(51) International Patent Classification [7] : G10L 21/02	A1	(11) International Publication Number: **WO 00/49602**
		(43) International Publication Date: 24 August 2000 (24.08.00)

(21) International Application Number: PCT/US00/03538

(22) International Filing Date: 11 February 2000 (11.02.00)

(30) Priority Data:
09/252,874   18 February 1999 (18.02.99)   US
09/385,996   30 August 1999 (30.08.99)   US

(71) Applicant *(for all designated States except US)*: ANDREA ELECTRONICS CORPORATION [US/US]; 45 Melville Park Road, Melville, NY 11747 (US).
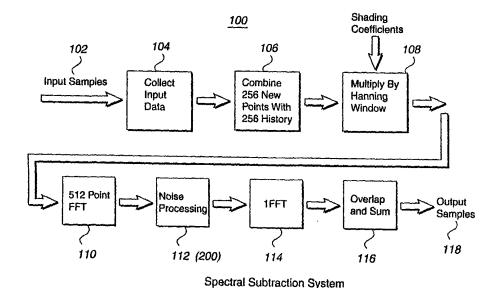
(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: MARASH, Joseph [IL/IL]; Shimkin Street 1A, 34750 Haifa (IL). BERDUGO, Baruch [IL/IL]; Hanarkisim Street 6, 28000 Kiriat–Ata (IL).

(74) Agents: KOWALSKI, Thomas, J. et al.; Frommer Lawrence & Haug LLP, 745 Fifth Avenue, New York, NY 10151 (US).

(81) Designated States: CA, CN, IL, JP, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: SYSTEM, METHOD AND APPARATUS FOR CANCELLING NOISE

Spectral Subtraction System

(57) Abstract

A system for cancelling and reducing an audio signal noise arising from electrical or electromagnetic noise sources such as AC to DC power converter used by computers. The system receives a digital audio signal (102) sampled at a frequency which is at least twice the bandwidth of the audio signal. The input samples are stored in a temporary buffer of 256 points (104). when the buffer is full, the new 256 points are combined in a combiner (106) with the previous 256 points to provide 512 input points which are multiplied by multiplier (108) with a shading window with the length of 512 points. The shaded results are converted to the frequency domain through an FFT processor (110). The FFT output is processed in a noise processor (112) which includes the noise magnitude estimation for each frequency bin, the substraction that estimates the noise free complex value for each frequency bin and the residual noise reduction process.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav	TM	Turkmenistan
BF	Burkina Faso	GR	Greece		Republic of Macedonia	TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's	NZ	New Zealand		
CM	Cameroon		Republic of Korea	PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

SYSTEM, METHOD AND APPARATUS FOR CANCELING NOISE

RELATED APPLICATIONS INCORPORATED BY REFERENCE.

This application claims priority from U.S. Patent Application Serial

5   Nos. 09/252,874 filed February 18, 1999 and 09/385,996 filed August 30, 1999 and

reference is made to U.S. Patent Application Serial No. 60/126,567 filed March 26,

1999, all of which are herein incorporated by reference.

The following applications and patent(s) are cited and hereby herein

incorporated by reference: U.S. Patent Application Serial No. 09/252,874 filed

10   February 18, 1999, U.S. Patent Application Serial No. 09/130,923 filed August 6,

1998, U.S. Patent Application Serial No 09/055,709 filed April 7, 1998, U.S. Patent

Application Serial No. 09/059,503 filed April 13, 1998, U.S. Patent Application Serial

No. 08/840.159 filed April 14, 1997, U.S. Patent Application Serial No. 09/130,923

filed August 6, 1998, U.S. Patent Application Serial No. 08/672,899 now issued U.S.

15   Patent No. 5,825,898 issued October 20, 1998; and U.S. Patent Application Serial No.

09/089,710 filed June 3, 1998, U.S. Patent No. 5,825.897 issued October 20, 1998,

U.S. Patent No. 5,732,143 issued March 24, 1998, U.S. Patent No. 5,673,325 issued

September 30, 1997, U.S. Patent No. 5,381,473 issued January 10, 1995, U.S. Patent

Application Serial No. 08/833,384 filed April 4, 1997. And, all documents cited

20   herein are incorporated herein by reference, as are documents cited or referenced in

documents cited herein.

FIELD OF THE INVENTION.

The present invention relates to noise cancellation and reduction and,

more specifically, to noise cancellation and reduction using spectral subtraction.

25   ### BACKGROUND OF THE INVENTION.

Ambient noise added to speech degrades the performance of speech

processing algorithms. Such processing algorithms may include dictation, voice

activation, voice compression and other systems. In such systems, it is desired to

reduce the noise and improve the signal to noise ratio (S/N ratio) without effecting

30   the speech and its characteristics.

Near field noise canceling microphones provide a satisfactory solution

but require that the microphone in the proximity of the voice source (e.g., mouth). In

many cases, this is achieved by mounting the microphone on a boom of a headset

many cases, this is achieved by mounting the microphone on a boom of a headset which situates the microphone at the end of a boom proximate the mouth of the wearer. However, the headset has proven to be either uncomfortable to wear or too restricting for operation in, for example, an automobile.

5   Microphone array technology in general, and adaptive beamforming arrays in particular, handle severe directional noises in the most efficient way. These systems map the noise field and create nulls towards the noise sources. The number of nulls is limited by the number of microphone elements and processing power. Such arrays have the benefit of hands-free operation without the necessity of a

10   headset.

However, when the noise sources are diffused, the performance of the adaptive system will be reduced to the performance of a regular delay and sum microphone array, which is not always satisfactory. This is the case where the environment is quite reverberant, such as when the noises are strongly reflected from

15   the walls of a room and reach the array from an infinite number of directions. Such is also the case in a car environment for some of the noises radiated from the car chassis.

OBJECTS AND SUMMARY OF THE INVENTION

The spectral subtraction technique provides a solution to further reduce

20   the noise by estimating the noise magnitude spectrum of the polluted signal. The technique estimates the magnitude spectral level of the noise by measuring it during non-speech time intervals detected by a voice switch, and then subtracting the noise magnitude spectrum from the signal. This method, described in detail in *Suppression of Acoustic Noise in Speech Using Spectral Subtraction, (Steven F Boll, IEEE ASSP-*

25   *27 NO.2 April, 1979),* achieves good results for stationary diffused noises that are not correlated with the speech signal. The spectral subtraction method, however, creates artifacts, sometimes described as musical noise, that may reduce the performance of the speech algorithm (such as vocoders or voice activation) if the spectral subtraction is uncontrolled. In addition, the spectral subtraction method assumes erroneously that

30   the voice switch accurately detects the presence of speech and locates the non-speech time intervals. This assumption is reasonable for off-line systems but difficult to achieve or obtain in real time systems.

More particularly, the noise magnitude spectrum is estimated by performing an FFT of 256 points of the non-speech time intervals and computing the energy of each frequency bin. The FFT is performed after the time domain signal is multiplied by a shading window (Hanning or other) with an overlap of 50%. The

5   energy of each frequency bin is averaged with neighboring FFT time frames. The number of frames is not determined but depends on the stability of the noise. For a stationary noise, it is preferred that many frames are averaged to obtain better noise estimation. For a non-stationary noise, a long averaging may be harmful. Problematically, there is no means to know a-priori whether the noise is stationary or

10   non-stationary.

Assuming the noise magnitude spectrum estimation is calculated, the input signal is multiplied by a shading window (Hanning or other), an FFT is performed (256 points or other) with an overlap of 50% and the magnitude of each bin is averaged over 2-3 FFT frames. The noise magnitude spectrum is then

15   subtracted from the signal magnitude. If the result is negative, the value is replaced by a zero (Half Wave Rectification). It is recommended, however, to further reduce the residual noise present during non-speech intervals by replacing low values with a minimum value (or zero) or by attenuating the residual noise by 3OdB. The resulting output is the noise free magnitude spectrum.

20   The spectral complex data is reconstructed by applying the phase information of the relevant bin of the signal's FFT with the noise free magnitude. An IFFT process is then performed on the complex data to obtain the noise free time domain data. The time domain results are overlapped and summed with the previous frame's results to compensate for the overlap process of the FFT.

25   There are several problems associated with the system described. First, the system assumes that there is a prior knowledge of the speech and non-speech time intervals. A voice switch is not practical to detect those periods. Theoretically, a voice switch detects the presence of the speech by measuring the energy level and comparing it to a threshold. If the threshold is too high, there is a

30   risk that some voice time intervals might be regarded as a non-speech time interval and the system will regard voice information as noise. The result is voice distortion, especially in poor signal to noise ratio cases. If, on the other hand, the threshold is too low, there is a risk that the non-speech intervals will be too short especially in poor

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS
Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS
Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS
Sync your system to PACER to automate legal marketing.