments.

THE FUZZY INFERENCE METHOD FOR CONSONANTS CLASSIFICATION

From both of the stochastic distribution of 4 kinds of feature parameters Φ , Γ , Δ , T concerning all consonants and the membership functions of those feature parameters, the fuzzy inference rule for the preliminary classification of consonants has been formed by means of preparatory try & test research. The rules are described as follows ;

- rule 1. $\Rightarrow$ If x(Φ) is small and x(Γ) is small and x(Δ) is large and x(T) is medium, then the input phoneme belongs to group (1).
- rule 2. $\Rightarrow$ If x(Φ) is small and x(Γ) is small and x(Δ) is medium and x(T) i s large, then the input phoneme belongs to group (2).
- rule 3. $\Rightarrow$ If x(Φ) is medium and x(Γ) is medium and x(Δ) is small and x(T) is large, then the input phoneme belongs to group (3).
- rule 4. $\Rightarrow$ If x(Φ) is large and x(Γ) is large and x(Δ) is small and x(T) is medium or small , then the input phoneme belongs to group (4).
- rule 5. $\Rightarrow$ If x(Φ) is large and x(Γ) is medium and x(Δ) is small and x(T) is large, then the input phoneme belongs to group(5).
- rule 6. $\Rightarrow$ If x(Φ) is large and x(Γ) is large and x(Δ) is medium and x(T) is medium, then the input phoneme belongs to group (6).
- rule 7. $\Rightarrow$ If x(Φ) is large and x(Γ) is medium and x(Δ) is medium and x(T) is large, then the input phoneme belongs to group (7).
- rule 8. $\Rightarrow$ If x(Φ) is large and x(Γ) is large and x(Δ) is small and x(T) is large, then the input phoneme belongs to group(8).

In the above rules, x(Φ), x(Γ), x(Δ), x(T) imply the values of respective feature parameters Φ , Γ , Δ , T of the input data. Figure 3 shows a conceptual figure of those rules.
From the above fuzzy rules, the inference result can be obtained by estimating the matching factors shown in Equation (2).

$$
\begin{aligned}
\alpha_1 &= m_{\Phi_1}(x) \wedge m_{\Gamma_1}(x) \wedge m_{\Delta_3}(x) \wedge m_{T_2}(x) \\
\alpha_2 &= m_{\Phi_1}(x) \wedge m_{\Gamma_1}(x) \wedge m_{\Delta_2}(x) \wedge m_{T_3}(x) \\
\alpha_3 &= m_{\Phi_2}(x) \wedge m_{\Gamma_2}(x) \wedge m_{\Delta_1}(x) \wedge m_{T_3}(x) \\
\alpha_4 &= m_{\Phi_3}(x) \wedge m_{\Gamma_3}(x) \wedge m_{\Delta_1}(x) \wedge (m_{T_2}(x) \vee m_{T_1}(x)) \\
\alpha_5 &= m_{\Phi_3}(x) \wedge m_{\Gamma_2}(x) \wedge m_{\Delta_1}(x) \wedge m_{T_3}(x) \\
\alpha_6 &= m_{\Phi_3}(x) \wedge m_{\Gamma_3}(x) \wedge m_{\Delta_2}(x) \wedge m_{T_2}(x) \\
\alpha_7 &= m_{\Phi_3}(x) \wedge m_{\Gamma_2}(x) \wedge m_{\Delta_2}(x) \wedge m_{T_3}(x) \\
\alpha_8 &= m_{\Phi_3}(x) \wedge m_{\Gamma_3}(x) \wedge m_{\Delta_1}(x) \wedge m_{T_3}(x)
\end{aligned} \tag{2}
$$

If the matching factor α_n has the largest value among those matching factors α_1,α_2,α_3,α_4,α_5, α_6,α_7,α_8, the input phoneme belongs to group (n).

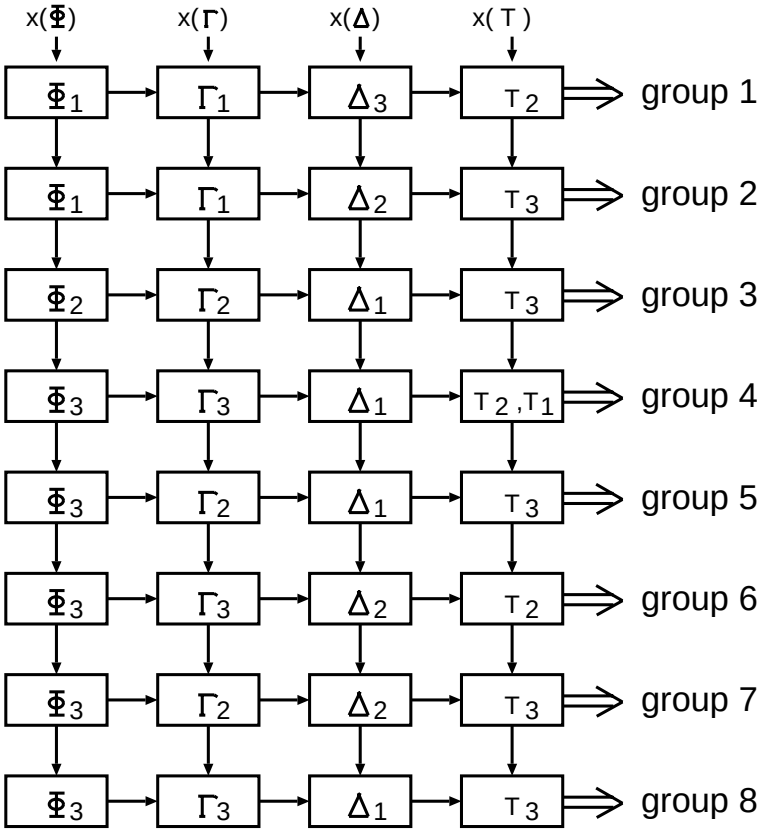


Figure 3: A conceptual figure of the rules

THE EXPERIMENTAL RESULT

The experiment for the preliminary classification of consonants was performed for one male speaker. From continuous speech data in a data base of a standard speech signal about one male speaker, 20 kinds of consonants shown in Figure 1 were extracted on the basis of the label data. It was attempted to extract 80 samples for each consonant, but consonants /h/ could be collected no more than 20 samples, and the number of samples of /f/ is only 14. To the other 18 consonants, it was succeeded to extract 80 samples. The half of the samples for each consonant were used to analyze the feature parameters Φ , Γ , Δ , T to get the stochastic distribution of those feature parameters. And, the other half of the samples were employed for the test data. The experimental result is shown by Table 1.

Table 1: The experimental result

group 1	group 2	group 3	group 4	group 5	group 6	group 7	group 8
90.0 %	83.8 %	97.5 %	93.0 %	27.5 %	93.8 %	48.6%	100 %

CONCLUSION

The fuzzy inference method using 4 kinds of feature parameters for the preliminary classification of consonants into 8 groups has been discussed. As the result of the expeiment for one male speaker, this method is recognized to be effective. But, the results of the classification for the consonants /f/, /h/, /j/, /z/ were poor. The improvement of classification capability for those consonants is remained problem.

REFERENCES

[1] Lawrence Rabiner;Biing-Hawang Juang "Fundamentals of Speech Recognition",PTR Prentice-Hall,Inc.

[2] Victor W. Zue;Ronald A.Cole,"Experiments on spectrogram reading,",IEEE ICASSP,pp.116-119,1979.

[3] Victor W. Zue;Lori F.Lamel,"An expert spectrogram reader:A knowledge-based approach to speech recognition," IEEE ICASSP.pp.23.2.1-23.2.4,1986.