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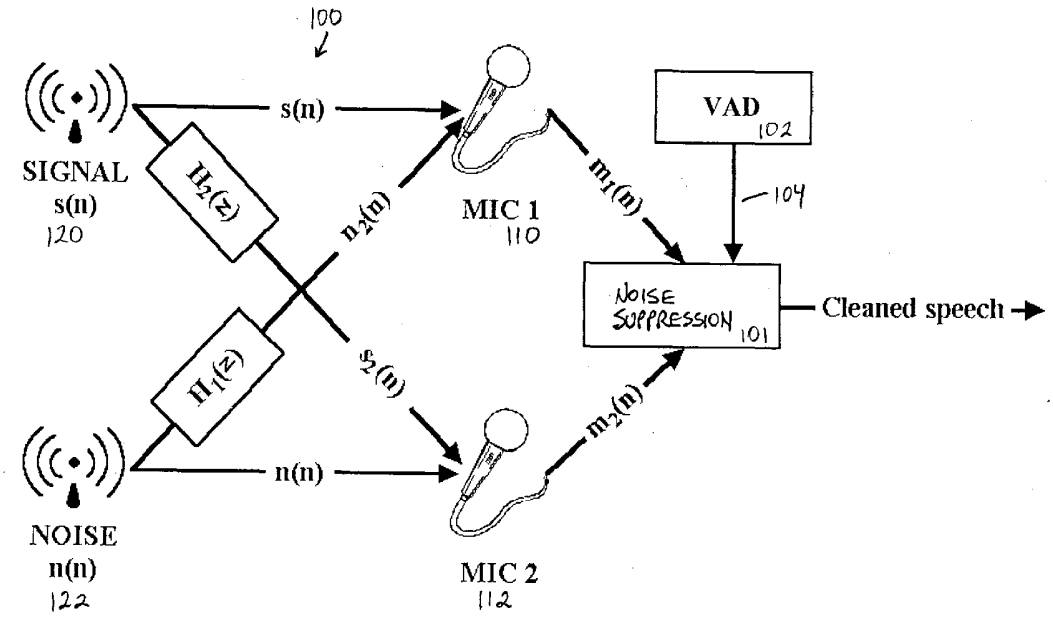
(54) Title: VOICE ACTIVITY DETECTION (VAD) DEVICES AND METHODS FOR USE WITH NOISE SUPPRESSION SYSTEMS



(57) Abstract: Voice Activity Detection (VAD) devices, systems and methods are described for use with signal processing systems to denoise acoustic signals. Components of a signal processing system and/or VAD system receive acoustic signals and voice activity signals. Control signals are automatically generated from data of the voice activity signals. Components of the signal processing system and/or VAD system use the control signals to automatically select a denoising method appropriate to data of frequency subbands of the acoustic signals. The selected denoising method is applied to the acoustic signals to generate denoised acoustic signals.

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I hereby certify that this application, and any other documents referred to as enclosed herein are being deposited in an envelope with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR §1.10 on the date indicated above and addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231

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(Print Name of Person Mailing Application) (Signature of Person Mailing Application)

Voice Activity Detection (VAD) Devices and Methods For Use With Noise Suppression Systems

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RELATED APPLICATIONS

This application claims priority from the following United States Patent Applications: Application Number 60/362,162, entitled PATHFINDER-BASED VOICE ACTIVITY DETECTION (PVAD) USED WITH PATHFINDER NOISE SUPPRESSION, filed March 5, 2002; Application Number 60/362,170, entitled ACCELEROMETER-BASED VOICE ACTIVITY DETECTION (PVAD) WITH PATHFINDER NOISE SUPPRESSION, filed March 5, 2002; Application Number 60/361,981, entitled ARRAY-BASED VOICE ACTIVITY DETECTION (AVAD) AND PATHFINDER NOISE SUPPRESSION, filed March 5, 2002; Application Number 60/362,161, entitled PATHFINDER NOISE SUPPRESSION USING AN EXTERNAL VOICE ACTIVITY DETECTION (VAD) DEVICE, filed March 5, 2002; Application Number 60/362,103, entitled ACCELEROMETER-BASED VOICE

ACTIVITY DETECTION, filed March 5, 2002; and Application Number 60/368,343, entitled TWO-MICROPHONE FREQUENCY-BASED VOICE ACTIVITY DETECTION, filed March 27, 2002, all of which are currently pending.

Further, this application relates to the following United States Patent Applications: Application Number 09/905,361, entitled METHOD AND APPARATUS FOR REMOVING NOISE FROM ELECTRONIC SIGNALS, filed July 12, 2001; Application Number 10/159,770, entitled DETECTING VOICED AND UNVOICED SPEECH USING BOTH ACOUSTIC AND NONACOUSTIC SENSORS, filed May 30, 2002; and Application Number 10/301,237, entitled METHOD AND APPARATUS FOR REMOVING NOISE FROM ELECTRONIC SIGNALS, filed November 21, 2002.

TECHNICAL FIELD

The disclosed embodiments relate to systems and methods for detecting and processing a desired signal in the presence of acoustic noise.

BACKGROUND

Many noise suppression algorithms and techniques have been developed over the years. Most of the noise suppression systems in use today for speech communication systems are based on a single-microphone spectral subtraction technique first develop in the 1970's and described, for example, by S. F. Boll in "Suppression of Acoustic Noise in Speech using Spectral Subtraction," IEEE Trans. on ASSP, pp. 113-120, 1979. These techniques have been refined over the years, but the basic principles of operation have remained the same. See, for example, United States Patent Number 5,687,243 of McLaughlin, et al., and United States Patent Number 4,811,404 of Vilmur, et al. Generally, these techniques make use of a single-microphone Voice Activity Detector (VAD) to determine the background noise characteristics, where "voice" is generally understood to include human voiced speech, unvoiced speech, or a combination of voiced and unvoiced speech.

The VAD has also been used in digital cellular systems. As an example of such a use, see United States Patent Number 6,453,291 of Ashley, where a VAD configuration appropriate to the front-end of a digital cellular system is described. Further, some Code Division Multiple Access (CDMA) systems utilize a VAD to

minimize the effective radio spectrum used, thereby allowing for more system capacity. Also, Global System for Mobile Communication (GSM) systems can include a VAD to reduce co-channel interference and to reduce battery consumption on the client or subscriber device.

These typical single-microphone VAD systems are significantly limited in capability as a result of the analysis of acoustic information received by the single microphone, wherein the analysis is performed using typical signal processing techniques. In particular, limitations in performance of these single-microphone VAD systems are noted when processing signals having a low signal-to-noise ratio (SNR), and in settings where the background noise varies quickly. Thus, similar limitations are found in noise suppression systems using these single-microphone VADs.

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