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Sewall et al.

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- (54) **VOICEBAND SIGNAL CLASSIFIER**
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5,579,435 A	*	11/1996	Jansson	704/208
5,602,938 A	*	2/1997	Akiyama et al.	382/155
5,611,019 A		3/1997	Nakato	
5,657,424 A	*	8/1997	Farrell et al.	704/255
6,061,647 A	*	5/2000	Barrett	704/208
6,240,282 B1	*	5/2001	Kleider et al.	455/226.1
6,272,479 B1	*	8/2001	Farry et al.	706/13

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Related U.S. Application Data

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- (51) **Int. Cl.⁷** **G10L 15/08**
 (52) **U.S. Cl.** **704/217; 214/215**
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(56) **References Cited**

U.S. PATENT DOCUMENTS

3,851,112 A	11/1974	Kusan	
4,027,102 A	5/1977	Ando et al.	
4,672,669 A	6/1987	DesBlanche	
4,720,862 A	1/1988	Nakata et al.	
4,815,136 A	3/1989	Benvenuto	
4,815,137 A	3/1989	Benvenuto	
4,982,150 A	1/1991	Silverstein et al.	
5,018,200 A	* 5/1991	Ozawa	704/222
5,210,820 A	5/1993	Kenyon	
5,276,765 A	1/1994	Freeman et al.	
5,295,223 A	3/1994	Saito	
5,311,575 A	5/1994	Oh	
5,315,704 A	* 5/1994	Shinta et al.	704/232
5,325,425 A	6/1994	Novas et al.	
5,353,346 A	10/1994	Cox et al.	
5,365,426 A	11/1994	Siegel et al.	

OTHER PUBLICATIONS

- Yatsuzuka, Y., "Highly Sensitive Speech Detector and High-Speed Voiceband Data Discriminator in DSI-ADPCM Systems," *IEEE Transactions on Communications* 30:739-750 (Apr. 1982).
- Roberge, C., and Adoul, J.-P., "Fast On-Line Speech/Voiceband-Data Discrimination for Statistical Multiplexing of Data with Telephone Conversations," *IEEE Transactions on Communications* 34:744-751 (Aug. 1986).
- Kobatake, H., Tawa, K., and Ishida, A., "Speech/Nonspeech Discrimination for Speech Recognition System under Real Life Noise Environments," Conf. Proceedings of the IEEE ICASSP (IV, 1989), 365-368.

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(57) **ABSTRACT**

A method and apparatus for classifying signals into a multiplicity of signal classes which employs discriminant functions of low-complexity discriminant variables that are computed directly from the passband signal. The method can be applied to the problem of classifying voiceband data (VBD), facsimile (FAX), native binary data, and speech on a 64 Kbps digital channel. In a hybrid two stage classification system, the first stage employs linear discriminant functions to make classification decisions into a smaller number of possible preliminary signal classes. The decisions of the first stage are then refined by a second stage that uses nonlinear discriminant functions such as quadratic or pseudo-quadratic functions. The second stage of a hybrid classifier then assigns the signal into a larger number of possible classes than does the first stage of the classifier alone.

20 Claims, 41 Drawing Sheets

